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Case Study XIII* - Sana'a, Yemen

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XIII.1 Introduction

The Republic of Yemen (Arabia felix) is located in the south and southeastern part of the Arabian Peninsula and covers an area of 555,000 km^2 (Figure XIII.1). The country is surrounded from the west and south by the Red and the Arabian Seas. To the east and north it is bordered by the Sultanate of Oman and the Kingdom of Saudi Arabia respectively. In addition to Sana'a city, which is the capital, the country consists of 17 governorates of which 11 are located in the north (prior to 1990 known as North Yemen) and six in the south (prior to 1990 known as South Yemen). According to the High Water Council (HWC, 1992a) the total population was estimated to be 12.4 million in 1990 and 14 million in 1992. Eighty per cent are thought to live in the central and southern highlands which receives most of the erratic, limited rainfall. It is projected that the country's population will reach 23.4 million by the year 2010. Increasing water demand in recent years and the limited availability of surface water resources have increased the pressure on the available, mostly non-renewable, groundwater resources.

According to the *World Development Report* (World Bank, 1993), the per capita gross national product (GNP) of Yemen in 1991 was US$ 520. The major sectors that play important roles in the country's economy are agriculture, industry, services and mining. HWC (1992b) summarised the share of those sectors in the Gross Domestic Product (GDP) in 1990 as 20.6, 12.9, 58.1 and 8.4 per cent respectively. Although agriculture is not the largest contributor to the national economy, it employs around 60 per cent of the active labour force. In 1990, the total cultivated agricultural land was estimated to be 1.12 × 10 ha of which 61 per cent was rain-fed, 28 per cent was irrigated with groundwater, 2 per cent was irrigated with permanent springs and the remaining 9 per cent was cultivated by spate irrigation. In 1992, irrigated agriculture consumed about 90 per cent of the total water demand and accounted for about 50 per cent of the value of agricultural production. While total exports in 1990 amounted to YR 8.3×10^9 (the 1995 official exchange rate was US$ 1 = YR 12 and the parallel market rate for January 1995 was US$ 1 $\approx$ YR 100), of which crude oil and agricultural products had the largest shares (87 and 10 per cent respectively), agricultural trade registered a deficit of 88 per cent. Inflation in 1988 was around 16 per cent, but as a result of the Gulf crisis and the return of more than a million labourers from the Gulf states, who previously provided hard currency, inflation increased to 50 per cent between 1990 and 1991.

Yemen depends mainly on external borrowing to implement its development programmes. As of 1990 the total debt stood at US$ 7.1×10^9, which was about 85 per cent of the GDP; 12 per cent of the debt comes from short-term commercial sources, 16 per cent from long-term multilateral sources, and the remaining 72 per cent from bilateral sources.

Figure XIII.1 Location map of Yemen indicating the Sana'a basin

XIII.1.1 Structure of the water sector

The two main institutions responsible for water in Yemen are the Ministry of Electricity and Water (MEW) and the Ministry of Agriculture and Water Resources (MAWR). The MEW is in charge of water supply and wastewater collection and treatment in urban centres, in addition to water supply in rural areas. Three organisations are directly attached to the MEW: the National Water and Sewerage Authority (NWSA), the General Directorate of Rural Water Supply (RWSD) and the High Water Council (HWC). The NWSA is a financially autonomous authority in charge of water supply and wastewater collection and treatment for the urban areas. Since the establishment of the authority in 1973, its jurisdiction has expanded to cover 12 cities in addition to Sana'a. The minister of MEW chairs the board of directors that runs the authority. The RWSD is mainly in charge of the rural water supply. The main role of this directorate has been the construction of small-scale water supply projects (mostly funded by external donors), which are usually handed to local councils for operation and maintenance. So far, rural sanitation has not received much attention, and on-site disposal facilities are the most common approach in the rural communities. The HWC was established under the same legislation that established the MEW in 1981, and its role is to co-ordinate the activities of all agencies in the water sector. The main task of the Council was to formulate national water plans and strategies and to prepare national water legislation. The Council consisted of deputy ministers of concerned ministries and was chaired by the Minister of Electricity and Water. As a result of under-staffing, the council was reformulated in 1986 to consist of concerned ministers and chaired by the Prime Minister. The Technical Secretariat of the HWC was also established in 1986 to assist the Council in the performance of its duties. Currently, no law had been passed to support the formulation of the Council as an independent agency and, therefore, it had been facing difficulties in meeting its obligations and duties.

After reunification of North and South Yemen in May 1990, the MAWR was formed from the previous Ministry of Agriculture and Fisheries in the north and the Ministry of Agriculture and Agrarian Reform in the south. These ministries had been in charge of development of water resources for agricultural purposes. However, since May 1990 the MAWR has been given the responsibility of managing national water resources, i.e. it has become a water manager and a major water user at the same time.

XIII. 1.2 Legislative framework

At present, there exists no national water legislation. Prior to May 1990, the HWC had prepared draft national water legislation and, because of the seriousness of groundwater depletion, the HWC also drafted a by-law on regulating groundwater extraction and a law to establish a National Water Authority. In the drafted law, the proposed National Water Authority was given the responsibility of allocating available water resources, specifying water use priorities and controlling annual consumption in order to ensure the sustainability of economic and social development. Due to the altered responsibilities for water resources management that occurred after May 1990, the MAWR drafted, independently, a second national water legislation in 1992 with a law to establish a National Water and Irrigation Authority.

However, neither of these laws were passed and the lack of water legislation has subsequently created an atmosphere of uncoordinated water use which is evident from the continuous decline of groundwater levels nation-wide. In short, the seriousness of the present water situation highlights the immediate need for water legislation and the establishment of a national agency to manage the scarce water resources in Yemen.

XIII.2 Water issues

The Sana'a basin is located in the central highlands (Figure XIII.2) and covers approximately 3,200 km^2, ranging from less than 2,000 m to more than 3,200 m above sea level. The climate of the basin area is characterised by a low and erratic rainfall pattern with an average of 250 mm a^{-1}. Sana'a, the capital of Yemen, is located in the Sana'a plain (Figure XIII.2) at an elevation of about 2,200 m above sea level. According to the first national census in 1975, the population of the city was 134,588 inhabitants and it had increased more than three-fold to 424,450 by 1986. Although the national population growth rate was around 3 per cent, the population of the city grew at an annual rate of 11 per cent and was then projected to continue at a similar rate. This rapid growth is mainly attributed to improved economic conditions which stimulated internal migration from the rural areas. At present, the population of the city is estimated to be over 1 million and is projected to increase to over 3.4 million by the year 2010.

XIII.2.1 Water resources

The principal source of water in the region is groundwater from three aquifer layers, namely alluvial deposits, volcanic units and the Tawilah sandstone. Of the three aquifers, the Tawilah is considered to be the most productive and has the best water quality. The capacity of the Tawilah is estimated at 2,230 × 10^6 m^3 (total storage) of which only 50 per cent is considered withdraw able. In addition to low recharge as a result of low rainfall in the recent past, increased extraction (mainly for agriculture) has resulted in a substantial drop in groundwater levels (3-4 m a^{-1}). It is important to realise that while the total water demand in the Sana'a basin area was estimated to be 220 × 10^6 m^3 a^{-1} in 1995, recharge estimates for the Tawilah aquifer vary between only 27 × 10^6 and 63 × 10^6 m^3 a^{-1}. The large difference between consumption and recharge is being filled with water from long-term storage, referred to as groundwater mining. The present pattern of water use in Sana'a is clearly unsustainable and, if allowed to continue, depletion of this valuable and scarce resource is inevitable.

Figure XIII.2 Map showing the major features of the Sana'a basin

XIII.2.2 Water use

Groundwater in the region is used exclusively to satisfy the water needs of the different water-using sectors, namely irrigated agriculture, municipal use and industrial use.

Prior to the Yemeni revolution in 1962, agriculture in the Sana'a basin area depended on dry farming practices and spate irrigation. The introduction of drilled boreholes in the 1970s, and the identification of the Tawilah as a highly productive aquifer, encouraged farmers to use groundwater for irrigation. Having realised the importance of the Tawilah, the government tried to regulate agricultural water use in the area by passing a law in 1973 which identified a local protection zone around the NWSA wellfields and prohibited further drilling of new wells or cesspits unless permitted. At present, agriculture in the basin area consumes about 175×10^6 m^3 a^{-1}, which accounts for 80 per cent of the total water demand in the basin area. Moreover, qat (a tree from which the leaves are chewed as a stimulant in Yemen) and grapes (a cash crop) are estimated to consume around 40 and 25 per cent respectively of the agricultural water demand in the region. The main reasons behind the over-use of groundwater for irrigation can be summarised as:

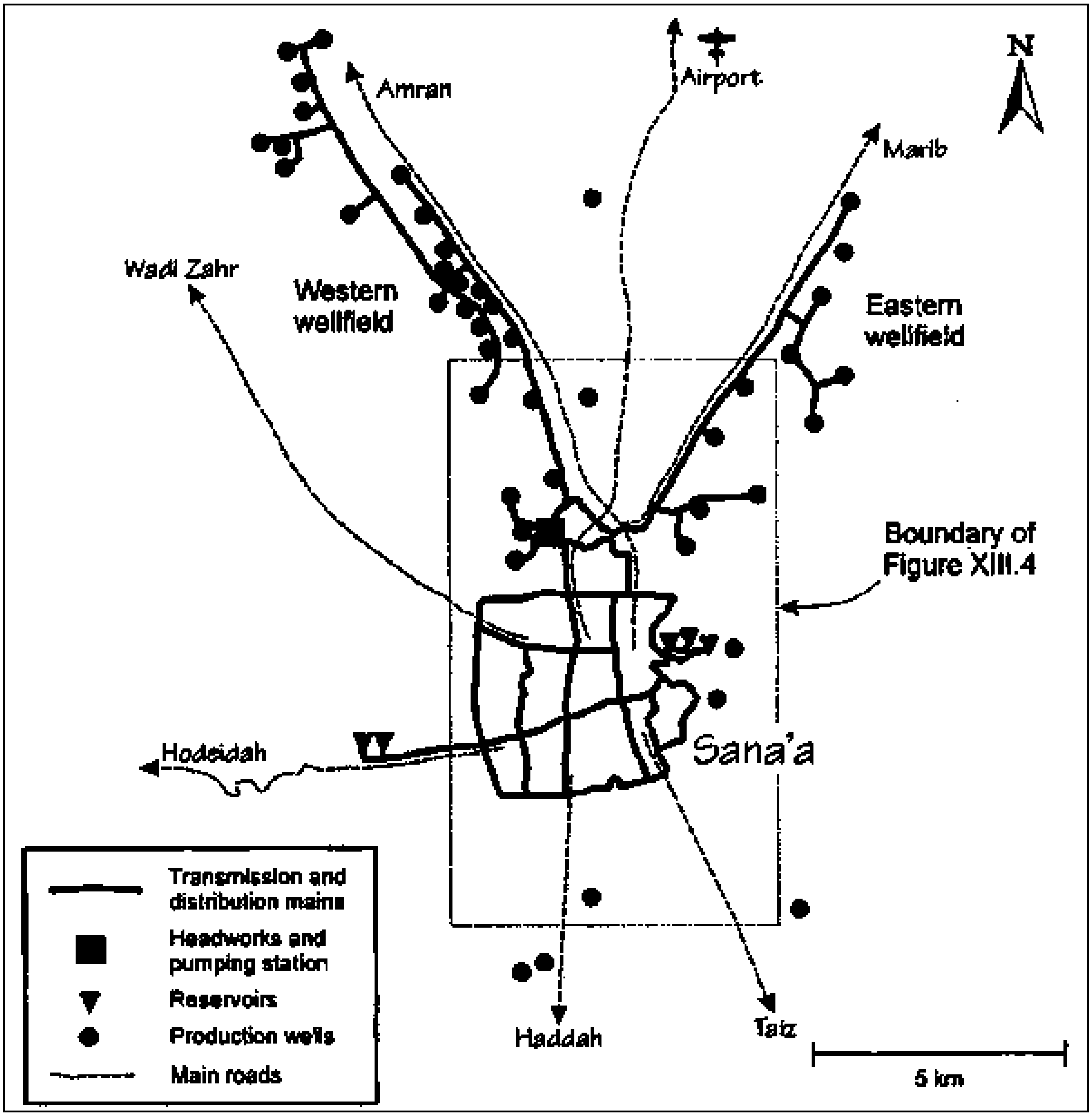
- Unclear water rights and thus unregulated extraction.
- Fuel subsidies and low import duties on agricultural equipment.
- High returns on cash crops.
- Inefficient irrigation practices.

Within the Sana'a basin, it is estimated that the present population is about 2.34 million, of which 1.4 million live in urban areas. Although the per capita consumption rate varies, it is estimated that the total municipal water demand in 1995 was 36.9×10^6 m^3 a^{-1}, of which about 29×10^6 m^3 a^{-1} was consumed in the urban areas. It was also projected that the total yearly municipal water demand would increase to 138×10^6 m^3 a^{-1} by the year 2010 (HWC, 1992c). The industrial water demand was estimated at 4.7×10^6 m^3 a^{-1} in 1990 and was projected to increase to 6.2×10^6 m^3 a^{-1} in 1995. Van der Gun *et al.* (1987) reported that the government of the Yemen Arab Republic (North Yemen prior to reunification in 1990) took measures to prevent the further establishment of major water-consuming industries in the Sana'a area and this could explain the low rate of increase in water use compared with the other sectors.

XIII.2.3 Sources of groundwater pollution

In the Sana'a basin area, unregulated direct disposal underground of municipal and industrial wastewater by means of on-site disposal facilities (cesspits) presents a potential threat of groundwater contamination. The thick, unsaturated zone, resulting from deep groundwater levels (100-170 m below ground level) suggests that groundwater pollution is unlikely. However, the complex geological structure and the presence of rock fractures could reduce the travel time of pollutants through this layer. The use of pesticides and chemical fertilisers in agriculture in Yemen is, however, still at a relatively low level and therefore groundwater contamination from this source is not of major concern at present.

Figure XIII.3 Map of the Sana'a area showing the location of pumping stations, reservoirs and the NWSA wells (After Al-Hamdi, 1994)



XIII.2.4 Water and wastewater in Sana'a city

In the city of Sana'a, the municipal water supply consists of both public and private water supplies. In 1993, the public water supply produced around 17.8×10^6 m^3 providing 43 per cent of the city's population with a per capita consumption of about 120 1 d^{-1}, including 35 per cent that was not accounted for. Groundwater from the NWSA wellfields (Figure XIII.3) is of good quality and meets the World Health Organization (WHO) drinking water guidelines. Nevertheless, chlorination is usually applied as a safety measure in the distribution network. Private water supplies, which depend on unmonitored private boreholes in the city, some of which also draw from the Tawilah, were estimated to have produced 6.7 × 10^6 m^3 in 1993. Although the private water supply is supposed to cover 57 per cent of the city's population, the high price of the water is suspected to reduce the per capita consumption to about 35 l d^{-1}.

As of 1993, only 12 per cent (10,000-12,000 m^3 d^{-1}) of the city was connected to the sewerage system which conveys wastewater to stabilisation ponds in Rowdda, north of Sana'a, for treatment (see Figure XIII.4). The rest of the city (35,000 m^3 d^{-1}) depended on cesspits with infiltration as the main mechanism of wastewater disposal. Al-Eryani *et al.* (1991) concluded that domestic wastewater had produced some changes in the quality of ground-water under the heavily populated area of the city and around the stabilisation ponds at Rowdda. Al-Shaik (1993) summarised an investigation of the water quality of some wells along the path of the effluent from the stabilisation ponds north of Rowdda. The study identified a contaminated area along the effluent channel and recommended continuous monitoring of the investigated area, as well as the NWSA wellfields. Al-Hamdi (1994) investigated the quality of groundwater in the city of Sana'a and classified the city into three quality zones: north, middle and south (Figure XIII.4). Groundwater in the middle zone contained more nitrate and chloride than the other zones, suggesting that wastewater disposal in this zone has had a negative effect on the quality of the groundwater. Furthermore, a polluted sub-area (sub-middle) was identified within the middle zone, which was characterised by NO_3^- concentrations within the range 100-160 mg l^{-1}, Cl^- concentrations within the range 220-400 mg l^{-1} and electrical conductivity within the range 975-2,045 mS cm^{-1}. It was argued that the present pollution could be attributed to wastewater disposal and that the polluted zone would expand towards the north, because the general direction of groundwater flow in the area is from south to north. No immediate risk was thought to exist for the NWSA wellfields but more than 50 per cent of the city's population depend on unmonitored private wells scattered within the city's perimeter.

The use of cesspits in the eastern and western parts of the city (Nokom and Allakama) has resulted in an overflow of wastewater to the ground surface because the local geology infiltration rates are very low. In addition to the potential health hazards resulting from direct human exposure, Al-Hamdi (1994) has suggested that intermittent de-pressurisation of the drinking water distribution network could induce some suction of wastewater into the network.

Based on groundwater samples taken near industrial activities, mainly large factories located outside the city, Al-Eryani *et al.* (1991) concluded that industrial wastewater in the Sana'a area was not presenting an immediate threat to the quality of the groundwater; however, no detailed information about the waste disposal methods and the characteristics of the industrial wastewaters was given. In addition to large factories, which are mostly located outside the city, many small workshops, oil-changing garages and car washes are located within the city. The results presented by Al-Hamdi (1994) suggest that direct disposal of wastewater from these activities could lead to serious groundwater contamination.

Figure XIII.4 Map showing the groundwater quality variation in the city of Sana'a. The general direction of groundwater flow is from South to North (After Al-Hamdi, 1994)

From the above discussion, it is evident that groundwater depletion is currently taking place, while at the same time the quality of groundwater under the city is threatened by extensive wastewater disposal. Water rights have not been settled with farmers and, therefore, they consider groundwater to be communal property whereby they have the right to fulfil their domestic and agricultural water needs. Competition for groundwater extraction could increase the rate of depletion of the aquifer leading to a subsequent decrease in irrigated agriculture in the area. In order to mitigate the possible future conflicts that could arise between farmers and the city over water resources, a management plan acceptable to both parties must be concluded. In this context water conservation and wastewater reuse for irrigation could prove to be two key issues. Water conservation in irrigated agriculture, the largest groundwater user in the area, involves many aspects, including agricultural economy, governmental policies and the national legal conditions. Such aspects are beyond the scope of this case study. Wastewater reuse is, however, closely integrated with groundwater management and pollution control and this aspect is therefore discussed below.

Current estimates show that 18×10^6 m^3 a^{-1} of wastewater are generated by the city of Sana'a, of which about 20-25 per cent is collected through the sewerage system. It has been estimated by HWC (1992c) that the agricultural water requirements in the basin area were about 175×10^6 m^3 a^{-1} in 1995, of which 160×10^6 m^3 were accounted for by groundwater irrigation for cash crops. These estimates suggest that wastewater from the city could reduce agricultural water use by around 12 per cent if reused for irrigation at properly selected hydrogeological areas, i.e. at the NWSA wellfield region. This reuse could provide the city with substantial additional water supplies while also reducing the potential threat of groundwater contamination under the city. Farmers could be convinced to reuse wastewater because it would be cheaper than groundwater (collection and treatment would be paid for by the Government and by consumers) and more reliable (especially with the continuous decline in groundwater levels and the threat of complete exhaustion of the aquifer). Such reuse should be constrained by legal agreements where treated wastewater (the property of the city) is traded for undefined groundwater rights. Thus farmers involved in these agreements would receive treated wastewater, in addition to possible privileges, such as extra attention from relevant governmental agencies, awareness programmes for wastewater irrigation and certain financial incentives (i.e. loans and subsidies), in return for discontinuing groundwater irrigation. The increasing scarcity of groundwater in the area could make such agreements attractive to farmers especially when long-term (sustainable) agriculture in the area is most likely to be wastewater-irrigated.

With respect to pollution control, wastewater reuse could serve three objectives simultaneously:

- It would eliminate all adverse health effects that could result from drinking contaminated groundwater, from direct exposure to overflowing wastewater, and from direct contamination of the drinking water distribution network.

- The private sector could continue to provide part of the population with safe drinking water.

• The increased groundwater supplies, as a result of less groundwater irrigation, would allow the NWSA to increase the coverage of the regulated and monitored public water supply.

However, the absence of a co-ordinating agency and the present divided responsibilities for water resources are major constraints to the implementation of such management options.

XIII.2.5 Critical water issues

As indicated above Yemen in general, and Sana'a in particular, are facing a critical water shortage due to unregulated and uncoordinated water use. Moreover, there is a potential risk of groundwater contamination as a result of unregulated wastewater disposal. The risk of groundwater pollution could incur serious health problems because more than 50 per cent of the city's population rely on private wells for their water needs. In addition to adverse health effects, polluted groundwater becomes very costly to treat.

XIII.3 Planned interventions

The government of Yemen realised that there was a critical water shortage in Sana'a and initiated, with the assistance of the Dutch government, a project in the late 1980s to look for alternative water sources for the city, i.e. a supply orientated approach. The government also realised the need for water legislation and for a national agency to manage, regulate and co-ordinate the use of water resources in a manner that will ensure sustainable development.

With regard to the risk of groundwater contamination in the Sana'a area, the NWSA has appreciated that direct wastewater disposal and the overloaded stabilisation ponds are the main contributors to changing groundwater quality in certain areas of the city. Thus collection and proper treatment of wastewater is viewed as the key to protect the Tawilah aquifer from further quality degradation. If the sewerage system is expanded to cover the entire city and if wastewater is adequately treated so that it can be re-used in agriculture, the quality of the groundwater will be protected and some of the agricultural water demand should be reduced. Recently, land has been acquired for a new activated sludge treatment plant, but funds still need to be allocated for its construction. In response to continuous public complaints, the NWSA intends, in an emergency programme, to connect the eastern and western parts of the city (Nokom and Allakama) to the sewerage system in order to eliminate the overflow of wastewater and to reduce the threat of drinking water contamination in the distribution network.

XIII.4 Lessons learned and conclusions

In an effort to manage the current unsustainable use of the groundwater resources in the Sana'a area, the Government has focused on a supply orientated approach with a project to evaluate different water sources. At the same time, the Government has failed to address demand management measures as a viable option in water resources management. Importing water from other regions to Sana'a, given the scarcity of water nationwide, would be very costly and could face strong local resistance in the supplying regions. Implementation of demand management in Yemen requires an in-depth understanding of water rights. Settlement of those rights would become essential if the Government wished to set water-use priorities and to control the (re)allocation of water resources.

The 1973 law to protect the NWSA wellfields from depletion and from deterioration in water quality can be considered ineffective for the following reasons:

• Small ratio of protection zone to total basin area.

• Such regulations are difficult to monitor and to enforce.

• There was no other alternative for wastewater disposal and therefore permits for cesspits were always granted.

The quality of groundwater under the central part of the city of Sana'a and around the stabilisation ponds has deteriorated as a result of unregulated direct disposal of wastewater. Although immediate action is required, the availability of financial resources to expand the sewerage system and to construct proper treatment facilities seems to be the major constraint. To date, economic and financial incentives have been neglected in water management and pollution control in Yemen.

Five main points have been highlighted by this case study:

• Unregulated disposal of municipal and industrial wastewater could cause serious changes in the quality of groundwater and therefore could have the potential to result in adverse health effects and high treatment costs. Reuse of wastewater in a water-scarce regions like Sana'a can be considered as an attractive and effective opportunity because it reduces the threat of groundwater contamination while also providing a water source with a high nutrient content for irrigation. However, the success of a wastewater reuse programme depends on several conditions:
• The sewerage system should expand to cover the entire city (very costly).

• Reclaimed wastewater for irrigation should be free of toxic substances that may arise from industrial discharges, and the hygienic and agronomic quality of the water should be suitable for irrigation.

• Farmers should be amenable to the use of reclaimed wastewater for irrigation (wastewater irrigation of cash crops could reduce the market price of those crops).

• The present institutional arrangement of the water sector in Yemen, where there is no proper co-ordination in the use of scarce water resources or effective management of pollution control, can be viewed as a prime factor leading to the unsustainability of those water resources.

• A demand-orientated approach should be considered as an important element in water resource management. This is particularly important in arid and semi-arid areas where water resources are limited although demand, due to increased populations needing water and food, is always increasing.

• Economic and financial incentives should be considered seriously in water management and pollution control. Pricing could play an important role in demand reduction and pollution prevention.

• Sustainable use of scarce water resources should be included in the regional and national economic and social development plans and strategies.

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Chapter 6* - Economic Instruments

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6.1 Introduction

In 1972 the Organisation for Economic Co-operation and Development (OECD) adopted the polluter-pays-principle. This principle, which was later adopted as official policy by the European Union (EU), expresses the central notion of environmental economics, i.e. that the cost of pollution should be internalised. Since the principle was introduced it has been extended to include resource use and, thus, the polluter and the user should pay (OECD, 1994b). The introduction of the polluter-pays-principle has also stimulated growing interest world-wide in applying economic instruments. When properly applied they have, in theory, the potential for encouraging cost-effective measures and innovation in pollution control technology. Moreover, water quality is one of the few environmental policy areas where economic instruments already play a significant role in OECD countries and in transitional economies. The purpose of this chapter is to review the most commonly used economic instruments for controlling water pollution, to highlight practical considerations in applying them to water pollution, to suggest criteria for selecting the most appropriate instruments, and to discuss implications for applying them in developing countries and in transitional economies that do not already use them.

6.2 Why use economic instruments?

Economic or market-based instruments rely on market forces and changes in relative prices to modify the behaviour of public and private polluters in a way that supports environmental protection or improvement. They represent one of the two principle strategic approaches to pollution control. The other main approach is regulatory, often referred to as "command and control" (CAC). Regulatory tools influence environmental outcomes by regulating processes or products, limiting the discharge of specified pollutants, and by restricting certain polluting activities to specific times or areas. Another means of influencing polluter behaviour is through persuasion. In the case of polluting industries, this approach may involve voluntary agreements to undertake pollution control measures. In the case of consumers, it may involve public education and information campaigns to influence patterns of consumption and waste disposal. This approach is applied in countries such as The Netherlands, Japan and Indonesia.

Since the inception of environmental policy in most industrial countries, governments have tended to use these instruments as their main strategy for controlling pollution. Many countries, however, are becoming aware that regulatory instruments are inefficient for achieving most pollution control objectives, and that the level of expenditure required to comply with increasingly stringent environmental laws and regulation is becoming a major cost of production. In the USA, for example, the US Environmental Protection Agency (EPA) estimates that the proportion of Gross National Product (GNP) devoted to environmental protection can be expected to grow from 1.7 per cent in 1990 to nearly 3 per cent by the year 2000, and that most of these costs will be borne by the private sector (US EPA, 1991). An increasing number of governments are, therefore, investigating alternative mechanisms to achieve the most cost-effective means for controlling pollution that will not place excessive financial burdens on businesses and individuals, and that will not undermine economic development.

In contrast to regulatory instruments, economic instruments have the potential to make pollution control economically advantageous to commercial organisations and to lower pollution abatement costs. They can be applied to a wide range of environmental problems and can involve varying degrees of incentives, information, and administrative capacity for effective implementation and enforcement. The principal types of economic instruments used for controlling pollution are:

• *Pricing.* Marginal cost pricing can reduce excessive water use and consequent pollution as well as ensure the sustainability of water treatment programmes. Water tariffs or charges set at a level that covers the costs for collection and treatment can induce commercial organisations to adopt water-saving technologies, including water recycling and reuse systems, and to minimise or eliminate waste products that would otherwise be discharged into the effluent stream. In Thailand, for example, many hotels along the country's eastern coast are treating and recycling their water for landscape irrigation because the cost of freshwater now exceeds the cost of treatment (Foster, 1992). Before considering the use of other instruments in environmental policy, it is advisable for countries to evaluate their water pricing policies because such policies can encourage over-use and water degradation.

• *Pollution charges.* A pollution charge or tax can be defined as a "price" to be paid on the use of the environment. The four main types of charges used for controlling pollution are: (i) effluent charges, i.e. charges which are based on the quantity and/or quality of the discharged pollutants, (ii) user charges, i.e. fees paid for the use of collective treatment facilities, (hi) product charges, i.e. charges levied on products that are harmful to the environment when used as an input to the production process, consumed, or disposed of, and (iv) administrative charges, i.e. fees paid to authorities for such purposes as chemical registration or financing licensing and pollution control activities.

• *Marketable permits.* Under this approach, a responsible authority sets maximum limits on the total allowable emissions of a pollutant. It then allocates this total amount among the sources of the pollutant by issuing permits that authorise industrial plants or other sources to emit a stipulated amount of pollutant over a specified period of time. After their initial distribution, permits can be bought and sold. The trades can be external (between different enterprises) or internal (between different plants within the same organisations).

• *Subsidies.* These include tax incentives (accelerated depreciation, partial expensing, investment tax credits, tax exemptions/deferrals), grants and low interest loans designed to induce polluters to reduce the quantity of their discharges by investing in various types of pollution control measures. The removal of a subsidy is another effective tool for controlling pollution. In many countries, for example, irrigation water is provided free of charge, which encourages farmers to over-irrigate, resulting in salinisation and/or water logging.

• *Deposit-refund systems.* Under this approach, consumers pay a surcharge when purchasing a potentially polluting product. When the consumers or users of the product return it to an approved centre for recycling or proper disposal, their deposit is refunded. This instrument is applied to products that are either durable and reusable or not consumed or dissipated during consumption, such as drink containers, automobile batteries and pesticide containers.

• *Enforcement incentives.* These instruments are penalties designed to induce polluters to comply with environmental standards and regulations. They include non-compliance fees (i.e. fines) charged to polluters when their discharges exceed accepted levels, performance bonds (payments made to regulatory authorities before a potentially polluting activity is undertaken, and then returned when the environmental performance is proven to be acceptable), and liability assignment, which provides incentives to actual or potential polluters to protect the environment by making them liable for any damage they cause. This chapter only addresses fines because they are the most commonly used enforcement incentives, particularly in the area of water pollution control.

Although economic instruments have several advantages over direct regulation, applying them to pollution control does not, and should not, preclude the use of regulatory instruments. In most cases, economic instruments supplement the existing regulatory framework, with ambient standards remaining the objectives for both. By selecting the right mix of regulatory and economic instruments, and in some cases other types of instruments such as property rights or educational approaches, policy makers can combine the positive elements of both approaches.

The main advantage of the regulatory approach is that, when properly implemented and enforced, regulation affords a reasonable degree of predictability about how much pollution will be reduced. In theory, the advantages of economic instruments are:

• They allow commercial organisations and individuals to respond flexibly and independently in line with market prices in order to meet environmental management objectives at the least cost.

• They provide a continuing incentive for commercial organisations to reduce pollution and therefore to develop and adopt new pollution control technologies and processes to minimise waste.

• They have the ability to raise revenue (in the case of charges) in order to finance pollution control activities.

• They accommodate the growth of existing industries and the entry of new ones more than would otherwise be possible under a regulatory approach.

• They reduce compliance and administrative costs for both government and industry. For example, the use of environmental taxes or tradable permits eliminates the need for government certification of production processes and technologies. They also eliminate the government's need for large amounts of information to determine the most feasible and appropriate level of control for each regulated plant or product.

The advantages of economic instruments offset the main drawback of the regulatory approach, i.e. regulatory tools can be economically inefficient and excessively costly to implement. For example, under the regulatory approach, all commercial organisations would be subject to the same emission standards regardless of their pollution abatement costs. Ideally, only the larger polluters would install pollution control equipment; the large scale of their operations makes the cost of pollution control per unit of output lower than that for small-scale polluters. The regulatory approach also tends to discourage innovation in pollution control technology. It gives little or no financial incentive to organisations to exceed their control targets. This is a particular disadvantage where the development of a new control technique could be subsequently held as the future standard but without allowing any opportunity to benefit from the innovation. Moreover, compliance in most cases depends on the enforcement capacity of the regulatory agency and the number of organisations or individuals being regulated. The greater the number of organisations or enterprises to be regulated, the more difficult it is to enforce the regulations properly. Economic instruments, by contrast, are better suited to a larger number of point and non-point sources of pollution.

While economic instruments can be more cost-effective than regulatory instruments and more appropriate for dealing with numerous point and non-point sources, the economic or market-based approach to pollution control also has its own drawbacks. The major weaknesses of economic instruments are:

• Their effects on environmental quality are not as predictable as those under a traditional regulatory approach because polluters may choose their own solutions.

• In the case of pollution charges, some polluters opt to pollute and to pay a charge if the charge is not set at the appropriate level.

• They usually require sophisticated institutions to implement and enforce them properly, particularly in the case of charges and tradable permits.

In addition to these drawbacks, both government agencies and individual polluters have resisted the introduction of economic instruments. Regulatory agencies, for example, have objected to them largely because they afford them less control over polluters. Industry and other polluters have resisted them because they feel that they have greater negotiating power over the design and implementation of regulations than they do over charges. Industries also view economic instruments as additional constraints (where they supplement existing regulations). For example, charges impose a financial burden beyond the cost of complying with regulations. A further deterrent to using economic instruments is their, often complicated, implementation requirements. The main difficulties relate to setting prices for environmental resources and estimating the full extent of environmental damage.

6.3 Applying economic instruments

Despite the general resistance of countries to using economic instruments in environmental management, water pollution control is one of the few environmental policy areas where they have played a relatively significant role. Charges for the collection and treatment of water are well established in most industrial countries. In many countries, charges also are applied to polluters who discharge their effluent directly into open water. In addition, combinations of direct regulation and economic instruments, particularly charges, have produced positive results in terms of revenue raising and pollution control.

The remainder of this section discusses how specific instruments are used in controlling water pollution. Among these instruments, water pricing, effluent charges, user charges, and subsidies are the principal economic instruments used in this respect by both industrialised and developing countries.

6.3.1 Pricing

Water pricing policies can be an effective tool for reducing pollution; not only by promoting water conservation, but by raising funds to support pollution control programmes. Mexico City, for example, has increased the price for industrial water consumption. This has discouraged the establishment of water intensive industries in the Mexico City Metropolitan Area (MAMA) and encouraged water conservation by making recycling an attractive proposition. It has also promoted the use of water saving technologies (World Bank, 1994). As has been demonstrated in Mexico City, where wastewater standards are defined in terms of pollutant concentrations, pollution charges and standards should be co-ordinated carefully with water prices to ensure effective pollution control. If water prices are low, polluters can meet the standard by dilution - leading to higher water use without reducing the overall pollution load.

6.3.2 Effluent charges

Several countries apply effluent charges in order to finance necessary measures for wastewater collection and purification, and to provide financial incentives for reducing discharges of effluent. The charge can be based either on the actual quality and quantity of wastewater (determined through yearly or more frequent monitoring by the responsible administrative body or through self-monitoring by the polluter), or on a substitute based on information on the output, treatment levels and number of employees within an organisation. In some cases, a flat rate is charged. Successful implementation of a charge system depends on four key factors (OECD, 1991):

- Recognising the fundamental characteristics of the environmental problem.
- Choosing a competent authority to legislate, implement, and monitor the tax.
- Establishing a suitable tax base.
- Setting an appropriate tax rate.

The experience of most of countries applying water effluent charges, e.g. France, Germany, Italy, and Central and Eastern European countries, indicates that charges are set far below the level required to induce polluters to reduce their discharges, although they do raise revenue for pollution control purposes. By contrast, in The Netherlands, the water effluent charge, which was designed as a tool for revenue raising only, has also served as an incentive because of the high charge rates. The Netherlands also adopted the following approach to reduce the need for large amounts of information to assess the fees to be charged:

- Households and small industrial polluters producing less than 10 pollution equivalents (pe) are not charged for the actual pollution they cause. Having relatively few opportunities to limit discharges, this category of polluters is of minor importance to the instrument's regulating power. The great benefit is that this allows the executive bodies to reduce drastically the amount of information required. Fixed rates are used instead.

- Charges for medium-sized polluters (10-100 pe) are not based on samples of their effluent but according to a coefficient table prepared by experts. This permits the probable amount of pollution to be estimated accurately for each branch of industry or sector on the basis of easily obtainable data, such as the amount of water used by the production plant and the amount of raw materials it processes. Nonetheless, the incentive to reduce pollution remains intact. Companies that believe they are overrated on the coefficient table can request their effluent to be sampled and then charged on the basis of the results (Braceros and Schuddeboom, 1994).

As demonstrated by effluent charge systems in numerous countries (Box 6.1), these systems are most successful when combined with regulation, when applied to stationary pollution sources and when marginal abatement costs vary amongst polluters (the wider the variation, the greater the cost-saving potential). Other determinants of success are the feasibility of monitoring effluents (either by direct monitoring or proxy variables), the ability of polluters to react to the charge, the ability of pollution control authorities to assess appropriate fees, and the potential for polluters to reduce emissions and to change their behaviour. Russia's pollution charge system demonstrates how administrative weaknesses can undermine environmental effectiveness (Box 6.2).

In Mexico, an effluent charge is directly tied to regulation, but its design and implementation could also be improved. The Federal Water Charges Law in Mexico establishes water pollution charges applicable to all discharges to national waters that exceed the applicable standard. The charges are based on volume of flow, discharges of conventional pollutants (suspended solids and chemical oxygen demand (COD)), the costs of pollution abatement and regional water scarcity. The charge, however, does not take into account the effluent's toxicity or the quality of the receiving body of water. The objective of the pollution charge is to encourage organisations to comply with effluent standards, and only those organisations that do not comply are subject to a charge. Those that do not comply but have a plan to control emissions can obtain an exemption for up to two years. The tax base has three components: the excess of COD emissions above the standard, the excess of suspended solids emissions above the standard and a volume component. The volume component is applied whenever the organisation is in violation of any of the pollutants for which it is subject to a standard, even when that organisation is in compliance with COD and suspended solids. For each of these three components, there are charges that depend on the zone in which the firm is located.

Box 6.1 Examples of effluent charge systems

Brazil

In Brazil, four States are experimenting with effluent charges in the form of an industrial sewage tariff based on pollutant content. Although the formulae adopted to define the tariff levels vary among States, cost recovery is the objective in all cases. In the State of Rio de Janeiro, the local environmental protection agency Fundaçao de Tecnologia de Saneamento Ambiental (FEEMA) is responsible for tax collection. It is creating an effluent charge to be approved by the State government. The charge will be levied on all polluters and will be based on the volume and concentration of the effluent, including BOD and heavy metals. Tariff rates will be calculated to recover the budgetary needs of the State agency. In the case of Rio de Janeiro, the budget of the state agencies is so low, at present, that the administration relies on revenue raising approaches to fulfil its funding requirements. Revenues are usually distributed for such functions as pollution abatement, financing of administrative costs, monitoring enforcement and educational campaigns.

France

To manage its water resources and to halt or reduce growing river pollution, the French government decided in 1964 to apply economic instruments to supplement its regulations. At the same time, the planning and financing water management responsibilities of the country were devolved to new operational agencies, i.e. river basin committees and water agencies. These institutions, created in the six river basins, play an essential role in water planning and controlling domestic and industrial pollution. The creation of these agencies made it necessary to take a consistent approach to pollution so that charges could be established on the basis of a small number of clearly defined variables. Initially the basis for the fee consisted of two variables: the weight of suspended matter and the weight of organic matter. Both were considered priorities, representing the most visible type of pollution, and the means to tackle them were also known. Much later, when new pollution variables began to cause concern or when techniques for evaluating and eliminating them became available, the basis for assessment was gradually extended (e.g. to include salinity, nitrogen, phosphorous, halogenated hydrocarbons, toxic and other metals). In each case, the aim was to use charges as an incentive to reduce pollution caused by the variable in question and to avoid charges being transferred to users who are not responsible for increased levels of pollution. The rates are set by each agency board and approved by the corresponding river basin committee. Their values are determined in such a way that the income from charges balances the financial assistance provided, while avoiding excessive discrepancies between charges to the various charge payers. The charge is also a source of information about users' activities, offering more precise knowledge of how water is used and a better understanding of the natural environment. The quantities of pollution discharged by a user, which is impractical to measure for each one, are assessed at a flat rate according to a national scale based on the type of activity (in the case of industry) or number of inhabitants (in the case of urban centres). The amount of pollution produced by a particular industrial establishment is measured only at the operator's or agency's request. When this occurs, measurements are taken by a laboratory approved by the agency and the costs are borne by the party making the request. The agencies also are authorised to promote measures to conserve water supplies. In addition to the pollution charge, therefore, a charge is levied on the basis of the volume of water taken by each user. Charge payers may choose between a flat-rate assessment of the volume of water they use and metering (the income from this type of charge is generally much less than the income from pollution charges). The law gives agencies a dual role in promoting water protection in their particular river basin, providing financial assistance for works of common interest and conducting studies and research in water-related matters. In the same way, polluters are taxed when their activity is harmful to the environment and polluters receive an award, in the form of subsidies, when their actions are beneficial to the environment.

Germany

The German Effluent Charge Law authorises States to levy charges on direct discharges of specified effluents into public waters. Commercial organisations and households discharging into municipal sewerage facilities are not charged directly. The pollutants considered for the purposes of effluent charges are settleable solids, COD, cadmium, mercury and toxicity to fish. In setting the charge base, the law established the right to discharge and includes all of the physical, chemical and biological data and monitoring procedures pertaining to wastewater quality. For each organisation, the State also specifies a total discharge based on historical volumes of wastewater allowable per year. Since the effluent charge is combined with a permit procedure, the maximum effluent level is also specified. The actual effluent discharged by the organisation must be of a quality equal to, or higher than, the minimum requirements laid out in the regulation. The taxable base is specified in terms of concentration per cubic meter of discharge volume or per tonne of product produced. An organisation's discharge is then converted into damage units using coefficients provided in the law. The tax liability is determined by multiplying the number of damage units by the tax rate per damage unit. This tax rate is revised annually based on an established increment. To provide an incentive to limit pollution loads, higher charges are imposed per damage unit if organisations exceed the permit limit. These excesses are allowed only twice a year. Lower Charges per damage unit are used to compute the total tax liability for those who discharge below permit limits.

Korea

The emission charge system combines elements of regulation and market-based incentives and applies to both air and water discharges. The charge is applied to organisations who are operating facilities that do not meet emission/effluent standards. The charge rate, however, is not directly linked to the level of excess discharges, nor is there an upper limit on the amount of the levy. In practice, however, charge rates have sometimes been set lower than the operating costs of a pollution treatment facility and so organisations have been known to under-use their treatment plants at the risk of being detected and fined. Another limitation of the system is that it does not encourage over attainment.

The Netherlands

The charge on water pollution can be imposed on everyone who emits waste, polluting or noxious substances directly or indirectly into surface water, or into a collectively-used water purification plant. The charge can be levied by public authorities or by Water Boards, i.e. non-governmental bodies governed by councils in which affected interests are represented. The charge can be based on the quantity and/or quality of the pollutants. In practice, the charge is applied to discharges of oxygen consuming substances and heavy metals (only for emissions into non-State waters). Both kinds of pollution are expressed in so called "population equivalents" (pe). The number of pes for households and small enterprises is fixed by the authorities. The emissions of larger organisations are assessed by means of a table of emission coefficients, or can be measured individually. Only in the latter case is an incentive effect to be expected. The water pollution charge has primarily a financial purpose; it is intended to finance the costs of water purification. The charge rate for authorities is relatively low because the State does not exploit its own water treatment plants. Apart from being an important source of finance for water purification plants, the water pollution charge also has had a strong incentive effect. In the 20 years since its existence, both the quality of water and the number of treatment plants have risen considerably.

Sources: Hahn, 1989; Cadiou and Duc, 1994; Freitas, 1994; O'Connor, 1994

Box 6.2 Administrative problems in Russia's pollution charge programme

In 1991-92, Russia adopted pollution charges for air emissions, water effluents and waste disposal. The rates were determined on the basis of maximum permitted concentrations and reflected the desire to mitigate environmental health and other pollution risks. Although, initially, the charges were intended to induce optimum pollution levels, charge rates were calculated to generate enough revenues to finance critical projects, such as the construction of water treatment facilities and the clean-up of hazardous waste sites. Within this context, the charge system worked to the satisfaction of national and local authorities. However, several administrative weaknesses in the programme undermined its capacity to encourage effectiveness in changing polluting behaviour. These weaknesses can be summarised as follows:

- The lack of an appropriate system (equipment, methods, personnel) for monitoring discharges.

- Inadequate equipment and expertise of inspection personnel responsible for identifying and punishing violators.

- Inability to enforce the collection of charges due to uncertainty and contradictions in the legislation.

- Absence of a clear assignment of responsibility between the federal and territorial levels.

- Absence of clear regulations spelling out how to distribute environmental costs among polluters, the federal and regional budgets, and the federal and regional environmental funds.

- Unresolved questions regarding economic liability for environmental damage resulting from an enterprise's previous and current technologies.

- Insufficient institutional support, including a lack of special staff training and a special implementation programme.

- Excessively complicated charge systems, partly because of the inclusion of hundreds of types of pollutants and the need to calculate precise charges.

- Erosion of the pollution charges by inflation. The 500 per cent increase in charge rates in 1992 was insufficient to offset inflation.

Nevertheless, the pollution charge system has become the cornerstone of environmental protection programmes in Russia. Since 1992, agreements between polluters and the environmental protection authorities have created the legal basis for the collection of charges. Such agreements specify the permitted level of discharge, base rates and penalty rates for each pollutant discharged, as well as the schedule of charge payments.

Source: National Academy of Public Administration, 1994

In practice, the implementation and impact of Mexico's effluent charge have been very limited. The total revenue collected from the charge in 1993 was only US$ 5.6 million, a very small proportion of the potential revenue. Just for one region, the potential tax yield is estimated to be US$ 35 million and would induce a pollution abatement of more than 70 per cent (World Bank, 1994). Although Mexico's water pollution charge is a positive initiative, its design and implementation can be improved in two ways. Firstly, separate charges for suspended solids are not necessary because the abatement of other substances (e.g. COD) normally leads to a relatively high abatement of suspended solids. Secondly, the volume component could be removed because it provides an incentive to increase pollutant concentrations because it is the largest component when estimating the pollution charge. Additional ways to improve the charge would be to include charges for heavy metals and to exclude suspended solids, as well as to vary the charge according to the quality of the receiving water body.

Although effluent charges are among the most commonly applied economic instruments, experience in many countries indicates that they are often set at too low a level to act as an effective deterrent to pollution. Most polluters prefer to pay the charge rather than to change their polluting behaviour. Consequently, the principal function of most effluent charge systems is to raise revenue. In several countries where charges are widely applied (e.g. China, Japan, Indonesia, Korea, Poland, Russia, Thailand), governments deposit revenues from pollution charges and taxes into environmental funds that provide loans and grants to municipalities or to local enterprises for the purchase of abatement equipment and the introduction of clean technologies (Box 6.3).

Box 6.3 Examples of environmental funds

China

To help bring industrial pollution under control, a revolving loan fund was established that provides below-market financing for pollution control efforts by local, mostly small and medium size enterprises. The loans are financed by proceeds from waste discharge fees. The basic fee is charged for releases up to a specified concentration, above which a penalty fee is imposed. The funds are administered by the provincial or municipal environmental protection bureau and directed by a board of representatives from the local economic planning, finance and environmental bureaus. To qualify, the industrial enterprise and target pollutants must be listed as part of the area's pollution control strategy. Loans are extended for 50-80 per cent of project costs; grants are for 10-30 per cent of costs.

Korea

The Environmental Pollution Prevention Fund is financed, in part, from Government contributions and, in part, from fines (or pollution charges) levied on organisations found to be exceeding emission standards. The fund, which was established in 1983, is administered by the semi-governmental Environmental Management Corporation. The resources for the fund are used to provide long-term, low-interest loans for pollution control investments, as well as to compensate pollution victims.

Thailand

In October 1991, Thailand launched an Environmental Fund with an initial capital contribution by the Government of roughly US$ 200 million. Partial grants and low interest loans from the fund are made available to municipalities, sanitary districts and private businesses which are required to set up treatment facilities. The city of Pattaya is the first to use this fund for its central wastewater treatment plant.

Indonesia

A Pollution Abatement Fund was established to provide US$ 300 million to banks to finance loans to companies investing in pollution control equipment or hiring environmental consultants.

Poland

The national environmental fund finances most environmental investments. Sources of revenue for the fund include air and water pollution charges, water-use charges and waste charges. The funds are allocated through grants and interest-free (and other soft) loans to support air and water pollution control as well as for other environmental management purposes (soil protection, monitoring, education).

Russia

According to a regulation issued in June 1992, environmental funds should apply their revenues from pollution charges to a wide variety of environmental activities. Among other uses, they can be applied to implement regional and inter-regional projects for: improving environmental and human health, conducting research and designing projects in the areas of pollution control, clean-up and treatment; to support enterprises, research and development organisations and individuals that introduce environmental-friendly equipment; to the design of computer systems for environmental monitoring; and to construct or share in the construction of treatment and other protective facilities. A World Bank loan to the Russian Federation is supporting the establishment of a National Pollution Abatement Facility (NPAF) which will fund economically and financially viable pollution abatement projects.

Source: Lovei, 1994; O'Connor, 1994; Kaosa-ard and Kositrat, 1994

6.3.3 User charges

User charges may be variable (i.e. linked to water consumption or property values), fixed or some combination of the two and they are assessed on both municipal and industrial discharges into public sewerage (Box 6.4). Experience in numerous countries suggests that the effectiveness of these charges in controlling pollution requires the setting of appropriate charges and ensuring the existence of necessary institutional capacity for monitoring discharges and enforcing regulations.

In Izmir and Istanbul, Turkey, for example, sewerage charges (wastewater charges) are assessed on industrial discharges into the sewer systems. These charges are significant because they motivate factories to treat industrial effluents. Enterprises face two costs: treatment costs and disposal costs (sewer charges). Generally, high sewerage charges encourage full treatment of industrial wastewaters such that they are suitable for discharge to surface waters, thereby eliminating sewerage charges. Low sewerage charges, by contrast, encourage only sufficient pre-treatment of wastewaters to make them suitable for discharge to the municipal sewer system. In this way, the enterprises minimise their treatment costs. When seeking to minimise their costs, therefore, the decision of an organisation to apply pre-treatment or full treatment will be a direct response to the level of the sewer charge. Nonetheless, the problem of illegal discharges complicates the application of an optimal tariff in Izmir and Istanbul. If the sewer charge is too high, firms may seek to avoid it by illegally discharging wastewater. Thus, the ability to monitor industrial polluters and to enforce pollution standards is critical (Kosmo, 1989).

Experience in the eastern part (Suzano) of São Paulo, Brazil, also demonstrates the importance of establishing sewerage charges at the appropriate level before public investment in sewage treatment. It also demonstrates the need for contracts that commit industrial users to the scheme, as well as demonstrating that the building of a treatment plan for, basically, one industry by the public sector is inadvisable. In this case, a sewage treatment plant was being constructed largely to treat the wastes of a local paper mill. About 90 per cent of the capacity of the plant was expected to be used by this company. Due to an unacceptably high tariff level set by the State sanitation company SABESP (Basic Sanitation Company of the State of São Paulo), the paper company chose not to connect to the new sewage treatment plant and constructed its own treatment facility at a lower cost. Consequently, the Suzano treatment plant operated at only 10 per cent of its full capacity for several years because it was necessary to phase investments in residential sewer networks.

Box 6.4 Examples of user charges

Canada

The sewage charge levied on domestic users may be based on residential property values or calculated according to a formula that includes consumption (in m^3). A flat rate residential sewage tax is also used.

Colombia

In Cali, sewerage tariffs are set at 60 per cent of the water tariff, in Cartegena 50 per cent and in Bogota 30 per cent.

Sweden

Municipalities levy a charge for treatment of sewage water. The charge consists of two elements: a fixed charge and a variable charge related to consumption. The charge appears to be effective because the numbers of households and smaller industries attached to the sewer system and extended water treatment facilities are growing. The charge has some incentive effect, in that industries try to reduce water use when extending or renewing their plants, although this could give rise to higher pollution concentrations. In some municipalities, a redistribution occurs because enterprises pay a relatively high charge, implying a subsidy to households.

Thailand

To control pollution, industrial enterprises discharging effluent are required to pay service fees to a central wastewater treatment facility or to set up their own treatment facilities. The revenues from the fees are used to cover the operating costs of the treatment facility.

USA
Towns receiving federal grants for the construction of sewer systems are required by the Water Pollution Control Act to recover their operating costs and part of the capital costs from their users, through municipal sewage treatment user charges. A number of States charge flat permit fees that entitle the permit recipient to discharge wastewater. For example, California levies a wastewater discharge permit fee, based on type and volume of discharged pollutants.
Source: OECD, 1989, 1994

A groundwater charge (or abstraction fee) can be used to discourage excessive pumping of aquifers which can result in salinisation and other types of groundwater contamination (as well as land subsidence). In the Netherlands, the provinces can levy a groundwater charge from those who extract groundwater, based on the amount of the resource extracted. The revenues can be used for research, necessary groundwater management and for compensation payments when damage caused by a drop in the groundwater level cannot be attributed to a specific individual abstractor (OECD, 1994a). In common with many effluent charge systems, this charge is too low to have any significant incentive or economic effect.

6.3.4 Product charges

Product charges can be applied to products that will pollute surface water or groundwaters before, during, or after consumption. They are best applied to products that are consumed or used in large quantities and in diffuse patterns (e.g. fertilisers, pesticides, lubricant oils). A special type of product charge is tax differentiation. Product price differentials can be applied in order to discourage the use of polluting products and to encourage consumption of cleaner alternatives. When a product is highly toxic, and when its use should be drastically or completely reduced, a partial or total ban is preferable to product charges.

Product charges can act as a substitute for emission charges whenever it is not feasible to apply direct charges to pollution. The rates of product charges should reflect the environmental costs associated with each step of the product life-cycle. The rates are fixed but can be re-calculated if the charge lacks incentive power. The effectiveness of a charge on polluting products or product inputs will generally depend on the elasticity of the demand for that product. For example, where input costs are a small fraction of total costs, doubling or tripling the price through an input tax is unlikely to have a significant effect on consumption, unless there are suitably priced substitutes. If less polluting substitutes are available, small increases in input prices may induce substitution and innovation over the longer term (Moore *et al.,* 1989). Revenues from product charges can be used to treat pollution from the product directly, to provide for recycling of the used product or for other budgetary purposes.

6.3.5 Marketable permits

Setting up effective marketable permit programmes involves establishing rules and procedures for defining the trading area or zone, for distributing the initial set of permits (e.g. direct allocation by a regulatory agency, grand-fathering, various types of auctions), for defining, managing and facilitating permissible trading after the initial allocation, and for carrying out monitoring and enforcement activities. Tradable permit systems work best where (OECD, 1991):

- The number of pollution sources is large enough to establish a well functioning market.
- The sources of pollution are well defined.
- The amount of pollution generated by each source is easily computed.
- There are differences in the marginal costs of pollution control among the various sources.
- There is potential for technical innovation.
- The environmental impact is not dependent on the location of the source and time of year.

Marketable permits are not as effective for controlling water pollution as other instruments because water pollution is directly tied to location and time of year. Where they have been applied to this purpose, they have not produced impressive results.

In the USA, for example, the state of Wisconsin implemented a programme to control biochemical oxygen demand (BOD) in the Fox River. The flexibility of the programme allowed limited trading of marketable discharge permits. Organisations were issued five-year permits that defined their waste load allocation, which in turn defined the initial distribution of permits for each organisation. Although early studies indicated several potentially profitable trades involving large cost savings (in the order of US$ 7 million), there has been only one trade and actual cost savings have been minimal since the programme began in 1981 (Hahn, 1989). Stringent restrictions have significantly inhibited trading under this programme (Oates, 1988). Numerous administrative requirements also add to the cost of trading and lower the incentive for facilities to participate. Some costs can be attributed to the small number of organisations involved and others to the absence of brokering or banking functions (Anderson *et al.,* 1989). In many developing countries, the absence of well-functioning markets would place further constraints on effective trading.

6.3.6 Subsidies

Numerous countries make available tax reductions, grants or low interest loans to mitigate those water pollution abatement or prevention costs that must be borne by polluters (Box 6.5). Policy makers tend to favour these instruments because they ease the transition to a more stringent regulatory environment (especially for established polluting enterprises) and because there may be an economic justification for applying them where there are clear positive externalities associated with private investment in pollution control. Nonetheless, there are some disadvantages to using them. First, subsidies can result in inefficiencies by encouraging over-investment in pollution control or over-expansion of the polluting activity. For example, large subsidy shares in the investment costs of pollution control, as implemented in the United States Construction Grants Program, can induce plant operators to design capital intensive facilities with excessive capacity. They also are not consistent with the polluter-pays-principle because the general taxpayer subsidises the control costs of specific polluters. Moreover, subsidies pose a drain on government resources (O'Connor, 1994).

Box 6.5 Examples of subsidies for water pollution control

France

River basin agencies may provide financial assistance in the form of grants or loans in addition to any other assistance that may be obtained from, for example, the government, region or department. The total amount of assistance must not exceed 80 per cent. Grants are the most common form of financial assistance. Where loans are involved, they are generally for a period of 10-125 years and the interest rate is lower than the market rate. In the Seine-Normandie river basin, for example, the interest rate is equal to half the rate of the Credit Local de France.

Indonesia

The Environmental Impact Management Agency (BAPEDAL), with support from Japan, has established a five-year US$ 103 million soft loan programme for industrial organisations investing in waste treatment. Loans are made available on a first-come, first-served basis and are for a period of between 2 and 30 years with a grace period of 1-5 years and an average interest rate of 14 per cent per year (well below market lending rates). The loan programme should facilitate the implementation of the Government's PROKASH, or clean rivers programme.

Korea

Two provisions under the Tax Exemption and Reduction Control law provide direct and indirect incentives for pollution control. First, there is a direct investment tax credit of 3 percent (or 10 per cent for equipment made in Korea) of the value of the investment which is restricted to facilities for increasing productivity, energy-saving facilities, anti-pollution facilities, facilities for preventing industrial hazards and other specified facilities. More indirectly, for persons starting a business using technology, there is a choice between accelerated depreciation of 30 per cent (50 per cent in the case of machinery manufactured in Korea) of the asset's acquisition price in the fiscal year of acquisition or an investment credit at the rate of 3 per cent (or 10 per cent in the case of machinery made in Korea) of the value of the investment for new assets.

Philippines

The Environmental Code enacted in 1977 allowed half of the tariff and compensating tax on imported pollution control equipment to be waived for a period of years from the date of enactment. The code also made available rebates for domestically produced equipment and a deduction for certain pollution control research.

Taiwan

The government offers a range of subsidies. Among activities eligible for subsidy are acquisition of land for waste treatment facilities and the installation of pollution control equipment. A real estate tax concession is also offered for the relocation of a polluting facility and a number of other tax concessions are offered for pollution control investments, including duty free importation of pollution control equipment, corporate income tax reduction for purchasing such equipment, two-year accelerated depreciation for pollution control facilities, and a 20 per cent profit tax reduction for research and development on pollution control.

Thailand

Partial grants and low interest loans are made available from the Environment Fund to local administrations and private businesses required to set up treatment facilities. Other subsidies include the reduction of import duties to no greater than 10 per cent for equipment used for any treatment facilities. During 1984-89, however, only 130.9 million baht (US$ 5.14 million) worth of waste-water treatment equipment had been imported under this incentive.

Turkey

The Government has provided subsidised credit for relocating polluting industries to alternative industrial zones. For example, leather tanneries relocating to the Maltepe Industrial Zone north of Izmir would be entitled to subsidised interest rates of 35 per cent for general loans and 22 per cent for construction and infrastructure investment, implying negative real interest rates at an 80 per cent annual rate of inflation. This is a clear incentive because interest costs in 1988 and 1989 accounted for 20 per cent of total investment expenditures. The Government also has offered a 40 per cent tax deduction on investment for tanneries relocating to another industrial zone during the first two years of estate construction and a 7 per cent reimbursement on investment for small and medium-scale tanneries.

Sources: Kosmo, 1990; Cadiou and Duc, 1994; Kaosa-ard and Kositrat, 1994; O'Connor, 1994

Subsidies, in general, should be selective and should be provided on a temporary basis. In many cases governments subsidise small and medium size enterprises because they suffer a competitive disadvantage when they adopt environmental control technologies where there are economies of scale. The problems of small enterprises may be especially acute in the case of process changes aimed at reducing waste rather than end-of-pipe treatment technologies. While the latter can be added on without disrupting the production process, the former may require the temporary shutdown of the production process during conversion or retrofitting. When introducing process changes, an organisation also may encounter costly start-up problems. While a large enterprise, with several processes running in parallel, may be able to make changes incrementally, small enterprises must face all-or-nothing decisions and face considerably higher financial risks than the larger enterprises. Therefore, even where such subsidies are not justified on the basis of efficiency, they may address equity concerns (O'Connor, 1994).

The removal of water or other types of subsidies can also have a positive effect on water quality. For example, the removal of a water subsidy can lead enterprises and residential users to conserve water and thereby reduce the amount of pollutants they discharge into the effluent stream. Ensuring marginal cost pricing for water can even help to ensure the sustainability of a water treatment programme. Similarly, the removal of subsidies on pesticides and chemical fertilisers can reduce water pollution, particularly groundwater contamination, and the poisoning of aquatic life through run-off into water systems. For residential polluters, however, water subsidies may have to be maintained in order to support the economically weaker segments of the population, particularly the urban poor. Nonetheless, a free-ride situation of a totally free resource is not sustainable. The poor should be required to pay a small charge for water (which should be increased incrementally) not only to cover the costs of water treatment, but also to promote water conservation.

6.3.7 Deposit-refund system

Although not a principal instrument for controlling water pollution, deposit-refund systems can be applied to this purpose if potentially polluting products which are not consumed or dissipated during consumption, such as pesticide containers, can be returned to an approved centre for proper disposal or recycling. Establishing successful deposit-refund systems requires products that are easy to identify and handle and users and consumers that are able and willing to take part in the scheme. It often also requires new organisational arrangements for handling the collection and recycling of products and substances as well as for managing the financial arrangements, and a national or state authority to establish the system. The advantages of deposit-refund systems are that most of the management responsibility remains with the private sector and incentives are in place for third parties to establish return services when users do not participate. A major disadvantage of this approach is that the costs of managing deposit-refund programmes, i.e. administrative, collection, recycling, and disposal expenditures, fall to the private sector.

6.3.8 Enforcement incentives

Penalties for failing to meet environmental standards are commonly-used instruments to encourage dischargers to comply with environmental standards and regulations. In Mexico, fines are set according to the severity of pollution and adjusted for inflation; repeated offences lead to plant closure. Combined with public pressure, these measures have been effective in controlling surface water pollution. In Argentina, by contrast, fines for discharging into water bodies without treatment are set too low to achieve the environmental objectives (Box 6.6).

6.4 Choosing between instruments

As illustrated in several of the examples above, economic instruments are rarely used alone to manage water pollution. The focus of any policy debate should not be weighing the relative advantages and disadvantages of economic and regulatory instruments, but instead the most important issue is to find the appropriate mix of instruments that would best respond to the special characteristics of each problem and locality, together with specific operators whose behaviour needs changing, and the desired behavioural response.

For effective water pollution control, pollution charges and standards have to be combined carefully with water prices which should be high enough to cover all costs and provide an incentive for water conservation and recycling. In this way, the incentive to achieve standards by dilution is reduced, resulting in less liquid effluent being discharged into rivers and streams.

In selecting instruments, policy makers need to take into account the nature of the environmental problem and its causes, as well as practical, economic, and political realities. In determining the most appropriate instruments, each country needs to establish clear and transparent criteria upon which to base its selection. In developing countries, where there are extremely limited financial resources and weak institutional capacity, the two most important criteria are cost-effectiveness and administrative feasibility. Other criteria include equity, consistency with other objectives, flexibility and transparency.

Box 6.6 Enforcement incentives in Buenos Aires Provincial

The Law Protecting Water Bodies that Supply and Receive Effluents in the Buenos Aires Provincial prohibits any discharges into water bodies (or to the air) without treatment. In practice, this means that industries must obtain a license to operate. In 1986 the law was modified to enable the application of fines to industries that do not comply with the legislation, according to the extent of the violation. The municipality would be responsible for imposing fines that would then be set aside for its own operations. The municipality also had the right to close production plants temporarily or permanently. The process of imposing these fines, however, is very slow. The fines are extremely low and can be applied "as many times as necessary" and, as a result, industries find it cheaper to pay the monthly fine rather than to adopt pollution control measures. Although this has financial benefits for the municipality, it undermines the main objective of the fine, which is environmental protection.

Source: Margulis, 1994

6.4.1 Cost-effectiveness

In selecting instruments, it is important to select those that achieve the desired outcome at the least possible cost and with a total cost that does not exceed the expected benefits. In theory, market-based policies offer the "least-cost" solution to environmental problems, but there is relatively little experience in using them, particularly for pollution charges on industry. Overall, the optimal instrument is one that leads to the so called "win-win" solutions, i.e. improvements in the environment and other sectors of the economy occur simultaneously and therefore do not involve difficult development-environment trade-offs. Although there will be winners and losers in almost all environmental decisions, some actions can bring about substantial social benefits with a minimum of cost, such as accelerating provision of clean water and sanitation.

6.4.2 Administrative and financial feasibility

An instrument should be selected only if the responsible agencies are prepared to deal with the often complex procedures required for implementing them properly, such as billing and collecting taxes and charges, measuring emissions, determining environmental effects, and taking the necessary enforcement action for non-compliance. All of these require good co-ordination between government agencies. Instruments that require strong enforcement capacity or a high rate of voluntary compliance are difficult to implement.

6.4.3 Consistency with other objectives

The chosen instrument should be consistent with other policies and instruments within or external to the sector. For example, the application of the instrument should not lead to cross-media pollution or conflict with relevant national laws, international agreements, treaties or principles. Moreover, no system of pollution charges or other economic instruments can change the underlying political climate. If a government gives priority to maintaining production and employment, then environmental policies that threaten these goals will be ignored. In addition, adopting policies that are not enforced will merely undermine the credibility of the environmental authorities and the government in general.

6.4.4 Equity

Equity considerations should be carefully balanced with environmental factors when selecting instruments. A major policy question when considering any tax system is who, ultimately, will bear the burden of the tax? Or, does the tax fall proportionately more on the rich or the poor? Most proposals for environmental taxes involve either taxes on environmentally harmful consumption or taxes paid by industrial polluters that may be passed on to consumers through higher prices. Poor people spend a larger percentage of their income on consumption of goods than do the wealthy and, therefore, consumption-based taxes affect the poor disproportionately. To avoid this situation, policy makers should ensure appropriate sharing of the costs and benefits of environmental protection, paying particular attention to the poor. For example, requiring private organisations to absorb the full costs of pollution abatement shifts the burden from those who normally suffer from environmental degradation (usually the poor) to those responsible for causing it (i.e. industry) and, eventually, the consumer of polluting goods.

6.4.5 Transparency

The process of adopting and implementing standards must be transparent so that enterprises can adapt to changing regulatory conditions. Enterprises and other stakeholders are more likely to comply with instruments when they understand how they were derived. In the case of an environmental charge, the polluter knows both the costs of investing in pollution abatement and the tax that would need to be paid if current levels of pollution continue. By contrast, in a tradable permit system, the polluter does not have advance knowledge of the price that the market might assign to permits in the future.

6.4.6 Flexibility

The flexibility of the instrument in adapting to a changing environment can be an important consideration where there are changing local conditions. For example, depending on local political conditions, changing a charge rate may be more easily accomplished than changing legislation, except of course if the rates are set within the legislation. Environmental taxes also confer, on producers and consumers, the flexibility needed to minimise the costs of achieving a given goal. Faced with an emission tax, for example, each enterprise can compare various ways of reducing emissions and choose the solutions that match its own circumstances. The various measures include changing the product mix, modifying production technologies and installing equipment that can filter or clean end-of-pipe discharges. To the extent that different organisations can have different costs for pollution abatement, a charge can encourage those facing lower abatement costs to go further in cleaning up their operations.

6.5 Application in developing countries

Despite growing evidence that environmental degradation is an important socio-economic problem, governments in developing countries have been unsuccessful in stopping it. A common argument is that environmental control is too costly and that countries should concentrate on other development priorities. Underlying such thinking may be a lack of information and insufficient awareness of the true costs involved, together with inertia, lobbying by powerful interest groups, and limited public support and participation. Even where there is strong political will, governments may not be able to act effectively because of institutional deficiencies. Under these unfavourable circumstances, therefore, opportunities for the effective application of economic instruments in developing countries can be very limited. Where they are contemplated, however, policy makers should take into account the following factors:

- *Weak institutional capacity.* Economic instruments cannot be implemented successfully without pre-existing appropriate standards and effective administrative, monitoring, and enforcement capacities. Moreover, there is little difference, if any, in the monitoring and enforcement capability required of government for regulatory and economic instruments. If there is uncertain monitoring and weak enforcement, there is little or no reason for an organisation to report its discharges and pay a fee. Similarly, if discharges are normally made without a permit, organisations will not be motivated to purchase permits or to engage in emission trading. Without existing regulations that establish baseline treatment standards for different kinds of discharges, it will be difficult to determine initial allocations of marketable permits. Moreover, subsidies for less than the total cost of pollution abatement activities will not influence organisations that have no other reason to change their practices. In addition the use of charges for industrial wastewater discharges into municipal sewer systems will be limited.

- *Inadequate co-ordination.* Institutional co-ordination is an important prerequisite for the effective application of most economic instruments. In the case of water management, however, there is often a traditional rivalry between the environmental and water and sanitation agencies. This may be due to a number of reasons such as political power and differing goals and perspectives. Nonetheless, the structure of an effluent charge system involves parameters and information that are more in the domain of the environmental agencies, while the implementation of the system is largely the responsibility of the water and sanitation companies. Unless the relevant agencies are well co-ordinated, the application of effluent charges will be undermined (Margulis, 1994).

- *Economic instability.* Economic stability is critical for the effectiveness of economic instruments. Although regulatory instruments probably depend less on the level of economic stability in a country, charges and taxes are highly dependent on it. For example, Brazil has not been using economic instruments as often as the institutional and legal frameworks would allow, largely because of its unstable economic situation. The fiscal system in the country is very complex and the collection of duties very deficient, and therefore the creation of an environmental tax would only complicate and weaken the system further (Margulis 1994).

- *Government resistance or inertia.* In some countries, there is a general perception by environmental agencies that the use of economic instruments will not only weaken their control over polluters, but that they will have to share their control with economic ministries, who are usually responsible for creating new taxes or charges. The application of economic instruments, therefore, is likely to make environmental agencies even weaker than they already are in most countries. Moreover, the results in terms of pollution levels would be less certain. In other countries, where regulators have relied on standards, inspections and penalties for managing pollution, there is a reluctance to try a new approach unless it is clearly demonstrated to be better than the existing regulatory system.

• *Resistance by polluters.* In developed countries, as in industrial ones, industrial polluters often have resisted economic instruments because they believe that they have greater negotiating power over the design and implementation of regulations than they do over economic instruments. Moreover, local industries rightly assume that it is easier to avoid compliance with a standard where there is poor monitoring and enforcement capacity, than to avoid fiscal and incentive mechanisms where there is less flexibility.

6.6 Conclusions

Finding the right mix of policy instruments can help to ensure effective water pollution control. In developing countries, cost-effectiveness and administrative capacity are the two most important criteria for selecting them. In every country, however, water pricing policies that may be encouraging over-use and water degradation should be considered first. Although the experience in applying other economic instruments remains limited, particularly in developing countries, there is evidence that effluent and user charges have the most potential for effective application by helping to pay for environmental improvement. Nonetheless, they are not sufficient for achieving water quality objectives. They should be accompanied by investment in wastewater treatment facilities and, locally, by appropriate regulatory instruments as well as programmes to persuade water users to change their polluting behaviour.

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5.6 Groundwater protection

Groundwater usually requires special efforts to protect it from pollution. Although general pollution control laws for discharges and measures taken to prevent non-point source pollution on land can apply equally to groundwater protection, practically any activity on the surface can have an effect on the quality of underground water. Being out of sight, it is not always apparent that damage has been, or is being, done to the groundwater resource. The need to prevent groundwater pollution is important because of the very high proportion of groundwater resources that are used for potable supply. This has been recognised in the EU by the proposal to set up a groundwater action and water resources management programme based on the precautionary principle and on the principles of prevention, rectification at source and "polluter pays". The action programme is expected to emphasise the need for national administrative systems to manage groundwater, preventative measures, general provisions for handling harmful substances safely and provisions to promote agricultural practices consistent with groundwater protection. A key part of preventative measures for groundwater is the identification of groundwater reserves and potentially polluting activities.

A groundwater protection policy has been written for England and Wales. A key objective has been to devise a framework which covers all types of threat to groundwater, whether large or small, from point or diffuse sources, and by both conservative and degradable pollutants. The policy, which is published as a guidance note and issued to all authorities whose work has a relevance to the issue (such as planning authorities, waste regulatory authorities and others) contains a classification of groundwater in terms of vulnerability, a definition of source protection zones, and statements on how activities may be controlled to reduce or to eliminate the risks of pollution occurring by those activities.

Factors which together define the vulnerability of groundwater are the presence and nature of the overlying soil, the presence and nature of drift, the nature of the strata and the depth of the unsaturated zone. Since these measures relate to the whole of the groundwater resource they are referred to as groundwater resource protection. A distinction needs to be made between the general protection of the resource and specific protection which may be needed for individual groundwater abstractions. It is possible to define the catchment area for a particular abstraction with information on the aquifer and on the rates of abstraction. A protection policy defines groundwater source protection zones: an inner zone, defined as a 50 day travel time from a pollutant input to the abstraction; an outer source protection zone, defined as a 400 day travel time; and a total source catchment zone. This approach enables different levels of protection to be applied at varying points in the catchment. Vulnerability maps are prepared for the overall resource, but not for individual groundwater sources. The policy sets out guidance for taking pollution prevention measures covering a number of key situations where it is necessary for the regulatory authorities to consider their potential impact on aquifers. These include:

- The control of groundwater abstractions.
- The physical disturbance of aquifers and groundwater flow.
- The impact of waste disposal to land.
- Problems associated with contaminated land.
- The disposal of slurries and liquid effluents to land.
- The control of discharges to underground strata.
- Diffuse pollution of groundwater.
- Developments which may pose a threat to groundwater quality.

The basic approach of the policy is that of developing a co-operative approach to solving potential problems and of preventing future ones by collaboration.

A similar approach has been taken in Brazil where a vulnerability map, based on 31 aquifer units with six levels of vulnerability index, was developed for the state of São Paulo. Critical areas for groundwater pollution were determined by comparing the vulnerability map with a potential contaminant load map drawn up on the basis of records of industrial activity, cities, mining activities and waste disposal sites. The concept of groundwater pollution risk was based on the interaction between the potential pollution load and the vulnerability derived from the natural characteristics of the strata.

Section 13(1) of the Canadian Environmental Protection Act applies specifically to groundwater. It contains a general prohibition that "*no person shall discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment that causes or is likely to cause an adverse effect*". The term discharge includes leaks, escapes and spills likely to affect groundwater. Contamination must be reported to the Ministry of the Environment which has powers to take action, including cleaning-up. Various other sections of this Act allow orders to be issued to clean-up discharges from waste disposal sites (Part V) and leakage or spills from other facilities such as storage tanks (Part IX). The penalties are very high where non-compliance is detected.

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Chapter 8* - Institutional Arrangements

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* *This chapter was prepared by G.J. Alaerts*

8.1 Introduction

Water pollution control is typically one of the responsibilities of a government as it aims to protect the environment for the good of the general public. Governments undertake to do this by establishing an appropriate set of organisations and launching specific programmes. These interventions aim at achieving national, or even regional, objectives that include, for example, enhanced economic productivity, public health and well-being (all of which should, ideally, form part of a sustainable development strategy). To meet these objectives resources are mobilised, notably financial resources (capital from local people, government and the market), physical resources (raw materials and agricultural products), environmental resources (such as water) and human resources (the active time and capabilities of people). These resources are scarce and have an associated cost, therefore their use must be efficient, that is maximum output (e.g. highest water quality) must be achieved at minimum resource input. Alternatively, it may be more important to organise the pollution control sector in such a way that governmental policy is implemented effectively; for example that wastewater treatment plants are actually built and operated or that sanitation facilities, once constructed, are actually used and remain maintained. Effective implementation can be extremely difficult, especially for pollution control. In reality, wastewater control always receives the lowest priority, although its infrastructure is at least as expensive as that for water supply.

Water is an environmental resource with a profound impact on public health, economic activity and environmental (and ecosystem) quality. Therefore, the prerequisite for any sustainable development scenario is that the organisations that are assigned with water management actually possess the capability to carry out this task. A well-balanced arrangement of flexible, dynamic organisations and other related institutions is the best assurance that unpolluted water resources remain available in the future, that the right quantity and quality of water are delivered to the water users (including the ecosystems), and that people can live in a healthy environment. These organisations, however, can only execute these functions if they have access to an appropriate financial base to expand and maintain the infrastructure, to attract qualified professionals, and to prepare well for the future.

8.2 The water pollution control sub-sector

The organisational structure and the administrative procedures to implement water pollution control are very much determined by the characteristics of the sub-sector and the functions to be performed. These differ between countries, as well as over time. Over the past decades, industrialised countries have learnt that water resources, although finite, must keep satisfying a variety of user demands (such as water supply, irrigation, amenity) and that they need protection (ICWE, 1992; World Bank, 1993). They have also learnt that different types of pollution (e.g. domestic or industrial) demand specific approaches and that pollution prevention is more cost-effective than the removal of the pollutants by end-of-pipe treatment (see Chapter 3). In addition, water pollution control is intricately linked to the work of other sub-sectors, particularly environmental management, water resources management, industrial development, and land use and urban management.

The water pollution control sub-sector typically concerns itself with four functions that are relatively distinct and that require specific expertise (see Chapter I):

- Water quality management of water resources such as rivers, lakes and wetlands. This involves setting of operational quality standards for the receiving water as well as for the waste discharged, and integrated planning in order to achieve water quality levels that allow appropriate water use (e.g. for the production of drinking water, fish cultivation, navigation) (see Chapters 2 and 5).

- Regulation of general quality standards for health, water and the environment. Regulation and setting of standards for industrial sewage treatment and stimulation of waste minimisation and pollution prevention instead of conventional "end-of-pipe" approaches.

• Organisation, construction and management of on-site sanitation in rural and peri-urban areas.

• Collection and off-site centralised treatment of domestic sewage, including its planning, construction and management.

The physical and socio-economic conditions of a country dictate which functions must take priority and hence determine the preferred institutional arrangement. Sometimes these functions are best served by two or more separate entities, because each function requires a specific mandate, organisational structure and procedures, as well as specific technical expertise.

The first two functions listed above are of a regulatory nature and the last two are executive. In most countries, setting discharge and water quality regulations has proved to be the easiest (and cheaper) aspect. The execution of the, relatively more, capital-intensive investment programmes in cities and towns has been much more difficult to achieve or even to initiate. In addition, in many countries, much of the new wastewater infrastructure ends up poorly operated and maintained, thereby lowering its effectiveness dramatically. Large and comparatively wealthy industries are often the first to build and operate treatment plants, while the majority of smaller industries find it exceedingly difficult to comply with standards.

On-site sanitation comprises a set of distinct activities. Much of the work is carried out by house-owners who have to invest in the construction of septic tanks or pit latrines. The maintenance, mainly desludging and disposal and treatment of the sludge, is usually carried out by private contractors. The sector organisations are responsible for ensuring that government targets are met by devising adequate building regulations and city ordinances, and through a strong, facilitating role. In most countries this is also an arduous task.

8.3 Institutions and organisations

Before discussing the role of institutions and organisations in water pollution control activities, it is first necessary to distinguish between them and to recognise that the function of all institutional factors goes well beyond the boundaries of the common, typical "sector organisations". Institutions are defined as the "rules" in any kind of social structure, i.e. the laws, regulations and their enforcement, agreements and procedures (see for example Uphoff, 1986; Israel, 1987; de Capitani and North, 1994). Organisations are a particular type of institution and are composed of groups of people with a common objective. Organisations can be formalised, such as "official" sector organisations with operational objectives, their own budget and professional staff (such as water departments in Government Ministries, Water Boards, Environmental Protection Agencies, laboratories, consultant companies) or they can be informal and less well described (such as "the public", the "customers" who pay for a water service, the socio-economic distinct groups in a village or town community).

The success achieved when implementing a government's policy for water pollution control primarily depends on the suitability of the chosen institutional arrangement. Other factors are also important prerequisites, such as availability of capital, of technology and of human resources (expertise). Generally, however, the maximum benefit can only be generated from available resources by an "optimum" institutional arrangement that makes the resources work effectively for the sub-sector. This "optimum" depends on the characteristics of the sub-sector, which differ from those of other water-using sub-sectors, such as water supply or hydropower, and the requirements of the country. Good institutional arrangements are essential to liberate and to develop resources further; for example to make more finance available by increasing the willingness of customers and citizens to pay for sewerage services or to educate and train the professional staff.

A sector can only prepare and manage its programmes properly if all institutions are appropriately involved in the three main phases; planning, implementation (construction), and operation and maintenance linked with cost recovery. Although this is normal for formal organisations such as government departments, it is also true for all other institutions that are indirectly implicated and will affect, in one way or another, the water pollution programme. Examples of such institutions are:

• Policies and regulations that determine tariff-setting and taxation. These commonly fall outside the jurisdiction of pollution control organisations, although their success depends on their financial strength. Responsibility for decision-making commonly lies with the Ministry of Finance, in municipalities or amongst the politicians.

• Enforcement of regulations and laws. Any pollution control law is only as strong as the will and the capability of the law enforcement institutions.

• Human resources and development of expertise. Pollution control is technically complicated and, therefore, education and research institutions must be able to support a national pollution control policy.

• Mechanisms to render organisations more responsive to customer demands, flexible and accountable. This generally requires devolution of decision-making and financial autonomy to the most appropriate, lower levels of administrative government. It can also lead to the inclusion of private partners. Rules that stifle initiative and good performance should be removed (deregulation) and replaced by other regulations that, typically, are based more on performance. Again, the required institutional framework is determined outside the environmental or water sector.

• Mechanisms that enable the definition of the economic value to the nation of good water quality. This requires a full appreciation and understanding of water uses and their significance for the nation's long-term sustainable development.

A crucial institution to the success of water pollution control is the group of people that will "benefit" from it. World-wide, numerous water supply and sanitation schemes have failed completely, or partially, because the designated users (and financial supporters) of the new infrastructure were not consulted about whether they valued the initiative and would be willing to contribute for its proper operation. Thus, inadequate involvement of the users during the planning phase created a situation with a lack of demand. Provision of a service, such as a clean environment, is not merely a question of meeting a presumed demand from customers. Without a clearly expressed demand, customers are not committed to the infrastructure and they will fail to use it properly or to pay a reasonable compensation for it. An existing demand may be insufficiently developed, for example, because prospective customers have not recognised the long-term benefits of the service (good public health or education) or because they may prefer "purchasing status" (increasing their consumer goods) rather than investing in the long-term benefits. Consequently, demand may need to be developed.

8.4 Criteria and determinants

No fixed, optimum model for institutional arrangements exists that would suit all countries, at all times. The organisations that would fulfil the requirements best in a given country and in a particular period of its development, depend on the local characteristics, i.e. the hydrogeology and topography, industrialisation, culture, economy and the natural environment. The institutional arrangement of a sub-sector will have to adjust continuously because the institutional environment around the sub-sector changes so much. Preferably this arrangement should prepare for and facilitate continuing change. Inevitably, institutional arrangements are very case specific; what works for one country in a given period may be detrimental to another. Nevertheless, experience suggests that good arrangements consist of a number of standard institutional components (e.g. organisation types, financial measures) that perform well in different arrangements. The determinants for these arrangements are usually external boundary conditions with which the sub-sector has to be able to work. Criteria are often derived from business and public administration and specify how a successful sector, and performing organisations, should be managed.

8.4.1 Prioritising functions and setting mandates of organisations

First of all, the priority issues for water pollution control in the medium term (with a planning horizon of 10-20 years) need to be determined. Countries with a high population density and high industrial output require a different approach from others which are predominantly rural and less industrialised. In the same way, arid regions may put a high priority on water conservation and re-use. Other regions may have to cope with the diverse effects of multifarious wastewater constituents that have long-term deleterious effects, sometimes at locations very distant from the discharge point. For example, the nutrients discharged by households along the Rhine River in Switzerland cause algal blooms along the Danish North Sea coast triggering oxygen deficiency and fish kills, and polychlorinated biphenyls (PCBs) discharged in Europe may, over a period of years, accumulate in the fatty tissue of seals near the North Pole. Institutional arrangements must reflect environmental priorities.

It is commonly assumed that water pollution control requires the same institutional arrangements as for water supply. However, often this is not the case. In many countries, domestic wastewater collection and treatment are administered within the same organisation as water supply, for example in India, Uganda, China, Brazil (some regions), Mozambique, Yemen, the Philippines, and England and Wales. In other countries, separate organisations have been created, such as in Indonesia (for the urban areas), Colombia, Argentina, and most West African and Western European countries. The executive functions for large infrastructure development, and for its management, commonly fall with an engineering-based government department, board, authority or enterprise. These can take many forms (see section 8.5). By contrast, the executive function of on-site sanitation is often best associated with urban management authorities that hold the mandate for land-use planning and housing regulations. Most urban authorities, unfortunately, show little interest in, or understanding of, water pollution control. In addition, they feel less accountable to the national goals of environmental management and, typically, limit their interventions to removing the local pollution to the border of the city. Similarly, urban planning authorities can force industries and workshops to move out from the inhabited areas into designated industrial zones, where they are (in theory) best equipped to separate and contain domestic and industrial wastewater flows (a condition for adequate water pollution control). The function of water quality management is often carried out by a government department but in many instances the management function has been taken up by the infrastructure organisation, especially when it covers a territory large enough to encompass a whole natural water system (e.g. a river basin). Finally, regulatory functions are typically the responsibility of a national government ministry (health or environment) although in some cases they are delegated to a full government agency (such as the Environmental Protection Agencies in the USA and China, and the Pollution Control Board in India).

Box 8.1 Operation and maintenance and cost recovery are two sides of the same coin

The World Bank, when monitoring projects, insists on good accounting and financial procedures. However, financial indicators such as cost recovery ratio and balance of payment can, when monitored over four or five years, hide structural weaknesses. An organisation can spend most of the recovered charges on hiring unqualified staff, while at the same time postponing essential maintenance. Thus it may as well remain totally unprepared for imminent major problems (such as eutrophication in a lake that should provide millions with good drinking water). The monitoring of key financial indicators is only appropriate if complemented with data on institutional performance, particularly capacity to improve in the future.

A second major consideration concerns the prioritisation of investment (construction) or operation and management (O&M). Sustainability is served by institutions that ensure the infrastructure serves a long, active life. Well-operated and maintained devices minimise resource losses due to spillage, breakage and leakage. Poor O&M also leads to a poor service to the consumer. Clogged drains and pumps, and treatment works that are out of order, provide an unreliable and low-level service that severely reduces the consumer's and citizen's willingness to pay.

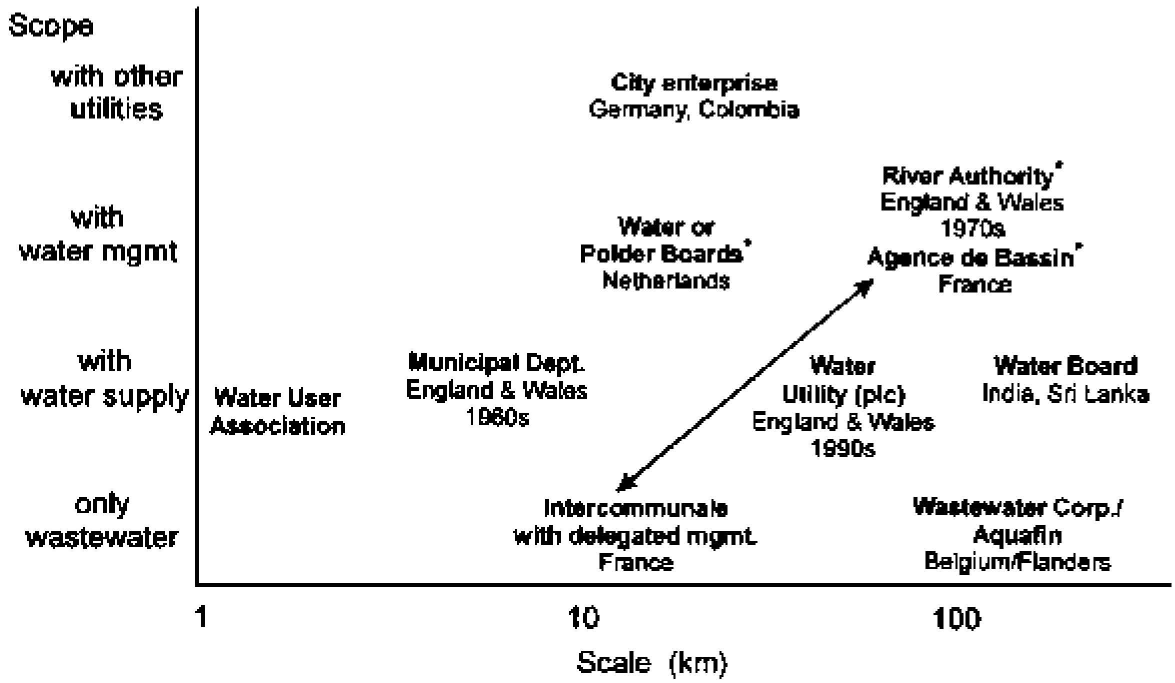
In many countries, the O&M of the water infrastructure is very weak. This is worrying because it renders many water organisations unable to recover the costs (including asset depreciation) of their water supply operations, let alone their sewerage operations. The consensus of opinion suggests that, in a healthy sub-sector, the water organisations should be able, in the long run, to recover full costs from their consumers. In many developing countries, the organisations need to be re-orientated and retrained to execute this task more efficiently (see section 8.5.8). Wastewater infrastructure, in particular, is an unpopular item on the budgets of authorities and citizens alike. As of today, wastewater treatment costs in several European countries have still not been fully recovered from consumers. Operation and maintenance is an expensive, yet unforgiving, item on the budget of any enterprise and is often neglected at the expense of the cost-recovery performance shown in an enterprise's accounts (Box 8.1). In many instances, a well-defined construction mandate (typical for many organisations in developing countries) is not particularly compatible with a cost recovery and O&M mandate. Often, a concentrated investment effort necessitates setting up a devoted organisation for a specific time period (see for example Case Study I, India, and section 8.5.5 for Aquafin in Belgium).

8.4.2 Scale and scope of organisations and decentralisation

The required sector organisations can be of different scale and scope. The scale reflects the typical size of the area for which the organisation has a mandate. This can range from small, such as a city quarter or village, to very large, the size of a country or state of over 100 million inhabitants within the country, e.g. India). The scope of the organisation defines whether it concentrates on (an aspect of) water pollution control or whether it also covers other utilities. Other utilities can be more or less related to wastewater, such as water supply, drainage, water quality management, river basin management, power generation and/or distribution, public transportation, environment protection. Importantly, because much O&M and cost recovery is physically associated with fine-detailed reticulated networks and individualised households, decentralisation or devolution of responsibilities to the lowest appropriate administrative level is an important guideline (ICWE, 1992). Part of the local network or infrastructure can then be entrusted to a local water users association.

Determining the preferred scale and scope depends on the local characteristics of the water sector, the possible interactions with developments in other sectors such as power, and the identified priorities; it also depends on the national policy on state organisation (see section 8.5). In many European countries there is, at present, a process of concentration (scale increase, sometimes with a broadening of scope). The rationale behind this development is that wastewater management, together with water supply, is increasingly complex in respect of technical expertise and water resources management. To cope with this, the organisations need strong and expensive central engineering and laboratory facilities, they need to be able to raise large sums of money, and they must be in a position to co-ordinate the works in a whole region efficiently. Interestingly, within a period of barely 15 years, England and Wales have changed the scale and scope of their water-related organisations twice (see section 8.5.1). Figure 8.1 provides an overview of possible situations.

Figure 8.1 Examples of scale and scope of the organisation responsible for waste-water management. Organisations with a purely regulatory function are excluded. The water quality management function is covered by the organisations marked with an asterisk. The double arrow connects, for France, the two complementary organisations that together cover the sector



8.4.3 Deregulation and regulation and enterprise autonomy

Institutional architecture should from one perspective ensure consistency of policy over the whole territory, and from the other it should allow for sufficient flexibility, particularly in order to respond to local issues and demands and to adapt to changing conditions in the country. The first requirement calls for a centralised, top-down approach, with adequate control from the top. The second, however, tends to put more responsibility at the local levels and calls for more local and sub-sectoral autonomy. While accepting that much of the work needs to be carried out by a variety of organisations at different levels, governments tend to keep control by means of regulations. For example, governments define national health and environmental quality standards and personnel structures in the public service, decide on the targets for pollution control achievements, set price structures and may attribute the market mechanisms a major or minor role and, importantly, decide on who will take the important decisions. Experience over the past decades has shown that too much regulation is inefficient, it creates its own distortions and stifles initiatives for improvement.

Mechanisms to reduce the level of top-down regulation include:

• Decentralisation and devolution of decision making to lower administrative levels, including the right to raise finance (e.g. through tariffs).

• Wastewater utilities, and in some cases water quality management organisations, allowed to operate as autonomous entities, i.e. they can decide on tariff structures and personnel management without explicit interference by the local or central government.

• Involve private partners to carry out (part of the) management, bring in finance, or buy the assets (infrastructure, land, the organisation) and operate them as a private company. These alternatives, with increasing private sector involvement, are called leasing, concession and privatisation.

• Identify (waste)water rights and allow their owners to trade them on the basis of their market values.

• Avoid introduction of measures such as subsidies or taxes that may distort the price-value ratio of the water as it is perceived by the water user.

• Apply financial (dis)incentives rather than inflexible command-and-control regulations to control, for example, waste discharges (see Chapter 6).

Although the purpose of deregulation is to allow decision-making outside direct government control, national government does retain an important policy making and monitoring function and, in particular, is responsible for the functioning of the sectoral organisations. Deregulation, therefore, must be compensated by other types of regulation. Typical regulations include:

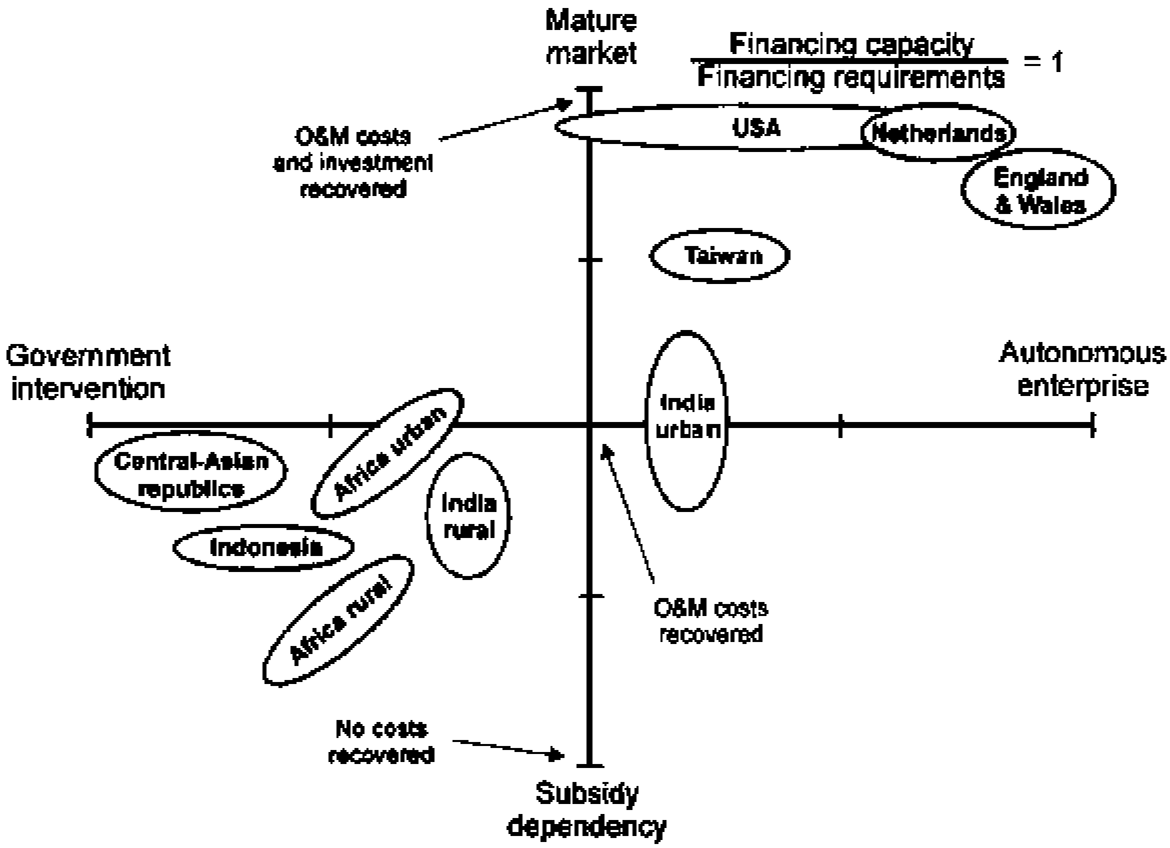
• Installing mutual control amongst the organisations by creating open competition, such as by tendering out all government contracts to private, as well as to semi-governmental, enterprises.

• Installing mutual control amongst the organisations by creating watchdog organisations and balancing the power of one organisation with that of another; for example by putting a powerful, objective regulatory agency in place (as in England and Wales following privatisation, see section 8.5.1). Whatever the situation, an executive organisation should be prevented from empowering and regulating itself (as was the situation with the Water Authorities in England and Wales in the 1970s, see section 8.5.1) because this creates internal conflicts of interest.

• Ensuring that utilities which benefit from a higher degree of autonomy are also more accountable to their clients, to their shareholders (commonly local government) and to the national government with respect to their support for achieving national goals.

• Preventing monopoly and cartel formation. Recent European Union (EU) legislation forbids cartel formation and attempts to break up monopolies, including those of the water services.

Figure 8.2 The relationship between national water sector organisations as a function of their autonomy and the development of the water services "market". A "mature" market implies that the willingness-to-pay of the consumers balances the financing requirements.



The degree of desired autonomy for an organisation is related to the "maturity" of the market, i.e. the willingness of the consumers to pay for the service. Figure 8.2 charts the relationship of a number of national institutional arrangements with respect to the degree of autonomy in their waste(water) sector organisation and the maturity of the market. A proportionality becomes apparent where local organisations are more autonomous where the market is mature and the demand is more developed. Arguably, England and Wales have the highest degree of autonomy, because their organisations are privatised and operate as independent companies. Most probably, maturity and autonomy must be developed in a co-ordinated fashion and must mutually reinforce each other. An organisation which is suddenly cut off from regular subsidies has no option other than to educate its consumers. Autonomy is measured by the absence of political interference in an organisation and not simply by its "name"; for example, city departments in Western Europe are allowed more true managerial autonomy than governmental enterprises in developing countries.

8.4.4 Capable organisations

Sector organisations can only perform well if they are properly managed, guided and staffed. This implies that:

• Management must offer leadership, to ensure that the organisation and its staff have a clear and shared view of their purpose and how this will be achieved.

• Staff must be adequate and with the right combination of levels of expertise.

• Personnel management must be dynamic, stimulating loyalty and minimising operational cost.

Instruments to further this include career development and salary measures to motivate staff to improve their performance, education and training (see section 8.5.8), and management consultancy. In France, it is argued that the system of delegated management (see section 8.5.2) allows municipal governments to concentrate on policy making and essential tasks, while technical management is left to private organisations that are more expert and better equipped for this purpose.

Sustainable institutions, in addition, possess built-in capacity to monitor critically the overall contribution of the sub-sector to the achievement of the nation's goals, and to influence these goals for the better, for example by introducing the economic replacement value of water and environmental quality in national economic planning, and by demonstrating the economic value of water for sustainable economic development. Such institutions possess the internal mechanisms that enable them to review the management performance and the effectiveness of the separate organisations and institutional measures. Ideally, an organisation should be allowed to operate in an institutional environment such that, without government interference, it gives maximum performance under its present mandate, it learns from errors and improves on its weaknesses, and it is able to identify the future requirements of the sector and to propose the new concomitant institutional arrangements (even if that means abolishing the organisation and replacing it with another).

8.5 Examples of institutional arrangements

8.5.1 England and Wales

In recent years England and Wales have gone through four phases of institutional arrangements. Before 1972, water pollution control infrastructure was under the responsibility of, and was owned by, local government departments, and was often combined with the water supply sub-sector. This led to serious inefficiencies because each municipality had its own small treatment plant and there was no critical mass of technical expertise and financial support. Regulation and water quality management rested with Inspectorates and the River Authorities (one for each of the nine major river basins).

Between 1972 and 1982 nine Water Authorities were created and all infrastructure, with the exception of local sewerage, was transferred to the new authorities in order to increase the scale of the organisations and to bring all water management functions into single entities. This led to the merger of many sub-sectors, including drainage and river management, and brought the regulatory and executive functions together, thus broadening their scope (for more detail see Okun, 1977). The newly created organisations proved too large and unfocused, struggling with internal conflicts of interest, and unable to generate sufficient investment to meet increasing environmental quality standards.

Between 1982 and 1989, the Water Authorities were made more business orientated in order to increase their efficiency as well as their effectiveness. In addition, they were placed primarily under the supervision of the national environment ministry. Preparations were made for privatisation. After 1989, the Government sold the water supply and wastewater infrastructure of the Water Authorities to public and private investors. These private enterprises remain operating in the same river basins. One of their main tasks is to generate finance for the overdue expansion and modernisation of the water and wastewater infrastructure in order to meet the strict EU environmental directives. As a result, tariffs have been raised. The regulatory and water quality management functions were taken over by the National Rivers Authority (NRA), which is also responsible for river management, and by the Inspectorates of the environment and of health. The enterprises are allowed to operate as monopolies within their region and, therefore, the new Office of Water (Ofwat) was created as a financial regulator (under the Ministry of Environment) to ensure that water companies meet government policy, and that they do not exploit their monopolistic position at the expense of the citizens or the nations. It is a matter of continuing debate whether this arrangement is considered successful.

In 1996 the water quality regulatory function of the NRA was merged with air and soil quality regulatory functions from the Inspectorates to create an American-style environmental protection agency (known as the Environment Agency).

8.5.2 France

In 1982, the French state structure was fundamentally altered by a decentralisation law that devolved a substantial part of the central government to local government. Traditionally, France had been strongly centralised, but the municipalities were now attributed more responsibility for infrastructure planning and financing. In addition, economic development and water management required a new regional approach with more integration between sectors. Thus, the new law allowed municipalities and Départements (counties) to develop appropriate institutions.

Wastewater collection and treatment is the responsibility of municipalities, which commonly make joint-ventures (intercommunales) to execute this task. However, in most cases the actual management (operation, maintenance and cost recovery) is delegated to private enterprises. Five such companies operate in France and compete with each other during the frequent public tendering of contracts, for example for operation and maintenance, all over the country. Such contracts are very specific, stipulating what the municipality wants the contractor to achieve in a given period of time (5-20 years) and the associated performance parameters. A water price is agreed, from which the contractor has to recover costs and pay a lease fee to the municipality. The contractor can carry out management tasks on the infrastructure owned by the municipality (lease), or it can also provide financing for investment which reverts after a suitable period to municipal ownership (concession) (Lorrain, 1995). Water quality management and regulation is carried out by the Agences de Bassin (river basin boards) which carry out planning, collect fees for abstraction and pollution of the water resources, and also provide subsidies to local government for wastewater infrastructure (Chéret, 1993). Quality standards are developed by the Ministry of Environment.

8.5.3 Germany

Wastewater management is the responsibility of the municipalities in Germany. If they are too small to address the financial and technical complexity of this task, the municipalities form Verbände (inter-municipal joint-venture autonomous enterprises) or, in the case of cities, the various utilities are amalgamated into one Stadtwerke (City Enterprise) encompassing water supply, power distribution, district heating, (often) sewerage and wastewater treatment and, importantly, public transport. The shares of such municipal enterprises are in the hands of the municipalities. The management has a large degree of autonomy, although critical decisions need approval by the board in which the representatives of the municipal enterprises have a majority. The enterprise is subject to taxation on any profits. However, because public transport and sewerage typically lose money, whereas power distribution and water supply commonly yield a benefit, the net profit is zero and taxation is avoided.

Depending on the local topography and pollution load, joint-ventures may be created, based on river basins, to manage water and wastewater, including the operation of treatment works. The Emscher Genossenschaft (Treatment Association for the Ems River) in the industrial heartland of the Ruhr region has an unusual arrangement, insofar as local municipalities (in proportion to their population), industries and other partners form a fully autonomous "water parliament". This "water parliament" undertakes to collect all domestic, and part of the industrial, sewage in the basin and, after pre-treatment, to treat it centrally near the mouth of the Ems in the Rhine. This arrangement has operated for almost a century although, currently, environmental quality is considered to be better served by providing more specialised decentralised treatment. Regulation and part of the water quality management are carried out by the Land's (State) Environment Department and in the Federal Ministry of Environment.

8.5.4 The Netherlands

Historically, The Netherlands has been very much influenced by the need to safeguard its low-lying lands from flooding from the sea or large rivers (Rhine, Meuse and Scheldt). Seventy per cent of the territory needs infrastructure to protect against floods, and the large areas of polders require continuous drainage and meticulous water management. Since the 12th century Polder Boards have been operational. These were unusual because they represented a separate line of local government; the councils of these boards were, and still are, composed of representatives elected by ballot by all those with a commercial or residential interest within the confines of the polder area. In return, all these groups pay a substantial contribution for dike maintenance and water management. After the 1950s, the task of water quality management and wastewater management, with a few exceptions, automatically became a new mandate of the newly-named Water Boards. The local sewerage remained the responsibility of the technical departments of municipalities. The boards cover an area of half to one full province, typically with half a million inhabitants. A move towards an increase in scale (mergers) started recently, in order to pool technical expertise and financial strength, and to allow a more integrated approach for complete water systems (e.g. inter-related canals, lakes).

The present water boards are not owned by local or national government, but have built up their own financial resources and institutional position. All polluting units in the country (households, industries and farms) pay a waste-water conveyance and treatment contribution which is added to the water supply bill and allows full cost recovery of all wastewater infrastructure. The boards also serve as water quality managers and, as such, report to the Ministry of Transportation and Water Management. Regulations are issued by this Ministry as well as by the Ministry of Environment.

8.5.5 Belgium, Flanders

Since 1986, Belgium has been a federal country, of which Flanders is the northern region. Flanders consists of five provinces with approximately five million inhabitants. In the early 1950s a comprehensive pollution control law was adopted investing the municipalities with the responsibility to treat sewage. However, although most industries gradually installed treatment works, reduced their pollution production or closed down, most domestic wastewater remained untreated due to the lack of institutional mechanisms to make municipalities co-operate, and due to the lack of financial means and political will. In the 1970s two regional governmental agencies were set up by national and provincial authorities to combine water quality management and wastewater management. This attempt again failed to produce more than a small proportion of the badly needed investments, partly because the country as a whole was in a state of re-organisation (with devolution of power to the regions) and partly because the government agencies could not generate the required finance. In 1989 the two agencies were reorganised into a "mixed" autonomous investment organisation, known as Aquafin, in which the regional government (responsible for 51 per cent) and a private partner co-operate, and into a Regional Wastewater Corporation (which became the Flemish Environmental Agency after 1992) for water quality management and operation of infrastructure. The private partner is one of the English private water companies which contributes technical expertise and substantial finance, for which it is compensated through tariffs. National and regional Ministries of Environment are responsible for regulation.

8.5.6 India

India must address the deficient sanitary conditions of the poor rural areas and urban squatter zones simultaneously with the industrialised and urbanised regions. Institutional analysis shows an allocation of mandates as illustrated in Figure 8.3.

	Regulation	Integrated planning	Construction	Operation of cost recovery
Rural and peri-urban	-	-	State Water Corp./Board	State Water Corp./Board; Local Govt
Urban	State PCB; CPCB	Min. Urb. Constr.; Min. Water Res.; State Water Corp./Board	State Water Corp./Board	Local Govt
Industrial	State PCB; CPCB	-	Industry	Industry

Figure 8.3 Typical mandate allocation amongst organisations for sanitation and waste-water management in India. The shaded area indicates the fields with comparatively weak effectiveness due to sub-optimal mandate definition and/or inappropriate organisational capacity. PCB: Pollution Control Board; CPCB: Central Pollution Control Board

Regulation and standard setting have achieved much progress and can be considered well organised. The Central and the State Pollution Control Boards were already functional by the 1960s. In the 1970s a basic comprehensive water quality standards system (MInimimal NAtional Standards - MINAS) was established which, among other things, specifies quality standards depending on the intended use of the water, and sets discharge standards that are specific for each industrial sector. These boards also regulate air and soil quality and monitor quality trends. The boards have been instrumental in forcing large factories to install primary or more advanced treatment, although they will not take any responsibility for the execution of the treatment programmes. Their effectiveness can be attributed, in part, to their clear, simple focus and well demarcated tasks, and to the relatively small size and high degree of professionalism which facilitate their management.

In the large cities, such as New Delhi, Bombay, Madras and Calcutta, city departments or corporations are responsible for drainage, sewerage, sanitation and sewage treatment. In the rest of the territory this responsibility falls with the state water boards or corporations, such as the Jal Nigam in Uttar Pradesh, and the Panchayat Raj Engineering Department in Andra Pradesh. However, these state organisations are primarily structured and equipped to develop and execute new construction schemes. Water supply and waste-water infrastructure for the larger towns, once built, are handed over to local government for O&M (local government is also supposed to take care of cost recovery). In the rural areas the state agencies retain responsibility for O&M. Implementation has proved to be more difficult than regulation. The state boards and corporations were effective in the planning and construction of water supply and drainage, but progress has been below expectation for collecting and treating urban sewage and for providing sustainable water supplies and sanitation to rural communities. A key reason for the first deficiency is the very weak technological and managerial capacity at the level of local government, especially the capacity to recover (high) costs from the city population. Local water supply and sewerage corporations have a weak financial basis, poor personnel management and suffer from continuing political interference. In most cities and towns they resort to continuous crisis management. In the rural areas, these boards and corporations are ill-equipped to communicate with the local communities, decide on the service level for which the communities are willing to pay, involve them in the planning of the scheme and, importantly, organise and train them to assume responsibility for some of the local management and collection of fees. Some state boards are now experimenting with schemes to delegate more power to the district level.

The Indian Government has followed an alternative path in order to by-pass the institutional weaknesses. In 1986 the then Prime Minister, Rajiv Gandhi, launched a separate, high-profile and devoted programme to "clean up the Holy River Ganges" which would involve the construction of numerous municipal and industrial sewage treatment plants in the river basin (see Case Study I). In the wake of the programme several integrated urban environmental sanitation programmes were developed, made up of sewerage infrastructure as well as water supply, and assistance by government agencies to industry to advise them on the options for minimisation and prevention of waste discharges. This Ganga Action Plan (GAP) has a limited-time mandate and is centrally financed and guided by a special Project Directorate in the Ministry of Environment and Forests, although it is executed by the state and local authorities. One of its components, focusing on one of India's largest and most polluted cities, Kanpur, includes substantial institutional development. The success of the GAP has led to the development, in 1993, of the Yamuna and Gumti Action Plans, and will be expanded into a National Rivers Action Plan (see Case Study I). Operation and maintenance cost recovery is claimed to be complete, although these figures often hide an underestimation of the true costs, such as for major repairs, warehouse stocks, and for qualified and well-paid staff. Plans are being developed for improving cost recovery while at the same time spending more funds on better O&M (Box 8.2).

Box 8.2 Achieving cost recovery and operation and maintenance

Weak organisations may recover part of their costs but may be too political to resist the temptation to use the funds for other purposes. The only escape from the "poor O&M-poor cost recovery" trap is to improve on service incrementally by improving O&M in part of the water pollution network. In this way a better service is delivered and more income is earned, that can be re-invested exclusively in further O&M improvement. To ensure institutional sustainability of the planned, large sewage infrastructure of the city of Kanpur (Uttar Pradesh), a phased programme with set targets was devised (Anon, 1993). At present the infrastructure suffers from poor, if any, maintenance and low technical standards and, because of the low service levels and frequent breakdowns, consumers are dissatisfied and unwilling to pay fees. The city corporation lacks professional capacity, despite being overstaffed, and is highly political. The programme for the city of Kanpur comprises five steps to improve gradually the operational efficiency, consumer satisfaction and, hence, cost recovery (see table below). The increased financial means will allow further quality improvement.

Step	Targets	Time-frame
1	Sub-standard O&M with poor service delivery for basic services. Partial cost recovery of O&M and substantial state subsidies. State pays for investment and O&M of sewage treatment	Present
2	Sub-standard O&M but with marginally improved service delivery (water supply and sewerage) to a target area. Full cost recovery for O&M. State pays for sewage treatment	Feasible in short term: 3-5 years
3	Systematically improved O&M with better service delivery of basic services. Full O&M cost recovery. State pays for sewage treatment	Feasible in medium term: 4-10 years
4	As for step 3. Assets partially, to completely, depreciated and debt for investment serviced. State pays for sewage treatment	Feasible in longer term: 8-15 years
5	As for step 3. Complete depreciation of all assets and debt servicing, including for major expenditure on pumping stations and wastewater treatment	Not feasible in foreseeable future; to remain centrally subsidised

The fact that full, local cost recovery of wastewater treatment may not be feasible in the foreseeable future is not surprising because in some rich Western European countries this expensive part of the infrastructure is also still subsidised from central funds.

In the mean time, on-site sanitation retains a low priority in Urban Development Departments. The understanding of water management, and also of community management, remains poor. Nonetheless, several promising initiatives are being taken, particularly those involving the local urban communities in planning and operational phases. In addition, the tendering of concessions to private companies and non-governmental organisations (NGOs) for the installation and operation of blocks with lavatories and bathing facilities are being relatively successful.

8.5.7 South Korea: towards institutions for sustainable management

South Korea went through rapid changes in its institutional arrangement between 1985 and 1995. This was spurred by the country's rapid economic development and the associated pollution pressure. In addition, the country is comparatively poorly endowed with freshwater resources, all of which are intensively used. The development process led to increasing scale and scope within the water pollution control organisations and necessitated an integral water management concept.

In 1985, urban wastewater collection and treatment were mandated exclusively to the municipalities. These were faced with the need for major investments. The typical sub-sectoral approach (with limited vision on long-term sustainability) taken at that time is illustrated by, for example, the hydraulic design guidelines for sewers and sewage works. These were based on a projected linear increase of water consumption from 100-440 litres per capita per day. However, it was not recognised that the available water resources would not be able to sustain this level of consumption beyond the foreseeable future. Similarly, the ensuing treatment works would be so costly that, at best, only secondary sewage treatment would be possible, followed by discharge to coastal waters (because most cities lie close to the coast). However, the coastal ecosystems which supported the harvesting of sea kelp (an important economic activity) would be badly affected by the nutrient-rich effluents from the secondary treatment plants.

To integrate water and wastewater planning and management more effectively, a National Water Improvement Program was developed at national level in 1990. In 1992, region-specific Catchment Water Quality Master Plans were drafted by the Ministry of Public Works and in co-ordination with other ministries. The plans attempted to avoid resource losses and minimise expenditure. This regional planning and co-financing of infrastructure works is administered by Catchment Authorities that direct and complement municipal initiatives. As a consequence, as of 1994, the cities of Kwangju and Seoul envisaged the application of more modest hydraulic design guidelines, with the full reuse of sewage in nearby agriculture, the avoidance of any nutrient disposal in coastal waters, and with much lower investments in wastewater infrastructure.

8.5.8 Sri Lanka: turning an organisation around

Between 1985 and 1991 the United States Agency for International Development (USAID) assisted a major institutional development programme with the Water Supply and Drainage Board (NWSDB) (Edwards, 1988; Wickremage, 1991). This Board was functioning reasonably well in terms of construction of new schemes, but performance was less than satisfactory in operation and financial viability. In 1983, for example, collections covered only 12 per cent of O&M costs. The basic problem with NWSDB was that it had not been able to adjust to the significant differences brought about by its change from a government department to a public corporation. The new role demanded that its attention be changed from capital projects to O&M and the consumers. Deficiencies included minimal commitment to financial viability, negligible budget discipline, lack of corporate planning, little attention to communities and users, and over-sensitivity to political pressures. These deficiencies could not be overcome without a change in staff attitude supported by new staff skills and organisation procedures. Major objectives of the institutional development programme were:

- Decentralisation of management to regional offices in order to put it closer to the consumers.

• Change of organisational structure and attitudes in order to make O&M the most important mission of NWSDB.

• Close co-operation with Ministry of Health, NGOs and communities to provide co-ordinated support to public health programmes.

The process consisted of consultations, practical and formal training sessions, organisational analysis, and changes in the administrative organisation and procedures. In doing this, a large degree of "ownership" of the staff was created. The most notable changes were decentralisation of financial responsibilities (including setting up an accountability and Management Information System), management skill development, corporate planning (including setting up a Corporate Planning Division), financial viability (including tariff reform and collection efficiency improvement), human resources development (especially in basic management and accounting skills, and exposure programmes abroad), and community participation. The incentive structure for engineers was also revised.

At a cost of US$ 14 million the whole organisation was restructured in six years. After the programme, the performance of NWSDB was vastly improved on all accounts, and it showed a high degree of commitment to public water and health services. Importantly, its managerial system now ensured "institutional sustainability".

8.6 Capacity building

Capacity building in the water sector is a new concept that starts from three premises (Alaerts and Hartvelt, 1996):

• Water is a finite resource, for which numerous users compete, most notably the waste dischargers (who lower the usefulness of the water).

• Water is essential for a healthy economy as well as for the environment and, therefore, it is a resource that should be managed in a sustainable way.

• Institutional rather than technical factors cause weakness in the sector.

Capacity building, therefore, takes a comprehensive look at the sector, analyses its physical and institutional characteristics in detail, defines opportunities and key constraints for sustainable development, and then selects a set of short- and long-term action programmes. Very often the water sector performs poorly because of inappropriate or rigid institutional arrangements. If these can be improved, structural constraints are removed. Water is a finite resource and, therefore, demand management rather than new development is necessary because any additional supply created from a new water development is soon fully used and creates even more demand, which can no longer be fulfilled.

Countries must build "capacities" in order to achieve the goal of good sector development, which is effective in service delivery, efficient in resource use and sustainable. Through the Delft Declaration, the United Nations Development Programme

(UNDP) developed the following definitions of the aims of capacity building which are applicable for the water sector (Alaerts *et al.,* 1991):

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

Experience, especially in developing countries and in economies in transition, shows that the main tasks ahead can be formulated as follows:

- Price setting, cost recovery and the enforcement of rules, are more difficult to implement than regulation (of water quality, for example) and, therefore, strategies to achieve these deserve priority.

- Many inefficiencies can be improved by allocating the right mandates and by reviewing the performance of the arrangement regularly. This will render organisations more alert and target-orientated.

- In rich as well as in poor countries, organisations must be orientated to the consumers of their "environmental services". In poor countries especially, engineers must be willing and able to co-operate with the community to facilitate O&M and cost recovery.

- Organisations must develop the right expertise profile.

A number of instruments can be applied in capacity building. These are:

- Technical assistance for sector analysis and programme development. Since 1992, UNDP has developed "water sector assessments" which analyse comprehensively national water sectors and which develop a priority action programme. Other agencies, such as The World Bank and the Asian and European Development Banks, are also engaged in similar exercises. Such analyses need to be performed by an interdisciplinary team.

- Technical assistance for institutional change. The expertise for this will differ depending on the institution that is under consideration and it may relate to policy, micro- or macro-economic structures, management systems, and administrative arrangements.

- Training for change at different levels, including decision-makers, senior staff and engineers with managerial assignments, junior staff and engineers with primarily executive tasks, technicians and operators, and other stakeholders (such as care-takers and people in local communities who have undertaken to operate or to manage community-based systems).

- Education of prospective experts who will play a role in the sector. This encompasses physical and technological sciences, as well as financial and administrative management, and behavioural sciences. The water pollution control sub-sector is so complex and develops so fast that in most developing countries not more than 10 per cent of the required technical expertise (as university graduates) is available. Many graduates are inadequately prepared for the tasks in their country (Alaerts, 1991).

8.7 Conclusions

Water pollution control comprises four main functions: water quality management, regulation and standard setting, on-site sanitation, and collection and treatment of domestic and industrial wastewater. Each function needs an appropriate institutional arrangement in order to make the whole sub-sector work effectively. In many instances the regulatory function has proved to be a comparatively easy part of the overall task.

The types of institutional arrangements for water pollution control often differ, but not always, from those for water supply. The "optimal" arrangement depends on the political and institutional environment, the economic policy, the roles and values of water in the country, the local topography and hydrogeology, and the natural environment.

Many types of arrangement exist and could fulfil the necessary requirements. No "ideal" type exists that could be prescribed to any country, at any moment, in the world. A prerequisite is that an appropriate match exists between the organisational mandates and structures and the institutional environment. Depending on local conditions, the preferred organisations may have a particular scale and scope. Typically, however, water pollution control requires a relationship with water management and hence large scales (10-100 km, covering a river or drainage basin or an agglomeration of municipalities). Usually, single municipalities are unable to generate the required vision, finance and technical knowledge. Where it is possible to enhance particular functions, mergers with other sub-sectors or utilities may be advisable.

As wastewater infrastructure is so expensive, the generation of finance is a key consideration for investment, and for operation and maintenance. Consequently, institutions must be designed to allow cost recovery. This necessitates devolution of decision making and operation and maintenance to lower administrative levels, i.e. closer to the consumer and citizen.

In order to render the organisations flexible, task and performance orientated, and financially well managed, they require a large degree of autonomy. For this purpose, the conventional command-and-control must be deregulated and replaced by measures that ensure self-regulation. This may include arrangements for competition (for service contracts, for example), avoidance or control of monopolies, or the prevention of executive organisations from regulating themselves. Delegated management and privatisation may be useful components in a deregulation strategy. However, the institutional environment must be equally developed to ensure adequate control of the private partners and to avoid monopoly and cartel formation.

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Chapter 10* - Framework for Water Pollution Control

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10.1 Introduction

This chapter synthesises the aspects of water pollution control presented in Chapters 1-9 and brings their main themes together in order to recommend an approach for comprehensive water resources management. There is, inevitably, some repetition of key messages from the preceding chapters. However, for a more detailed treatment of the specific aspects of water pollution control presented below, readers are advised to study the appropriate chapters. Examples of the different approaches to water pollution control can be found in the case studies indicated.

10.1.1 Background: Agenda 21

In recent years water quality problems have attracted increasing attention from authorities and communities throughout the world, especially in developing countries but also in countries in transition from centrally planned economies to market economies. In the latter, previously neglected aspects of environmental protection are now becoming a major obstacle for further and sustainable economic and social development.

Degradation of surface and groundwater sources has previously been an inherent consequence of economic development and remedial action to compensate for, or to reduce, environmental impacts have always been a lesser priority. Consequently, when the impacts of pollution and the costs of remedial actions are finally acknowledged, the cost of preventive precautionary measures is higher than if they had been implemented at the appropriate time. Thus, negligence of water quality problems often leads to a waste of (economic) resources, resources that might have been used for other purposes if the water quality problems had been given proper attention in the first place.

The international community has now acknowledged the severity of the problems incurred by deteriorating water quality and agreed formally to take action to protect the quality of freshwater resources. The most recent demonstration of this was provided by the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, from which came "Agenda 21". In Chapter 18 of this document (UNCED, 1992), on protection of the quality and supply of freshwater resources, key principles and recommendations for sound water resources management are laid down. These were crystallised, matured and elaborated through a series of preparatory meetings, including the Copenhagen Informal Consultation (CIC) in 1991 and the International Conference on Water and the Environment (ICWE) in Dublin in 1992.

The principles for water resources management that have formed the basis for the guidelines presented here are derived from the conclusions reached in Dublin and Rio de Janeiro and are:

- Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment.

- Land and water resources should be managed at the lowest appropriate levels.

- The government has an essential role as enabler in a participatory, demand-driven approach to development.

- Water should be considered a social and economic good, with a value reflecting its most valuable potential use.

- Water and land-use management should be integrated.

- Women play a central part in the provision, management and safeguarding of water.

- The private sector has an important role in water management.

10.1.2 Scope of guidelines

The recommendations and principles from Agenda 21 cover water resources management in general, i.e. including availability of water, demand regulation, supply and tariffs, whereas water pollution control should be considered as a subset of water resources management. Water resources management entails two closely related elements, that is the maintenance and development of adequate *quantities* of water of adequate *quality* (see Case Study V, South Africa). Thus, water resources management cannot be conducted properly without paying due attention to water quality aspects. It is very important to take note of this integrated relationship between water resources management and water pollution control because past failures to implement water management schemes successfully may be attributed to a lack of consideration of this relationship. All management of water pollution should ensure integration with general water resources management and vice versa.

The approach presented in this chapter concentrate specifically on aspects that relate to water quality, with special emphasis on the conditions typically prevailing in developing countries and countries in economic transition (e.g. eastern European countries). The intention is to demonstrate an approach to water pollution control, focusing on processes that will support effective management of water pollution. A step-wise approach is proposed, comprising the following elements:

• Identification and initial analysis of water pollution problems.

• Definition of long- and short-term management objectives.

• Derivation of management interventions, tools and instruments needed to fulfil the management objectives.

• Establishment of an action plan, including an action programme and procedures for implementation, monitoring and updating of the plan.

The suggested approach may be applied at various levels; from the catchment or river basin level to the level of international co-operation. The Danube case study (Case Study IX) is an example of the latter. This chapter demonstrates the approach by taking the national level as an example.

10.2 Initial analysis of water quality problems

Management of water pollution requires a concise definition of the problem to be managed. The first task is recognition of an alleged water quality problem as being "a problem". This assumes an ability to identify all relevant water quality problems. The next task is to make sure that useful information is acquired that enables identification and assessment of existing and potential future water quality problems. Thus managers must be able to identify problem areas that require intervention within the water quality sector or the sector for which they are responsible. Nevertheless, even if all existing and potential water quality problems could be identified it may not be feasible to attempt to solve them all at once. All managers are limited by budgetary constraints imposed by political decision makers. Therefore, tools for analysis and prioritisation of water quality problems are indispensable and help make the best possible use of the available resources allocated to water pollution control.

10.2.1 Identification of water quality problems

On a national scale, or regional scale depending on the size of the country, the initial step should be to conduct a water resources assessment. In this context, a water resources assessment is an integrated activity, taking into account water pollution control as well as more general water resources issues. At this very early stage it may be difficult to determine whether a certain problem is purely one of water quality or whether it also relates to the availability of water resources. For example, an identified problem of supplying clean water to a local community may be a problem of scarcity of freshwater resources but may also be caused by inadequate treatment of wastewater discharged into the existing water supply source, thereby rendering the water unfit for the intended use. The water resources assessment should constitute the practical basis for management of water pollution as well as for management of water resources. The recommendation of preparing water resources assessments is fully in line with that given in Agenda 21 (UNCED, 1992), according to which water resources assessments should be carried out with the objective "... *of ensuring the assessment and forecasting of the* *quantity and quality of water resources, in order to estimate the total quantity of water resources available and their future supply potential, to determine their current quality status, to predict possible conflicts between supply and demand and to provide a scientific database for rational water resources utilization".*

Box 10.1 Summary of water resources assessment

Objective

- To establish a basis for rational water resources management and water pollution control

Action

- To estimate the spatial and temporal occurrence of quantities and qualities of water resources.

- To assess water requirements and development trends, and associated requirements for water quality.

- To assess whether the available resources meet the present and projected demands and requirements in terms of both quantity and quality.

Result

- An overview of the current and expected status and problems of general water resources and water quality.

More specifically, the recommended assessment should identify the occurrence (in space and time) of both surface and groundwater quantity and their associated water quality, together with a tentative assessment of trends in water requirements and water resources development (see Box 10.1). The assessment should be based, as far as possible, on existing data and knowledge in order to avoid unnecessary delays in the process of management improvement. The objective of the assessment is not to solve the problems but to identify and list the problems, and to identify priority areas within which more detailed investigations should be carried out. As stated by WMO/UNESCO (1991), "*Water Resources Assessment is the determination of the sources, extent, dependability, and quality of water resources, on which is based an evaluation of the possibilities for their utilization and control".* An example of implementation of water resources assessments is given in Case Study IV, Nigeria.

10.2.2 Categorisation of water quality problems

Identified water quality problems may fall into different categories requiring application of different management tools and interventions for optimal resolution of the problems. For example, it is important to know whether a certain water quality problem pertains only to a local community or whether it is a national problem. If a problem exists at the national scale it might be necessary to consider imposing general effluent standards, regulations or other relevant measures. By contrast, if the problem is limited to a small geographic region it might only be necessary to consider issuing a local by-law or to intervene to settle a dispute through mediation.

It may also be useful to categorise water quality problems as either "impact issues" or "user-requirement issues". Impact issues are those derived from human activities that negatively affect water quality or that result in environmental degradation. User-requirement issues are those which derive from an inadequate matching of user-specified water quality requirements (demand) and the actual quality of the available resources (supply). Both types of issues require intervention from a structure or institution with powers that can resolve the issue in as rational a manner as possible, taking into consideration the prevailing circumstances.

According to the traditional water pollution control approach, user-requirement issues would often be overlooked because the identification of such problems is not based on objectively verifiable indicators. Whereas an impact issue can be identified by the presence of, for example, a pollution source or a human activity causing deterioration of the aquatic resources (e.g. deforestation), user-requirement issues are identified by a lack of water of adequate quality for a specific, intended use.

10.2.3 Prioritisation of water quality problems

In most cases the resources (financial, human, and others) required for addressing all identified water quality problems significantly exceed the resources allocated to the water pollution control sector. Priorities, therefore, need to be assigned to all problems in order to concentrate the available resources on solving the most urgent and important problems. If this is not done the effect may be an uncoordinated and scattered management effort, resulting in a waste of scarce resources on less important problems. Ultimately, the process of assigning priority to problems requires a political decision, based on environmental, economic, social and other considerations, and therefore it is not possible to give objective guidelines for this. Nevertheless, some aspects to be considered when assigning priority to water quality problems can be identified as follows:

- Economic impact.
- Human health impact.
- Impact on ecosystem.
- Geographical extent of impact.
- Duration of impact.

As an example, the uncontrolled proliferation of the water hyacinth, *Eichhornia,* in some water bodies may lead to a deterioration in water quality, for example due to oxygen depletion caused by the decay of dead plants, but may also hamper navigation and transport, perhaps with considerable economic consequences. Thus, based on this simple analysis, combating the proliferation of water hyacinth should be given a higher priority than might be indicated by purely environmental considerations.

Another aspect to take into account in assigning priority is the geographical extent of the impact, i.e. whether a particular problem, for example caused by a discharge of wastewater, has only a local impact in an area of a few hundred meters along the river or whether there is an impact in the entire river system downstream of the discharge. The likely answer depends, for example, on the size of the discharge and the retention time in the receiving water bodies, the degradability of the pollutant, and the occurrence of sensitive species in the receiving water body. In addition, the duration of impact should be considered. A discharge of easily degradable organic material may cause considerable deterioration in water quality but only for the duration of the discharge.

When the discharge ceases the impact also disappears, although there is often a time lag between the discharge ceasing and no further effects being detected. By contrast, the discharge of a persistent pollutant that is bioaccumulated in the aquatic environment can have an effect long after the discharge has ceased.

10.3 Establishing objectives for water pollution control

When establishing objectives for water pollution control, an essential task is the definition of the ultimate aim. An ultimate aim of effective water pollution control might only be achievable after some considerable time due to financial, educational or other constraints. The further the aims are from the initial situation the more difficult it is to put strategy into practice because a lot of assumptions and uncertainties need to be included. To overcome this problem the following step-wise strategy should be considered:

- Identification of required management interventions.
- Definition of long-term objectives.
- Analysis of present capacity.
- Definition of realistic short-term objectives.

10.3.1 Required management interventions

Having identified and classified relevant water pollution problems, and having assigned priority to them, the next step is to identify appropriate interventions to cope with the problems. For every problem identified, therefore, an assessment should be made of the most appropriate means for intervention. Furthermore, an indication should be given of the relevant administrative level(s) to be involved. The proposed interventions may vary significantly in detail and scope. Depending on the problem in question and the existing institutional framework for management of water pollution, they may range from formulation of a national policy for a hitherto unregulated issue to the establishment of a database containing water quality monitoring results in a local monitoring unit. Examples of typical, required management interventions are:

- Policy making, planning and co-ordination.
- Preparation/adjustment of regulations.
- Monitoring.
- Enforcement of legislation.
- Training and information dissemination.

In many countries, no comprehensive and coherent policy and legislation exists for water pollution control or for environmental protection (see Case Study XIII, Yemen). This does not prevent water pollution control from taking place before such policies have been formulated and adopted, but the most efficient and effective outcome of water pollution control is obtained within a framework of defined policies, plans and co-ordinating activities. There may be obvious shortcomings in the existing situation that need urgent attention and for which remedial actions may be required independently of the overall general policy and planning. Such interventions and remedial actions should be taken whether or not an overall policy exists. A lack of policy should not delay the implementation of identified possibilities for obvious improvements in water pollution control. In many developed countries, regulations supporting legislation are also lacking, inadequate or outdated (see Case Study X, Russia). Adjustment of regulations is an ongoing process that has to adapt continuously to the socio-economic development of society.

A typical weakness in legislation, which should be avoided, is the tendency to state explicitly within the act economic sanctions for non-compliance (such as fees, tariffs or fines). It is much more complicated and time consuming to change or to amend an act than to amend the supporting regulations and management procedures. Hence, stating economic sanctions within an act entails an associated risk that enforcement of the legislation could become ineffective and outdated due to economic inflation. Examples of inadequate, or lack of enforcement of, existing legislation are widespread and can be illustrated by Case Studies III, IX, X and VI (Philippines, Danube, Russia and Brazil).

Improvement in water quality monitoring systems is an intervention required world-wide, not only in developing countries. There are, however, huge differences from country to country in the shortcomings induced by inadequate, existing monitoring systems. In most developing countries the problem is one of too little monitoring due to a lack of allocated resources for this activity. In several central and eastern European countries the problem is different. Extensive monitoring programmes have been functioning for many years and many raw data have been collected. What has been missing in a number of cases is an ongoing analysis and interpretation of the data, i.e. transformation of the data into useful information, followed by a subsequent adjustment of the monitoring programmes.

10.3.2 Long-term objectives

Definition of long-term objectives includes the identification of key functions that will have to be performed in order to achieve reasonably effective water pollution control at all administrative levels. This evaluation and description of necessary management functions and levels should be made without giving too much consideration to the existing administrative capacity at various administrative levels. It may be assumed, for example, that there is a reasonable capacity to carry out the necessary tasks designated at each level in the long-term strategy. However, a reasonable assessment of the full potential for development of the general level of management should form the basis for the long-term objectives. If the present situation is characterised by extremely scarce financial and human resources and major obstacles to economic and social development, it would not be appropriate to define very high standards of water pollution control in the long-term objective, simply because this situation would most likely never occur. The situation obtained by fulfilling the long-term objectives for water pollution control, should be one that is satisfactory to society (considering the anticipated general level of development at that future moment).

The guiding principles for water resources management (see section 10.1) should be reflected in the long-term strategy. For example, management at the lowest appropriate level should be pursued through the identification of the lowest appropriate level for all identified key functions, irrespective of the present level of management. For some functions, the lowest appropriate level is a local authority or unit, while for other functions it is a central authority (e.g. Case Study I, India). The case study for China (Case Study II), however, provides an example of the opposite approach, i.e. centralised control of pollution. Table 10.1 gives an example of how elements of a long-term strategy for water pollution control could be described.

10.3.3 Analysis of present capacity

Having defined long-term objectives it is necessary to assess how the present situation matches the desired situation. The key issue is identification of the potential of, and constraints upon, the present management capacity and capability in relation to carrying out the management functions defined in the long-term objectives. Such aspects as suitability of institutional framework, number of staff, recruitability of relevant new staff, educational background, and availability of financial resources should be considered. The needs for training staff and for human resources development to enhance management performance should also be identified and plans made for initiation of this development.

In many countries, problems associated with an absence of clear responsibilities, with the overlapping of institutional boundaries, duplication of work and a lack of co-ordination between involved institutions, are common obstacles to effective water pollution control (see Case Studies V, III, XIII, X and IV for South Africa, Philippines, Yemen, Russia and Nigeria).

The analysis must include all relevant administrative levels, for example through intensive studies at the central level combined with visits and studies in selected regions at lower administrative levels. The regions or districts should not be selected randomly but with a view to selecting a representative cross-section of diversity in water quality problems and their management. An example of such an analysis is given in Table 10.2.

10.3.4 Short-term strategy

In relation to short-term strategy, the duration of the "short-term" has to be defined. A period of approximately five years is suggested, because this is roughly the planning horizon that can be controlled reasonably well and foreseen without too much dependency on future development scenarios.

Table 10.1 Summary of long-term strategy for water pollution control

Function	National level	Intermediate level	Local level
Formulation of international policies	Defining the country's position with regard to cross-border issues of water pollution. Providing information for negotiations with upstream and downstream riparian states	None	None
Wastewater discharge regulation	Processing waste-water discharge applications and issuing discharge permits	Commenting on applications in relation to district development planning. Organising public hearings. Assisting in checking that permissions are adhered to. Disseminating information	Assisting in the monitoring of potentially harmful discharges; framing and enforcing local rules and maintaining structures to avoid contamination of domestic water sources

		on national standards through public health authorities	through sub-district water and sanitation committees and water user groups

Source: Directorate of Water Development/Danida, 1994

The output of the capacity analysis provides the basis for establishing a short-term strategy, taking into account the identified potential for, and constraints associated with, achieving the long-term objectives. For example, a long-term objective might be to decentralise water quality monitoring activities. However, if the current manpower skills and analytical capabilities at the lower administrative levels do not allow implementation of this strategy (see Case Study VII, Mexico), a short term strategy might be defined, maintaining monitoring activities at a central level but simultaneously upgrading the skills at the lower levels by means of training activities and orientation programmes. Alternatively, monitoring could be restricted in the short-term to those activities that can currently be carried out by the lower levels, and additional monitoring activities could be gradually included along with upgrading of manpower skills and analytical facilities.

In general, when defining the short-term strategy it should be ensured that the fulfilment of the short-term objectives will significantly contribute to achieving the long-term objectives. An example of definition of a short-term strategy for water pollution control, based on the above example of a long-term strategy with identified potentials and constraints, is given in Table 10.3.

Table 10.2 Example of an analysis of present management capacity

Functions	Potentials	Constraints
Formulation of international policies	Establishment of a Water Policy Committee has been agreed	Lack of formal agreements between upstream and downstream riparian countries. Lack of reliable information on the quantity and quality of shared water resources
Wastewater discharge regulation	Staff with necessary knowledge available at national level. Required administrative structures and procedures at national level are relatively uncomplicated. District Water Officers can assist in monitoring activities	Lack of qualified staff at district local level to deploy for discharge control. Lack of monitoring equipment. Very limited access to laboratory facilities

Source: Directorate of Water Development/Danida, 1994

Table 10.3 Example of a short-term strategy for water pollution control

Functions	National level	Lower levels
Formulation of international policies	Establish Water Policy Committee, its secretariat and its international subcommittees	None
Wastewater discharge regulation	Establish unit for administering wastewater discharge permits as per regulations	Identify wastewater dischargers requiring licensing. Establish procedures for administering the licensing system as per regulations. Local authorities to report on pollution problems and to comment on wastewater discharge applications

Source: Directorate of Water Development/Danida, 1994

10.4 Management tools and instruments

This section discusses a number of management tools and instruments together with principles for their application and for the combination of different tools (for a more thorough description of tools and instruments see preceding chapters). The range of tools and instruments should be considered as an input to the overall process of achieving effective water pollution control, that is a toolbox for the water pollution manager. They are necessary means to address the identified problems. The manager's task is to decide which tool(s) will most adequately solve the present water pollution problem and to ensure that the selected tool(s) are made available and operational within the appropriate institutions.

10.4.1 Regulations, management procedures and by-laws

Regulations are the supporting rules of the relevant legislation. Regulations can be made and amended at short notice, and in most cases need only the approval of the minister to become binding. In specific cases, approval by the cabinet may be necessary. Regulations specify the current policies, priorities, standards and procedures that apply nationally.

Management procedures are a set of guidelines and codes of practice that ensure consistent responses in problem solving and decision making. Such procedures contain a further level of detail supporting the legislation and the regulations and specifying the steps to be taken in implementing particular provisions, such as regulation of wastewater discharge. Regulations and procedures pertaining to wastewater discharge would typically include, for example, descriptions of procedures for applying and granting a permit to discharge waste-water to a recipient, procedures for monitoring compliance with the permit, fees and tariffs to be paid by the polluter, and fines for non-compliance.

As a general rule it should be ensured that only regulations that are enforceable are actually implemented. If the existing enforcement capacity is deemed insufficient, regulations should be simplified or abandoned. Regulations and management procedures made at the national level need not necessarily apply uniform conditions for the entire country, but can take account of regional variations in water pollution and socio-economic conditions.

By-laws (that are binding on local residents) can be made by a legally established corporate body, such as a district or province government and can, for example, determine the regulation and pollution of local water resources. By-laws made by lower level institutions cannot contradict those made by higher level institutions (see Chapter 5).

10.4.2 Water quality standards

Water quality standards are, in fact, part of regulations but are discussed separately here because some important aspects relating specifically to the use of standards should be noted (see Chapters 2 and 5). Numerous sets of water quality standards, or guidelines for water quality standards, have been issued during the course of time by various agencies and authorities (e.g. United States Environmental Protection Agency (EPA), World Health Organization (WHO), European Union (EU)) intending to define the maximum acceptable limit of water pollution by various pollutants. Standards for ambient water quality (quality objectives) are commonly designated according to the intended use of the water resource (e.g. drinking water, fishing water, spawning grounds), while effluent standards are usually based on either of the following two principles, or a combination of both (see Case Study II, China):

- Fixed emission standard approach, requiring a certain level of treatment of all wastewater, regardless of the conditions and intended use of the receiving water body.

- Environmental quality standard approach, defining the effluent standards in order to enable compliance with the quality objectives for the receiving water body.

Standards or guidelines developed according to the first approach must be very restrictive in order to protect the environment effectively, because they must take into account the most critical situations and locations. Thus, this approach might lead to unnecessary treatment costs in some situations. In other cases, it may lead to inappropriate treatment and excessive pollution, depending on the applied emission standards and the assimilative capacity of the receiving water body (see Case Study V, South Africa). The major advantage of this approach is its rather simple administrative implications.

The second approach allows for a more flexible administration of environmental management, and optimisation of treatment efforts and costs because the level of treatment may be tuned to the actual assimilation capacity of the receiving waters (which must be assessed on an individual basis). The problem with this approach is the difficulty in practical application; knowledge of the assimilative capacity requires studies of the hydraulic, dispersive, physico-chemical and biological conditions prevailing in the water body. In addition, plans for future development in the area should be taken into account. The above factors suggest that a strategy based on the fixed emission standard approach may be the most appropriate, at least as a starting point in many developing countries because of their often limited administrative capacities. However, the dangers associated with automatically adopting water quality standards from western industrialised countries must be emphasised. The definition of water quality standards should, to a large extent, be a function of the level of economic and social development of a society. For example, a number of water quality standards applied in western countries are based on the best available technology (BAT) and generally achievable technology (GAT) principles. These require organisations to treat their wastewater according to BAT for hazardous substances and according to GAT for other substances. Whereas the economic costs of applying these principles may be affordable in a highly industrialised country, they may be prohibitive for further industrial and economic development in developing countries.

In central and eastern European countries, water quality standards and emission standards are often more stringent. In some cases they are too stringent to be met and in other cases they are even too stringent to be measured (see Case Study IX, Danube). As a result the standards have often been ignored by both polluters and managers. In addition, the necessary administrative capacity to enforce very high water quality standards may exceed that available. As mentioned previously, it is highly recommended that only regulations that can be enforced are implemented.

Water quality standards applied in developing countries should, therefore, be adjusted to reflect the local (achievable) economic and technological level. The implication of this approach is that standards may be tightened along with the rise in economic capability to comply with higher standards. Furthermore, since a high level of wastewater treatment is often easier and cheaper to achieve when considered during the planning and design phase of any industrial production, more strict effluent standards (when compared with existing discharges) may be imposed on new discharges of wastewater. These measures would allow for both economic development and the gradual increase in environmental protection.

10.4.3 Economic instruments

The use of economic instruments is on the increase in many countries but is far from reaching its full potential. Until now, most governments have relied primarily on regulatory measures to control water pollution. However, application of economic instruments in water pollution control may offer several advantages, such as providing incentives for environmentally sound behaviour, raising revenue to help finance pollution control activities and ensuring that water quality objectives are achieved at the least possible (overall) cost to society.

The main types of economic instruments applicable in a water pollution context include (Warford, 1994; see Chapter 6):

- Resource pricing.
- Effluent charges.
- Product charges.
- Subsidies or removal of subsidies.
- Non-compliance fees (fines).

Prerequisites for the successful implementation of most economic instruments are appropriate standards, effective administrative, monitoring and enforcement capacities, institutional co-ordination and economic stability. Various degrees of administration are associated with the application of different economic instruments. Effluent charges, for example, require a well-established enabling environment and large institutional capacity and co-ordination. By contrast, product charges are relatively simple to administer (Warford, 1994).

Among the key factors in the successful implementation of economic instruments is the appropriate setting of prices and tariffs. If prices are set too low, polluters may opt to pollute and pay, as seen in some eastern and central European countries (see Case Study IX, Danube). Moreover, artificially low prices will not generate adequate revenues for system operation and maintenance (see Case Study VII, Mexico). Setting appropriate prices is very difficult because, ideally, prices should cover direct costs, opportunity costs and environmental costs (externalities) (Nordic Freshwater Initiative, 1991).

Economic instruments incorporate the polluter-pays-principle to various degrees. Subsidies, for example, clearly counteract the polluter-pays-principle but may, in some cases, be applied for political or social reasons. By contrast, effluent charges go hand-in-hand with the polluter-pays-principle. In the case of resource pricing, progressive charging scales may be used to allow large-scale users to subsidise the consumption of small-scale users, and thereby balance considerations of social needs and sustainable use of the resource.

10.4.4 Monitoring systems

There are a number of important elements to consider in relation to the implementation and functioning of a monitoring system (see Chapter 9):

- Identification of decision and management information needs.

- Assessment of capacity (economic and human) to maintain the monitoring system.

- Proper design of the monitoring programme and implementation of routines according to defined objectives.

- Data collection.

- Data handling, registration and presentation.

- Data interpretation for management.

Traditionally, monitoring programmes collect data either from chemical and biological analysis of water samples or from on-line field equipment. However, depending on available laboratory facilities, instruments, transport and human resources, for example, all monitoring programmes are restricted in some way and may collect data primarily by direct sampling. A number of information gaps often have to be filled, therefore, before a rational decision about monitoring system design can be taken with respect to a specific water quality problem. Although they are less accurate, indirect techniques for obtaining the necessary information exist for a variety of water quality-related factors. It is possible, for example, to obtain reasonable estimates of pollution quantities from various sources from a knowledge of the activities causing the pollution (see Box 10.2).

Box 10.2 An example of indirect estimation of pollution load

Load estimates can be based on, for example, measurements available from a monitoring system. However, very often it is only possible to cover part of a lake or river catchment with monitoring stations, and hence only some of the major contributors to pollution load, due to the limited resources available. The rest of the catchment has to be taken into consideration using experience and representative measurements from elements of a similar catchment. Furthermore, it is possible to give recommendations of unit loads from personal equivalents (p.e.) in relation to economic status. Unit loads from different types of industry and run-off of pollutants from, for example, agricultural land and forests can also be deduced according to the farming or forestry practised.

Another frequent problem associated with traditional monitoring programmes is the lack of coupling between measured concentrations and water flow or discharge measurements, thereby rendering quantification of pollution transport difficult. Estimation techniques also exist for these situations, where hydrometric networks are not established or functioning, or where instruments are not available for measuring flow, such as in wastewater discharges.

The actual design of a fully operational and adequate national monitoring system must, from the beginning, take account of the requirements of the additional management tools which are being considered for use (see Case Study III, Philippines). The complexity and size of the area to be monitored, the number of pollutants monitored, and the frequency of monitoring, have to be balanced against the resources available for monitoring. To a large extent the data that become available determine the level of complexity of the management tools that can be supported by the monitoring system. An example of the kind of support needed for other management tools is the requirement for reliable and frequent data to support the enforcement of effluent standards (see Case Study XII, Jordan). In this situation the monitoring programme needs to be tailored to suit the detailed requirements for enforcement, as defined in the supporting regulations.

10.4.5 Water quality modelling tools

Modelling tools are treated here as any set of instructions based on a deterministic theory of cause-effect relationships which are able to quantify a specific water quality problem and thereby support rational management decisions. This can be done at different levels of complexity, some of which are discussed below:

• *Loadings.* Preliminary decisions can be taken with respect to reduction of loadings from a ranking of the size of actual pollution loadings to a particular receiving water body. The rationale is to assess where the greatest reduction in pollution can be obtained in relation to the costs involved.

• *Mass balances.* Mass balances can be established using load estimates from pollution sources in combination with the water flow or residence time in the water body. The significance of the different loadings can be evaluated by comparing their magnitude to their contribution to the resulting concentration of the pollutant in the receiving waters. The significance of the different loadings for the pollution level of the receiving water body provides the rational basis for decisions on effective reduction of the pollution level in those waters.

• *Effect evaluation.* Assessment of changes in the identified pollution sources and their resulting concentration in the receiving waters can be made at various levels, from using simple, empirical relations to long-term mass balance models. An example of a well known empirical relation is the Vollenweider method for estimating eutrophication effects in lakes (Vollenweider, 1968, 1975, 1976). Based on experience from measurements in a large number of lakes, the method relates pollution discharges and static lake characteristics (such as water depth and retention time) to expected effects on the Secchi depth and algal concentrations. Effect evaluation may also combine considerations about cost effective pollution reduction at the source, the resulting pollution concentration in receiving waters and the resulting effects in the ecosystem.

• *Simple mathematical mass balance models.* Application of this tool allows consideration of the possible changes over time in relation to any reductions proposed in pollution load. Many types of these biogeochemical models have been developed over the years and some are available in the public domain.

• *Advanced ecological models.* If higher level effects of pollution loadings on an ecosystem are to be determined, more sophisticated ecological models are available. Such models may create the basis for a refined level of prediction (see Case Study III, Philippines) and should be used in cases of receiving waters with high complexity and importance, provided sufficient resources (financial, human or institutional) exist or can be allocated.

The above examples serve to illustrate that quantitative assessments of pollution problems can be performed at various levels of complexity, from hand calculations to advanced state-of-the-art ecological modelling.

10.4.6 Environmental impact assessment and cross-sectoral co-ordination

Impact assessment plays a central role in the process of providing information on the implications for water quality arising from development programmes and projects. However, in addition to impacts on the physical environment, impacts on the water resources often imply impacts on the biological and socio-economic environment. Assessments of impacts on water quality should, therefore, often be seen as an integral part of an environmental impact assessment (EIA). Environmental impact assessments are being used increasingly as environmental management tools in numerous countries (see Case Studies II and IV, China and Nigeria).

The main objectives of impact assessments used for the purposes of water quality management are to identify potential impact on water quality arising from proposed plans, programmes and projects. They therefore serve:

• To assist decision makers in making informed decisions on project developments and final project prioritisation.

• To provide, where possible, relevant and quantitative water quality information so that potential impacts can be avoided or reduced at the project and programme design stage.

• To provide a basis for development of management measures to avoid or reduce negative impacts under, and/or after, project implementation.

The impact assessment should form an integral part of multiple resource development planning and feasibility studies for the projects. It should provide for a quantified assessment of the physical, biological and related economic and social impacts of proposed projects as well of the likelihood of such impacts occurring. Thus, the impact assessment should accomplish its purpose by providing decision makers with the best quantitative information available regarding intended, as well as unintended, consequences of particular investments and alternatives, the means and costs to manage undesirable effects, and the consequences of taking no action.

An important element in any impact assessment is the encouragement of public participation in the process. The general public should be given an opportunity to express their views on proposed projects and programmes, and procedures should be established for considering these views during the decision making process. In many cases, non-governmental organisations (NGOs) with considerable insight in environmental issues can be identified and may provide valuable contributions to the impact assessment. Public participation can often ease the implementation of projects and programmes as a result of the increased feeling of ownership and influence that it produces amongst directly-involved users (see Case Studies III, V, VI and IX for the Philippines, South Africa, Brazil and Danube).

In addition to identifying and describing water quality impacts that a proposed programme or project would cause if no management measures were taken, an impact assessment should:

• Specify the necessary measures to protect water quality.

• Ensure that these are included in the project implementation plan.

Finally, evaluations of water quality impacts and technical and economic feasibility should be linked so that effective project modification and water quality management can be developed. Water quality aspects and economic evaluations should be linked to ensure that both water quality benefits and drawbacks of the project, as well as the costs of water quality management, can be accounted for in a subsequent cost-benefit analysis.

The operational functions of the water quality impact assessment should be to provide the necessary background for:

• Approval or rejection of wastewater discharge permit applications.

• Inclusion of operation conditions in wastewater discharge permits.

• Input to EIAs.

• Inclusion of water quality consequences in the final prioritisation of development projects (made by authorities at different levels).

• Developing modifications in the technical design of development projects with the aim of protecting water resources.

Capacity for making and overseeing water quality impact assessments should be developed within the relevant water or environment authorities, although the actual assessments should not necessarily always be made by the authority itself, for example line ministries, local authorities or private companies may undertake the task. However, detailed procedures and guidelines should be developed and co-ordinated with the development of general EIA procedures within the country.

The integrated water resources management approach implies that sectoral developments are evaluated for possible impacts on, or requirements for, the water resources and that such evaluations are considered when designing and allocating priority to development projects. Consequently, the water resources management systems must include cross-sectoral information exchange and co-ordination procedures, techniques for evaluation of individual projects with respect to their implications for water resources, and procedures ensuring that water resources aspects are included in the final design and prioritisation of projects.

As a general rule a rapid screening of the project for possible water resources implications, regarding water quality as well as other aspects, should be carried out and if the project is likely to cause water related problems it should be subject to:

- Impact assessment (possibly EIA).

- An evaluation of possible specific requirements affecting the involved water resource and recommendations for project design to fulfil such requirements.

- Identification of possible interaction with, or competition from, other planned or ongoing projects in relation to use of the same water resource.

- Recommendations on possible improvements in project design to provide optimal exploitation of water resources.

Finally, the evaluations and recommendations should be included in the prioritisation process of the project emphasising both environmental and economic implications arising from the water resources issues.

The integration of water pollution issues in the prioritisation process makes it necessary that tools and procedures exist for securing adequate exchange of information between bodies preparing the project, the water pollution authorities and the final decision makers. These requirements are:

- That information about new proposals for projects which may impact or imply specific requirements for water quality should reach the water pollution authorities in good time for the elaboration of impact assessments and recommendations before final decisions are taken (including consideration of potential alternative exploitation of the involved water resources).

- That the same authorities should possess rapid access to relevant information about registered, planned and ongoing water-related projects through, for example, adequate database tools.

10.4.7 Principles for selecting and combining management tools

When deciding on which management tools and instruments to apply in order to improve water pollution control in a given situation, some underlying principles should be considered to help achieve effective management. The principles are:

- Balance the input of resources against the severity of problem and available resources.
- Ensure sustainability.
- Seek "win-win" solutions, whereby environmental as well as other objectives are met.

Balance the input of resources

This principle entails a reasonable input of financial, human or other resources to handle a specific problem, according to the priority and severity previously assigned to that problem. For example, if the discharge of waste-water is concentrated at a few locations in a country, leaving most regions or districts unaffected by wastewater discharge, and if this situation is anticipated to continue, there would be no need to build technical and administrative capacities to handle the problem in all regions or districts. Similarly, the treatment requirements and the threshold size for activities requiring a wastewater discharge permit might be more lenient if only a few dischargers exist and if the receiving waters show no symptoms of pollution.

Ensure sustainability

This principle has a bearing upon the methods and technical solutions that should be considered for the purposes of water pollution control. In most developing countries possibilities for the operation and maintenance of advanced technical equipment are very scarce or non-existent. Among donors and recipients of projects there has been a tendency to favour quite advanced and sensitive technical solutions, even in situations where more simple and durable equipment would have been sufficient and adequate (see Case Study VII, Mexico). This can result in entire development programmes failing to be implemented successfully. Thus, as a general rule in many developing countries, it is best to keep technical solutions simple. The recommendation to use simple stabilisation ponds for wastewater treatments is one such example (as in Case Study VII, Mexico).

Sustainability also entails building on existing structures, where appropriate, instead of building new structures. Existing institutions or methods have, to some extent, proved their viability. It is more likely that the allocation of resources for existing institutions would be continued rather than additional resources would be allocated for new institutions.

Seek "win-win" solutions

"Win-win" situations (Bartone *et al.,* 1994; Warford, 1994; see also Chapter 6) are created by applying instruments that lead to improvement in water pollution control as well as in other sectors (e.g. improved health or improvement in economy). This means that the difficult balancing between environmental benefits and other drawbacks is avoided. Economic instruments are often in the "win-win" category.

Regulatory versus economic instruments

Compared with economic instruments, the advantages of the regulatory approach to water pollution control is that it offers a reasonable degree of predictability about the reduction of pollution, i.e. it offers control to authorities over what environmental goals can be achieved and when they can be achieved (Bartone *et al.,* 1994). A major disadvantage of the regulatory approach is its economic inefficiency (see also Chapter 6). Economic instruments have the advantages of providing incentives to modify the behaviour of polluters in support of pollution control and of providing revenue to finance pollution control activities. In addition they are much better suited to deal with non-point sources of pollution. However, setting of appropriate prices and charges is crucial to the success of economic instruments and is often difficult to achieve.

Against this background, it seems appropriate for most countries to apply a mixture of regulatory and economic instruments for controlling water pollution. In developing countries, where financial resources and institutional capacity are very limited, the most important criteria for balancing economic and regulatory instruments should be cost-effectiveness (those that achieve the objectives at the least cost) and administrative feasibility.

Finally, in cases of highly toxic discharges, or when a drastic reduction or complete halt in the discharge is required, regulatory instruments (e.g. a ban) rather than economic instruments should be applied.

Levels of water pollution control

According to Soliman and Ward (1994), the various management tools available may be applied and combined at five categories (levels) of water pollution control, reflecting an increasing level of development and economic and administrative capacity:

• *Crisis management.* Non-proactive mode; doing very little management (e.g. no regulation); action is taken only in response to disasters or emergencies, where a group of specialists is assigned to handle the problem; no efforts made to prevent the problem in the future. This approach is adequate in only a very few cases today.

• *The criteria/standard only strategy.* At this stage, the risk of environmental problems occurring justifies a more proactive approach to water pollution management; water quality criteria and standards may be formulated; monitoring of compliance with standards; still a passive mode of management in which no attempts are made to modify the system.

• *Controlling strategy.* If the results of monitoring using the previous strategy showed that water quality standards have been violated, additional management tools are applied; effluent standards and wastewater discharge permits may be introduced in combination with enforcement and penalty procedures to handle violations. Management has entered the proactive mode.

• *Compliance assistance strategy.* In many developing countries, widespread violations of permits may still occur because the treatment costs needed to meet the effluent standards are higher than many industries can afford. In this situation, decision makers may decide to offer financial aid to firms and municipalities in order to treat their effluents adequately, rather than closing down the installations, which would often be the only alternative to accepting continued violations. Setting priorities for financial and technical assistance is a vital component at this stage, where management has reached a supportive mode.

• *Enhancement of the science/policy of management.* Management designing the future; grants for research in water pollution control and for application of modern techniques; forecasting future potential problems and preparing to prevent the occurrence of such problems; management in an interactive mode.

10.5 Action plan for water pollution control

10.5.1 Components of and processes within an action plan

The preceding sections have described various elements and aspects of what could be considered as an action plan for water pollution control. Some elements are identical to elements from traditional master plans but, contrary to prescriptive and rather rigid master plans, the action plan concept provides a flexible and dynamic framework for development and management of water resources. It is very important to recognise the dynamic nature of the action plan concept because a significant value of the concept lies in its flexibility. The action plan should be continuously monitored and adjusted in order to take account of recent development trends. Only a flexible and non-prescriptive approach will allow for such changes.

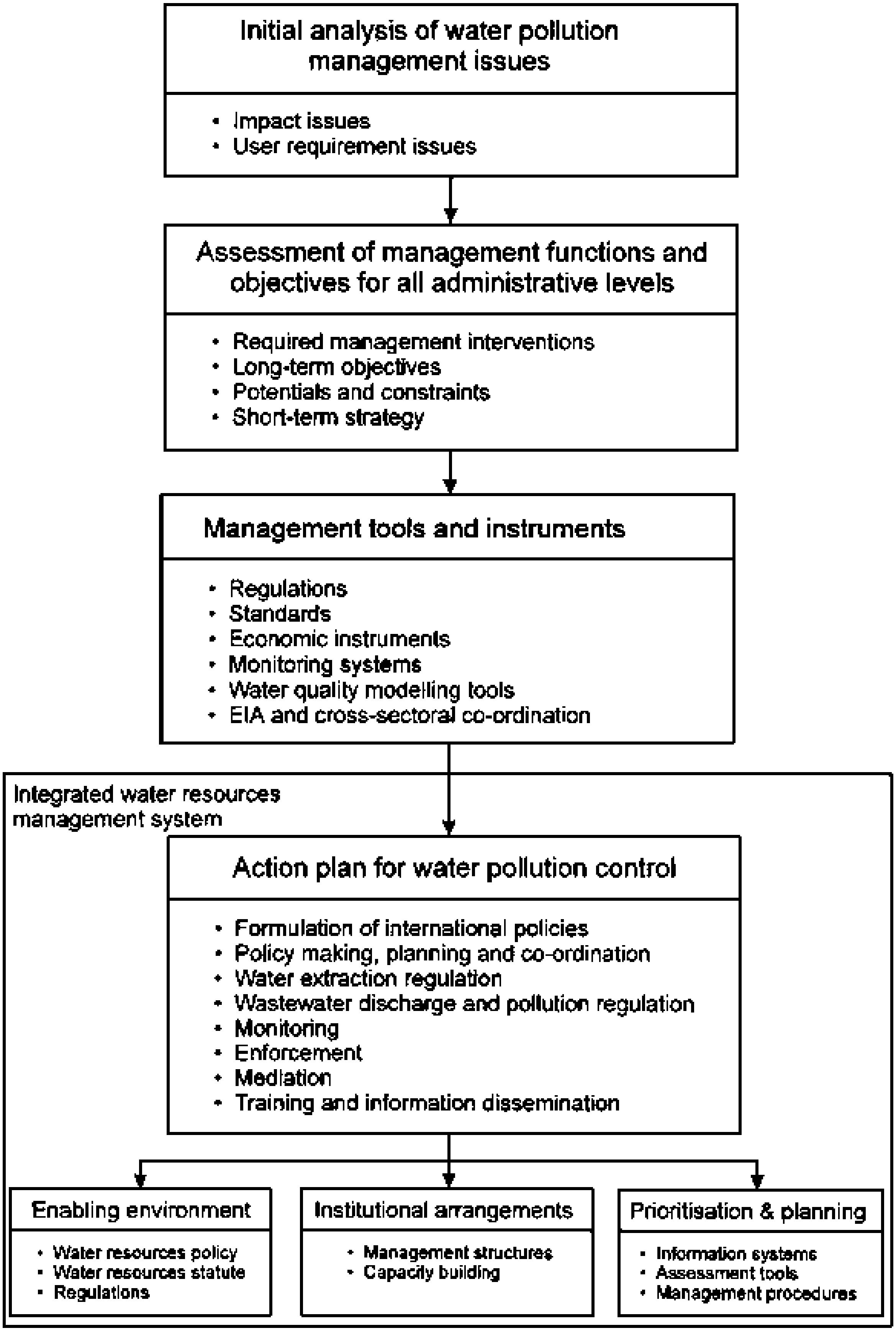
An overview of the components and the processes within the action plan concept are given in Figure 10.1. One of the main results of the action plan is a list of actions proposed for implementation in order to achieve the goal of effective and sustainable water quality management. For easy implementation and updating, the action list should preferably be prepared using a common format for each identified necessary action. For example, each action could be accompanied by information on the background (justification) for inclusion, objective and expected output, and the tasks necessary to be carried out. This information will facilitate easy transformation of the relevant actions into projects, if appropriate. The actions can typically be organised according to the following categories (Figure 10.1):

- Actions supporting the development of an enabling environment, i.e. a framework of national legislation, regulations and local by-laws for encouraging sound management of water pollution and constraining potentially harmful practices.

- Actions supporting development of an institutional framework which allows for close interaction between national, intermediate and local levels.

- Actions enhancing planning and prioritisation capabilities that will enable decision makers to make choices (based on agreed policies, available resources, environmental impacts and the social and economic consequences) between alternative actions.

Figure 10.1 Elements and processes of an action plan for water pollution control


Initial analysis of water pollution management issues
• Impact issues
• User requirement issues
Assessment of management functions and objectives for all administrative levels
• Required management interventions
• Long-term objectives
• Potentials and constraints
• Short-term strategy
Management tools and instruments
• Regulations
• Standards
• Economic instruments
• Monitoring systems
• Water quality modelling tools
• EIA and cross-sectoral co-ordination
Integrated water resources management system
Action plan for water pollution control
• Formulation of international policies
• Policy making, planning and co-ordination
• Water extraction regulation
• Wastewater discharge and pollution regulation
• Monitoring
• Enforcement
• Mediation
• Training and information dissemination
Enabling environment
• Water resources policy
• Water resources statute
• Regulations
Institutional arrangements
• Management structures
• Capacity building
Prioritisation & planning
• Information systems
• Assessment tools
• Management procedures

Training and capacity development are an integrated element of the proposed actions that apply to all categories. In addition to skill-based training related to developing assessment capabilities, there may be a need for different training, education and information activities at various levels (such as orientation programmes, curriculum development and extension training) in order to carry out the functions described in the short term strategy.

In accordance with the underlying principles of the government as an enabler in a demand-driven approach but with management occurring at the lowest appropriate levels, it is necessary to create a structure that facilitates decentralisation of management (see Case Study IX, Danube). National agencies should be concerned with essential functions that are not dealt with at other levels and they should act as enablers that review and revise the overall structure so that it responds to current needs and priorities.

The recommended framework should be one that attempts to reach a balance between national and local levels carrying out the identified management functions previously outlined. The envisaged organisational framework should, as far as possible, build on existing structures.

10.5.2 Implementation, monitoring and updating of the action plan

Depending of the number of proposed actions contained in the action plan, a phased implementation of the actions may be desirable. For example, the actions could be scheduled according to the following criteria:

- *Cohesion.* Some actions may cluster together.

- *Conditionality.* The pattern of actions may largely follow the overall pattern of the action plan, i.e. creating the legislative framework which establishes the enabling environment, building the appropriate institutional structures, and producing the required water quality management procedures and tools.

- *Dependency.* Some actions cannot be started until others are completed; for example, training related to developing an integrated extension service cannot take place until agreement has been reached to establish such a service.

- *Urgency.* Some actions are started in the initial phase because they are ranked as high priority.

A feasible, overall concept for phased implementation that might be considered is:

- Creating/adjusting the enabling environment, e.g. policies, legal procedures, regulations.
- Building/shaping the institutional structures.
- Producing/applying the required management tools and instruments.

It is very important to recognise that the action plan will have no significance if the action programme is not implemented, and unless all concerned parties are aware of the principles and procedures of the plan and are prepared to co-operate in its implementation. The action programme is the backbone of the action plan. Therefore, procedures for monitoring the progress of implementation should form part of the plan. Key indicators should be identified illustrating the progress, as well as the associated success criteria.

As indicated above, an obvious key indicator for monitoring the progress of the action plan would be the progress of setting up key institutional structures. Other useful indicators, depending on the actions listed, could be attendance at training courses and workshops, whether or not a permit system for wastewater discharges is implemented, number of analyses performed as part of a water quality monitoring programme. To document the progress of the action plan (or lack of it), a regular system for reporting on the monitoring activities should be instituted.

The action plan as a continuous process calls for frequent updating (see Case Study III, Philippines) and the addition of new actions as contexts change, requirements develop, or as progress falls below expectations or schedules. Modifications of earlier proposed actions may also be relevant. Regular monitoring reports should be accompanied by updated project/action lists.

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XII.5 Management solution alternatives

In this section management alternatives for solutions to the problems discussed above and their associated needs are considered in the same order as above. Water conservation and sustainable quality effects are also noted.

Expansion and improvements in the Ain-Ghazal/As-Samra wastewater treatment system are believed to be in progress in order to alleviate the major problems in this area. This expansion should meet all current and future effluent requirements through to the year 2015. Assuming that the existing As-Samra waste stabilisation pond system will be expanded and improved, there will be some increase in evaporation losses from the ponds. These losses could be partially off-set by covering the anaerobic ponds with floating Styrofoam sheets or other floating material. These ponds do not need to be open to the atmosphere. Based on an area of 18 ha of anaerobic ponds with an evaporation rate of approximately 2.0 m a^{-1}, covering the ponds would save approximately 360,000 m^3 a^{-1}. Covering the other ponds, i.e. aerated, facultative and maturation ponds, is not recommended because it would interfere with the treatment processes and because the costs of such untried methods would be uncertain. The bottoms of the ponds can be sealed thereby eliminating seepage losses equivalent to about 5 per cent of the pond inflow. Seepage losses for a flow of 100,000 m^3 d^{-1} a^{-1} at 5 per cent loss would be 1.8×10^6 m^3 a^{-1}. Such a water loss is worth recovering using a low cost method such as bottom sealing.

An alternative also worth investigating is the possible development of a small hydro-power station using the flow and head of the pond effluent. A suitable site could be downstream on the Zarqa river where heads in the range of 50-100 m may be available. Based on a flow of 100,000 m^3 d^{-1}, the following power generation could be possible:

- For a head of 50 m: approximately 600 horsepower or 400-500 kW.
- For a head of 100 m: approximately 1,200 horsepower or 800-1,000 kW.

Although the power that could be generated is not great, there would also be some water quality benefits downstream. In fact, the most important effect of the As-Samra treatment system improvements will be realised in downstream water quality improvements in a range of water resources.

Emergency standby handling and containment facilities for all WWTPs and industrial plants are needed to contain spills and accidental discharges. The Ain-Ghazal siphon-pump system is currently causing the most concern. The benefits of installing such facilities include the prevention of water quality degradation in rivers and streams. These benefits could be quantified using risk analysis techniques.

Control of disposal of WWTP sludges and industrial toxic and hazardous materials is required. Municipal WWTP sludges are normally not considered to be hazardous and therefore may be used as a soil conditioner in certain restricted areas. Although they have some fertiliser value, it is generally not worth further processing to market as a cost-recovery product. Waste stabilisation pond systems produce very little sludge, which is one of their major advantages. The existing As-Samra anaerobic ponds require de-sludging only after intervals of several years of operation. In addition, the sludge quantities produced are relatively small. The other ponds, employing facultative and maturation processes, never need to be de-sludged if properly operated.

The disposal of industrial sludges, including toxic and hazardous materials, is a much more difficult problem requiring special handling and disposal methods. A hazardous waste treatment facility for the Amman-Zarqa industrial complex is currently in the planning stage through the World Bank Industrial Waste Unit. This will allow industries to use a central service and should prevent indiscriminate disposal and miscellaneous discharges into the sewers and streams. Similar facilities in other governorates may be needed as industrial development increases.

As far as possible, all industries should be required to connect to the sewer system and to provide on-site, pre-treatment which will control effluents according to standards. As an economy measure certain industries in close proximity could combine their discharges for treatment in a common facility. An industrial waste discharge fee system, based on quantity and quality, would also encourage on-site pre-treatment and compliance because of the costs incurred for violations. However, this approach must be combined with an efficient monitoring and enforcement mechanism.

By instituting a fee system, based on quantity and quality, it is expected that industries will be much more responsive to reductions in water use and waste disposal, mainly because of the possible cost associated with non-compliance. Coupling this system with an industrial waste minimisation programme is expected to reduce industrial water demand by 50 per cent within an 8-year period. Vast improvements in water quality control could also be expected. Further, the collection of fees would help to fund better monitoring and enforcement.

Industrial waste minimisation is the application of low-cost, low-risk alternatives for reducing and reusing waste materials. A broad range of cost savings is possible for conservation of water as well as for conservation of other valuable materials. A typical industrial waste minimisation programme should include the following management initiatives: waste audits, improved housekeeping, substitute materials, and recycling and re-using wastes.

In wet-type industries, water savings can be dramatic in well-managed programmes, with savings in water consumption up to 70 per cent or more in certain industries over an 8-year period (Center for Hazardous Materials Research, 1991). Although difficult to quantify, improvements in the water quality of industrial effluents can be expected to be even more dramatic than those achieved in water conservation, especially for toxic discharges. Many of the industrial chemicals in waste streams can be recovered and reused, e.g. chrome in tannery wastes, with considerable cost recovery benefits to the industry. Benefits may also occur in reduced wastewater effluent charges under the industrial waste discharge fee system.

Industrial managers have expressed the need to be more closely advised on their WWTP requirements so as to be more responsive to the discharge regulations. An alternative approach to this problem would be to arrange for direct technical assistance through existing private industrial support agencies in close co-ordination with the governmental ministries in charge of monitoring and compliance. This technical assistance should be closely coupled with monitoring results obtained by the appropriate Ministry. Although not possible to quantify, long-term improved technical assistance should accrue significant benefits.

Consistent and effective monitoring is fundamental to the enforcement of compliance with effluent standards. Currently, the system only identifies non-complying WWTPs and industries sporadically and often problems are not corrected. Therefore, in order to be more effective in correcting problems, it has been suggested that non-compliance notifications should be coupled with immediate technical guidance either from the appropriate ministry or from a private industrial support agency, together with a deferred time period in which to make corrections and to achieve compliance. Although such measures can be expected to enhance water quality, the benefits cannot be measured directly.

Comprehensive water quality management programmes are required through river basin authorities. A wide range of environmental emissions occur, particularly in industrial areas such as the Zarqa river basin, and therefore it has been suggested that water quality management and monitoring should be co-ordinated to trace contamination in the full range of water resources and environmental media. This would include flowing surface waters, impoundments, water supplies, drinking waters, irrigation waters, groundwaters, wells, soil contamination, irrigation use, pesticide applications, pollution from urban run-off, non-point pollution sources, air pollution and solid waste disposal. Such a basin-wide programme is best accomplished through river basin authorities or through an environmental protection agency which would cross ministerial boundaries but could still integrate the efforts of various ministries. Through this approach, problems can be traced and corrected more responsively. These new authorities or the environmental protection agency should have certain enforcement powers.

River basin authorities have been highly successful for water pollution control in various developed countries; examples include Ruhr Verbands in Germany and River Commissions in the USA. The expected benefits include enhancement of water quality and enforcement efforts that will be more responsive and better co-ordinated.

Certain training programmes have been recommended as being required immediately and could be the key to most of the problems discussed above. The most immediate need is for the training of appropriate government engineers and scientists, WWTP managers and operators of municipal and industrial plants. Beyond this initial need, a broader training programme should include other government water resource control management personnel, private sector industrialists, selected consultants and industrial service company principals. The subjects that could be included in the training programme, depending on the personnel to be trained and their needs, are as follows:

- Basic water pollution control.
- Point-source pollution.
- Non-point source pollution.
- Pollution prevention and waste minimisation.
- Pollution measurement and monitoring.
- Industrial water conservation.
- Pollution control audits and feasibility studies.
- WWTP design and equipment requirements.
- WWTP operation and maintenance.
- Equipment requirements, costs and project financing.

Along with the proposed training programmes, two demonstration facilities should be set up for use in connection with the training programme. These would be a typical industrial plant with a WWTP and a typical municipal WWTP.

The overall objective of the broader training concept programme is to produce an environmental awareness which will form the basis for establishing higher priorities in water conservation and quality control throughout the country. Although the benefits of these training programmes are not directly measurable, they will be immediate and far reaching.

XII.6 Recommendations and possible results

The major discharges of wastewaters in Jordan are from municipal and industrial WWTPs, with the largest plants located in the Amman-Zarqa region. The effluents from the As-Samra waste stabilisation pond system and from over 100 wet-type industries in this region constitute by far the largest portion of the total available wastewater flows that require water conservation and quality management. The most immediate priority recommendations for achieving benefits in water conservation and water quality are:

- An improved Ain-Ghazal/As-Samra treatment system.

- Implementation of an industrial waste discharge fee system.

- Implementation of an industrial waste minimisation programme.

- Training programmes in water pollution control and WWTP operation and maintenance.

- Investigation into a small power station using the As-Samra effluent.

Longer-term water conservation and water quality effects will result from the following actions:

- Basin-wide water quantity and quality management through river basin authorities or an environmental protection agency.

• Effective water quality monitoring and compliance.

• Technical assistance to industrial waste dischargers.

• A central toxic and hazardous waste handling and treatment facility.

• Emergency handling and containment facilities for all WWTPs and industrial waste dischargers.

The above recommendations will result in significant water conservation savings, but the greatest effects are expected to be achieved in water quality enhancement. Although the benefits of water quality improvements are difficult to quantify, the effects of the improvements become quantifiable in terms of water available for reuse for a variety of purposes. Thus water quality improvements will have far reaching benefits for overall water use throughout Jordan.

XII.7 References

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