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# THE ROLE OF INDUSTRY IN THE DEVELOPMENT AND CONSERVATION OF WATER RESOURCES IN THE ARAB REGION: CHALLENGES AND PROSPECTS*

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of the United Nations Industrial Development Organization (UNIDO). Mention of firm names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

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## EXECUTIVE SUMMARY

The challenge confronting the Arab region at present is how to maintain economic growth and improve living standards in a manner consistent with conserving the resource base and sustaining environmental amenities. The region which encompasses 250 million people and 21 countries stretching from Iraq in the East to Morocco on the Atlantic Ocean possesses 62 percent of the world oil reserves but has limited water resources.

Economic growth in the past three decades was remarkable; the total gross domestic products in 1993 was US $ 508 billion and the per capita income averaged US $ 2117. Unfortunately, this growth has been accompanied by appreciable depletion of natural resources, particularly water, which may in the long-term affect productive growth, and threaten human well-being.

Extensive petroleum deposits and natural gas reserves have provided opportunities for the oil-reach countries to rapidly expand manufacturing industries, while populated countries are striving to increase agricultural productivity to feed their growing populations. The dramatic rise in water demand for agriculture, industry and human settlements exerts severe pressures on the finite water resources. In addition, major water streams of the region are shared between countries within and outside the region which creates complex riparian issues.

The ever increasing water use is expected to cause a net shortage in the region by the turn of the century, and as the demands continue to climb the deficit will reach 188 percent by 2030. Notwithstanding the urgency of the problem, almost all countries of the region still subsidize water supplies for domestic and industrial uses, and provide it free of charge for irrigation purposes. In addition to aggravating water problems, subsidies encourage wastage of municipal supplies, and cause waterlogging due to over-irrigation of agricultural lands.

Facing this critical situation, the region has no alternative but to improve demand management through promotion of water-saving technologies, proper reallocation among users, and institution of policy reforms to rationalize use and improve water utilization efficiency..

In view of the above considerations, industry may assume a leading role in conserving water in manufacturing processes as well as promoting new technologies to improve water efficiency in agriculture and municipal uses. UNIDO commitment to industrial development implies an intense concern with ecological sustainability. Putting this concern into a perspective, UNIDO has adopted a global strategy of ecological sustainable industrial development ESID to ensure that patterns of industrialization can achieve social benefits for present and future generations without impairing ecological processes.

A United Nations inter-agency strategy for the Arab region should reflect this evolving perception. The strategy should lead to the formulation of a regional action programme that respond to a changing water demand pattern consistent with efficient use for industry, agriculture, and domestic purposes, without outstripping available water resources. Governments should be encouraged to regard water as a unitary resource to be planned and managed in a coherent manner to reflect maximum socio-economic benefit for all stackholders

With such broad-based approach, inter-agency as well as other international and regional activities may be framed to and prioritized within appropriate collaborative plans to assure consistency and effective implementation of projects involving water conservation.

In an attempt to achieve this objective, UNIDO will convene a workshop on " The Role of Industry in the Development and Rational Use of Water Resources in the Arab Region", in Amman, Jordan in October 1995. The workshop will focus on defining the role of industry in developing resources and managing demands, and on delineating the outline of an inter-agency water conservation action programme in cooperation with other concerned national, regional and international entities.

This background paper has been prepared for presentation in the workshop. The paper focuses not only on the role of industry in conserving water resources, but also on its interactions with other development activities.

The paper comprises 7 chapters. An introduction to the scope of the problem is presented in Chapter 1. Chapter 2, briefly reviews major water resources in the region, and describes water demands in various sub-regions. Chapter 3, provides a profile of industrial development in selected Arab countries, assesses practices of end-of-pipe treatment of effluents and containment of hazardous residues, and delineates adverse impacts of industrial pollution on water resources.

Chapter 4, discusses the role of industry in improving water supply and demand management in the region. First, it discusses opportunities for improving supply management through harvesting of rain and stormwater, desalination, , and water reuse in industrial, domestic and agricultural activities. Second, it considers existing constraints and alternatives for improving demand management in these three major sectors with illustrative case studies from the region.

Chapter 5, focuses on contribution of industry to water infrastructure with particular emphasis on the impact of clean technology on minimizing water use and pollution generation, the new technologies and equipment to minimize use of pesticides in crop protection, and innovative technology measures to improve urban potable water systems and rural sanitation. Apart from conserving raw materials and improving process operations, these new technologies can drastically reduce water consumption and diminish release of pollutants in waterways.

Chapter 6 addresses priorities of a strategy on water conservation in the region including strengthening institutional systems, creating markets for equipment and consulting services, and strengthening inter-agency cooperation in the water field.

Chapter 7, deals exclusively with a proposed inter-agency action programme for the development and rational use of water resources in the Arab region. An outline has been presented for the proposed programme of action within the context of national, sub-regional and regional needs and priorities. The proposed programme then, identifies specific activities to be implemented by agencies of the United Nations system, in cooperation with international donors, regional organizations and national institutions.

It is hoped that this paper will stimulate interest to pursue the subject more intensively in the follow-up activities.

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## 1. INTRODUCTION

Management of water resources encompasses two basic activities: (i) ***supply management*** consisting of augmentation of existing resources through location, development and use of new ones, and expansion of non-conventional uses through treatment and reuse of wastewater, desalination, and exploitation of fossil aquifers, and (ii) ***demand management*** involving reallocation and optimization of resources among users, upgrading water utilization efficiency, employing new water conservation technologies, and influencing consumers' behaviour through regulations, financial incentives and public awareness (1).

In the recent past, water management in the Arab region has focused on developing additional supplies by building new dams, reservoirs, and diversion canals to meet the growing demands for water. However, as conventional resources have been fully utilized or rapidly approaching their limits, and as developing non-conventional sources is expensive, a far greater emphasis should be placed on new technologies to improve demand management in countries of the region.

While investments in water efficiency, recycling and conservation cost less per unit of usable water than that provided through conventional water supply projects, rational use of available supplies is still undermined by the pricing policies and water regulations, that encourage inefficiency and waste.

This attitude may soon be reversed as evidence regionwide suggests that water-saving technologies, can help sustain agriculture development where water supplies are diminishing, curb damage to overtaxed water resources, ensure adequate supplies for the expanding industrial activities, and secure extra water sources for the ever increasing population. However, promotion of these technologies must be associated with motivating incentives, which in turn may halt further expansion of inordinately expensive and ecologically-disruptive water supply projects.

Imported water-saving technologies are mostly expensive, and difficult to operate and maintain. Modification of these alien technologies and proper design of equipment to suit local conditions should, therefore, receive utmost priority.

As conceived by UNIDO, ecologically sustainable industrial development ESID is a major instrument for attaining a symbiosis between development and a healthy environment. Within this context ESID may help in promoting development and rational use of water resources, particularly in the Arab region where the impending water crises could be avoided through improved demand management.

In this connection, UNIDO is convening a workshop in October 1995, on the role of industry in developing and rational use of water resources in the Arab region. This paper seeks to identify key issues related to water conservation and to delineate an outline for an action programme to improve demand management in the region.

## 2. WATER RESOURCES IN THE ARAB REGION: AN OUTLOOK BEYOND 2000

### 2.1. Water Resources in the Region

The Arab region possesses considerable oil and gas reserves, however, it has semi-to hyperarid climate and scarce fresh water resources. The burgeoning population, coupled with rapid industrialization and adoption of inappropriate life styles, exert severe pressures on the region's ecosystem and overwhelm its limit' d water resources.

At present, the estimated annual water supplies from renewable sources in the region are 338 billion $m^3$. Of this amount, surface water provides about 80 percent of the supplies, and 13 percent is derived from ground sources. The share of recycled drainage water is 6 percent while desalination of sea water provides about 1 percent of the total water use in the Arab region.

The non-renewable fossil groundwater aquifers have a total reserve of 7,734 billion $m^3$. The combined reserve of the central sub-region of Egypt, Sudan and Libya is 83.2 percent, while the share of the Magreb countries is 12 percent and the Arabian peninsula is 4.6 percent (2).

Groundwater from these fossil sources are inaccessible, as the water comes from depths ranging between 1000-2000 meters and hence requires considerable investment for construction and operation. Due to the high cost of abstraction, fossil water is expected to contribute a minor share of the future water needs of the region. Furthermore, the high dissolved solids content of most aquifers requires desalination or dilution with other fresh water supplies to render these sources fit for potable uses.

In addition to water shortage, the region faces a precarious problem as it shares major water bodies with countries beyond the region. Upstream of the region is Turkey where the Euphrates and Tigris receive 94 percent and 40 percent of their flows, respectively. Both rivers feed downstream water systems of Iraq and Syria. Withdrawal for irrigation represents more than 80 percent of the total abstractions from both basins. Recent construction of large hydroelectric and irrigation projects in Turkey caused significant reduction of the Euphrates flow to both Iraq and Syria. which could result in a deterioration of the situation in the lower reaches of the water systems in the long term.

To the west, the key rivers are Jordan and Yarmouk which flow from Lebanon and Syria. The Upper Jordan discharges its flow into Lake Taberias from which Israel diverts water to its national water carrier. Yarmouk flows between Syria and Jordan for about 40 Kilometers before joining the Jordan river 10 Kilometers downstream of Lake Taberias. Irrigation and municipal return flows from the surrounding settlements contribute to the Jordan river before ultimate discharge in the Dead Sea. These flows are heavily polluted, which together with the large-scale water diversion by Israel out of the basin, are causing sever deterioration of water quality before it reaches the lower Jordan Valley (3).

In the central sub-region, the Nile is the dominant source of water for both Egypt and Sudan. A treaty signed between both countries in 1959, allocated an annual water share of 55.5 billion $m^3$ to Egypt and 18 billion $m^3$ to Sudan. Water withdrawals and distribution of use among countries of the region is given in Table (1).

**Table (1): Water Withdrawal and Use in the Arab Region**

| | Annual Water Withdrawal | | Percent of water used for | |
|---|---|---|---|---|
| | Total billion $m^3$ / year | Percent of available water | Municipal & Industrial | Agriculture |
| ***Algeria*** | 3 | 16 | 26 | 74 |
| ***Egypt*** | 56.4 | 97 | 12 | 88 |
| ***Iraq*** | 42.8 | 43 | 8 | 92 |
| ***Jordan*** | 0.8 | 89 | 35 | 65 |
| ***Lebanon*** | 0.8 | 21 | 15 | 85 |
| ***Libya*** | 2.8 | 374 | 25 | 75 |
| ***Morocco*** | 11 | 37 | 9 | 91 |
| ***Oman*** | 0.4 | 22 | 6 | 94 |
| ***Saudi*** | 2.3 | 106 | 96 | 4 |
| ***Sudan*** | 18 | 14 | 1 | 99 |
| ***Syria*** | 3.3 | 61 | 17 | 83 |
| ***Tunisia*** | 2.3 | 61 | 10 | 90 |
| ***Yemen*** | 3.4 | 136 | 7 | 93 |

Source: World Resources Institute, "World Resources 1994-95"

The rights of downstream users is a legal concept that has been implicitly addressed in several multilateral takes between countries within and beyond the region . Recent contacts between the Nile basin countries indicated a growing interest of the reparian nations in developing a mechanism for integrated management and conservation of this vital water body. However, elsewhere in the region, the conflicting claims of the reparian countries, and the Middle East volatile politics are expected to obstruct achieving equitable solution to existing water disputes in the near future.

## 2.2. Future Water Demands (4).

As water demands continue to increase, it is anticipated that the region as a whole will face net water shortage by the turn of the century. By the year 2030, total water requirement in the Arab region for municipal, industrial and agricultural uses, based on present rate of growth, is expected to reach 640 billion $m^3$, with a staggering deficit of 280 billion $m^3$ (See Figure 1).

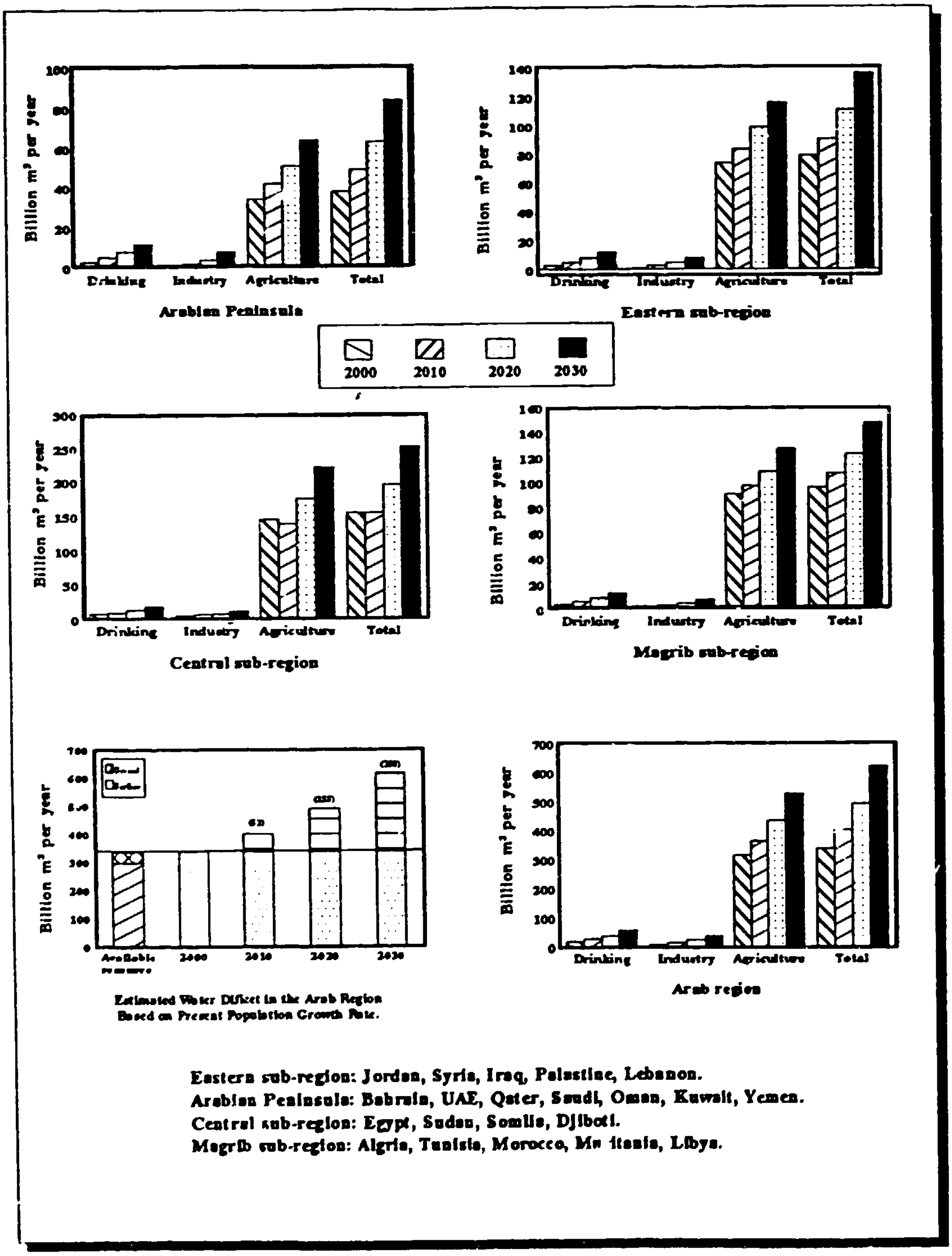


Fig. (1): Projected Water Demand in the Arab Region to the Year 2030.

## 3. IMPACT OF INDUSTRIAL DEVELOPMENT ON WATER RESOURCES IN THE ARAB REGION

### 3.1. Profile of Industrial Development in the Region [5].

In the past, industrial development in the Arab region, suffered from intense polarization as manufacturing facilities tended to concentrate near major streams where water demands and convenient receptacles of process effluents are found. Use of water-intensive technologies were predominant, while pollution prevention regulations were enforced with laxity. Government polices promoted industrial growth with the expectation that gains in material well-being would exceed losses in environmental quality.

As a result of this chaotic development, natural resources and human welfare have been afflicted with severe problems. Industrial emissions have led to deterioration of water streams, impaired agricultural productivity and posed serious public health risks.

In the early 1970's, a strong commitment towards conservation of water in industry started to emerge in the region. At first, industry responded to the mounting environmental concerns by adopting a strategy of pollution control through waste treatment. However, in most instances, the end-of-pipe approach faced serious operational problems, and transferred pollutants from one receiving medium to another. This forced manufactures to look for other viable options to solve their pollution problems.

At present, and in concert with the global transition to cleaner technology, most industries in the region are starting programmes for pollution prevention through optimizing use of material inputs, expanding reuse of waste and secondary products, and conserving water and energy.

New technologies and processes are being installed in some manufacturing facilities in the region for source reduction and recycling, resulting in an extra benefit for the industry which will have new assets at its disposal and an edge in the market. Technology changes in process and equipment range from minor modifications with little associated costs to major changes involving heavy capital investment. Such types of changes usually involve production processes, equipment, layout, piping, automation, or changes in operating conditions. Other changes or improvements involve material substitution, changes in composition of the product, recycling a waste stream back to the process that created it, recycling a waste by using it as a raw material in a different process, and substituting a mechanical process for a chemical one.

The inherent benefits to conservation of water resources in industry stemming from implementing an effective waste minimization strategy are self-evident, because of the reduced amounts of pollutants released directly into water bodies or indirectly through air emission or leaching of polluted soils.

In the Gulf countries, most industries are relatively new and rapidly growing; annual investments are large in relation to existing stocks, and adoption of pollution prevention measures has been easily accommodated in the normal process of expanding or modernizing existing production establishments. On the other hand, low-income countries of the region possess a relatively aging industry, with high proportion of older manufacturing units and limited investment in improving or expanding existing facilities. In these countries, the cost of pollution prevention is usually higher per unit output.

### 3.2. Practices of On-site Wastewater Treatment and Containment of Hazardous Wastes.

The following is a brief review of end-of-pipe treatment practices in selected Arab countries (6):

*Egypt*:: Few facilitates exist for controlling water pollution and air emissions from industrial sources. Wastewater is discharged without adequate treatment to the Nile, lakes, sewers, drains or the Mediterranean. Raw effluents are being discharged directly in the Nile from 20 major industrial locations in Upper Egypt and the Delta. The impact of water pollution is evident from diminishing fish catches from water bodies, deteriorating recreational areas, and the declining quality of water resources. Many industrial establishments generating solid and hazardous wastes are dumping the wastes at random in unauthorized sites or burning the combustible matter in open sites. Total projected industrial wastewater discharge for 1995 is 4,2 billion $m^3$, of which approximately 85 per cent is cooling water used for power generation.

*Jordan:* The urban area of Amman-Zerga which occupies the upper watershed of the Zerga river is densely populated and accommodates several major industries such as phosphate mining and benefaction, soft drinks and alcoholic beverages, tanning, paper, textiles, soap and detergent, and chemical industries. The underlying area is the extensive Wadi Sir aquifer which is still underexpolited but if properly managed, could provide a considerable part of the total water supply. Most industries in the area are currently disposing of their effluents without treatment into adjacent waterways, or by direct land application. Exceptions are the paper mill, phosphate plant, and tannery, which operate earthen wastewater impoundments. Measures are taken by polluting industrial establishments to conform with decrees concerning protection of the Zerga river basin and Wadi Sir aquifer against pollution from municipal and industrial sources.

Major industrial projects are being developed in the Red Sea Port of Aqaba. The Jordan Fertilizer plant produces diammonium phosphate, phosphoric acid and aluminum fluoride. The plant generates about 5,000 ton per year of by-product gypsum, which is stockpiled in the area while process effluents are disposed in the Sea.

*Syria:* Initiatives for industrial development were taken at the beginning of this century, but it was not until the 1950s that the actual industrial development of the country began. Refineries are located in Homs and Baniyas while textiles, fertilizer, soap, glass, cement, food processing, sugar and mechanical industries are concentrated in the major cities (Damascus, Homs, Aleppo and Hama). Industrial development aimed at satisfying domestic demands was, until recently, based on outdated technologies and made no provisions for emission control. As a result, large industrial centres suffered increased environmental impoverishment through air and water pollution.

*Bahrain:* Despite the recent decline in economic growth, the country's industrial base continues to widen along the path of economic diversification necessitated by the depletion of oil reserve. Major industries comprise topping refinery, primary aluminum, oil-associated gas processing, fertilizer, iron palletizing, power and shipping services. Most existing and anticipated developments point to a rapid expansion of energy intensive industries, depending primarily upon the use of natural gas. The largely export-oriented industry is expanding through joint investments with the neighboring Gulf states in steel, petrochemicals and aluminum. Effluents from existing plants are treated on-site before discharge to the Gulf. Several light industries are located in the capital city of Manama; their effluents are directly discharged to the public sewerage for combined treatment in the city sewage treatment plant.

*Saudi Arabia:* To house its new petrochemicals and heavy industries, the kingdom built two new centres, Jubail on the Arabian Gulf and Yanbu approximately 1200 km on the Red Sea. In the planning efforts that went into their construction, environmental protection received a high priority. Environmental design guidelines and an environmental monitoring plan were developed and cover air, water, solid, liquid, hazardous waste, noise and occupation health criteria, standards and practices that apply to design, construction and operation of both complexes.

Major plants of the Jubail Industrial Complex (JIC) are provided with on-site treatment facilities, pre-treated effluents receive final treatment in a conventional activated sludge plant which is followed by rapid sand filtration and ozonation. The estimated flow in 1986 was 60,000 $m^3$ per day, and the ultimate flow in 1999 is estimated at 125,000 $m^3$ per day. Part of the treated effluent will be used for irrigation and the remainder will flow to the Gulf.

The amount of hazardous wastes generated in JIC was about 32,000 ton in 1984 and will reach 341,000 ton in 1996. Hazardous wastes consist mainly of inorganic sludges (brine, oily scales, desalter solids from petrochemicals, steel, copper and sulphur industries), organic liquids (oil skimming, spent monoethanolamine, hydraulic fluids and waste paints) and organic sludges (air flotation sludges, tars, heavy ends and polyethylene benzene). On-site incineration, transport or disposal of hazardous wastes outside the complex are prohibited. A new area in the general landfill of JIC has been set aside for interim storage and final treatment which encompasses incineration, sludge dewatering, and landfilling.

*Kuwait:* Major industries are petroleum-based, with heavy industries being concentrated in the Shuaiba Industrial Area SIA south-east of the capital city. SIA now accommodates 30 industrial plants ( power and desalination, refining, petrochemicals, fertilizer, cement, plastics, paper, canning, asbestos, insulating materials, construction and fabricated steel ). Industries in SIA are equipped with on-site effluent treatment facilities; their discharges to the Gulf are strictly monitored by the Environmental Protection Centre which has an autonomous status. The stringent wastewater discharge standards are enforced to protect the water quality intakes for the nearby desalination plants. Small-scale industries are mainly located in the Shuwaikh and Subhan industrial zones These industries include food processing, chemicals, paper conversion, furniture, metal, and mechanical workshops. Most industries in both zones discharge their raw effluents in the municipal sewage system for combined treatment with domestic wastewater.

*Iraq:* Labour intensive industries are mainly concentrated in Baghdad, in the north (Mousl) and south (Basra) regions. The concentration of major industries in these areas has placed a tremendous burden on water streams and aggravated environmental pollution problems. The impact of industrial pollution is evident in the deteriorated water quality in the vicinity of direct industrial discharges, problems in sewerage and sewage treatment works, and degradation of air quality, especially in areas close to oil refineries and cement plants. The consensus of Government and industry concerning environmental conservation is yet to materialize into concrete actions to alleviate industrial pollution.

*Oman:* The existing industries are mostly located in the capital city of Muscat (power, dairies, grain mill, soft drinks, poultry processing and canning), while new establishments are housed in an industrial centre 40 km west of Muscat. Some small agro-industries and a new cement plant are located in the southern province of Salalah. In general, few or no facilities exist for controlling industrial emissions from small-scale industries, while large-scale state-owned industries are equipped with efficient wastewater treatment facilities.

*Qatar:* Major industries are located in Umm Saied industrial complex (refining, petrochemicals, power, iron and steel, and fertilizer). A large cement plant is located south of Dukhan on the west coast of Qatar. Light industries are located in the capital city of Doha (soft drinks, dairy, poultry, grain mills, workshops, etc.), and their effluents are discharged to the city sewerage network for combined treatment in the Naijah wastewater purification plant. Most industries in Umm Saied have end-of-pipe treatment facilities and the treated effluents are either utilized for landscaping or discharged to the Gulf. At the oil terminal, about 35,000 tons per year of oily sludge is produced and incinerated in an open pit, which creates serious air pollution problems in the area.

*UAE:* Several industrial plants are dispersed in major cites; Abu Dhabi (power, refining, dairies, soft drinks, steel), Dubai ( refining, power, cement, dairies, soft drink), Sharijah (cement, soap, beverage, dairies ), Ras Al-Khaimah ( cement, steel ) and Al-Ain

( power, cement ). In addition, two major industrial complexes exist in the country: in Dubai ( Jebel Ali, which houses aluminum and natural gas plants ) and in Abu Dhabi (Rawaus which houses oil-based industries ). Cement plants in the UAE are generally equipped with efficient electrostatic precipitators for dust recovery. The aluminum plant recovers most of the emitted fluoride for recycling as a catalyst. Most light industries within the major cities pre-treat their effluents before discharge into the municipal system, while refineries, power and aluminum plants discharge their treated effluents directly to the Gulf. At present about 15,000 tons per year oil sludges from the inverted underwater storage vessels are released to the sea.

### 3.3. Effect of Industrial pollution on Water Resources.

The specific responses to a given pollutant depend on its load and the characteristics of the receiving water. Pollutants may cause a toxic action, an aesthetic insult or blanketing effect that hinders photosynthesis and limits the process of self- purification.

Colouring matter may substantially decrease light penetration and hence prevent photosynthetic oxygen production; increased turbidity and bacterial slimes represent aesthetic insults that also cause detrimental effects on water quality.

Industrial effluents containing concentrations of heavy metals and other micro-pollutant either individually or in combination may pose hazard to human health and aquatic organisms. Fish kills are often the result of acute toxicity due to dumping of sludges or accidental release of highly toxic matter. Chronic toxicity due to steady release of low-level toxic pollutants results in changing the entire aquatic population balance through destroying susceptible species and flourishing of the less desirable but more tolerant species; diminishing algal and invertebrate food supply; reproductive potential may be altered as eggs are more susceptible to sub-lethal concentrations of toxicants than are the adults.

Toxic substances also pose detrimental health effects; cyanides are extremely toxic as they inhibit the phosphorylative oxidation reactions which permit cellular respiration. Mercury and its compounds, especially methyl mercury, have been associated with a number of episodes characterized by impaired hearing, vision and muscular coordination, and in some outbreaks, by high mortality; lead, which is considered a global pollutant, can produce a variety of serious effects, including neurological disorders.

Eutrophication due to enrichment of water by nutrients discharged with industrial effluents, notably phosphates and nitrates bearing wastes, may cause accelerated formation of objectionable algal growth.

Many organic materials may be biologically degraded in water streams, thereby causing excessive demands of oxygen. Examples of wastes generated in industrial processes include: urea-formaldehyde used in paint manufacture, and organic wastes from food, paper, textile, yeast and chemical industries. These substances constitute a considerable pollution load on water resources. Similarly, chemical oxygen demand COD as in the case of iron-pickling discharge, would have a de-oxygenating effect on the stream. Oils, by floating on water surface impose a barrier, while detergents interfere with the uptake of atmospheric oxygen in water.

Complete exhaustion of dissolved oxygen in a polluted stream would render the water incapable of supporting fish-life; and in the absence of dissolved oxygen, some of the microorganisms would use the oxygen combined in certain materials such as sulphates, thereby creating malodor and nuisance. Some materials, such as phenols, may produce taste and odour problems in the water, all in addition to a delayed oxygen demand.

In the stream stretches that are anaerobic, the variety of species decreases compared to that in cleaner ones, often to 10 percent or less of the clean-zone number. The relatively few species that dominate in this case include organisms such as the rat-tailed maggot, the sludge worms, blood worms, and the sow bug. All are bottom feeders, adapted to anaerobic conditions.

The depreciation of property for residential uses and recreational development is a tangible resource loss due to gross industrial pollution of water bodies. In addition, in some urban centres of the Arab regi6n stretches of rivers and reaches of lakes have been written off as large open industrial sewers. Pockets of industrial pollution forces dwellers in the adjacent areas to move out which involves additional expenditures to build and run new infrastructure.

Measurable economic losses in such cases can be estimated when they represent direct costs such as loss of materials, cost of treatment, or decreased value of marketable fish. However, intangible costs such as impact on health, loss to tourism and employment, and aesthetic damages are extremely difficult to quantify in monetary terms.

It should be also noted that the value of the water to downstream users can not be undermined; industry as a whole has an interest in protecting the quality of its water inputs as deterioration of water supplies and the added costs of water treatment may represent unbearable economic burden.

**Box (1)**
**Environmental Degradation in Industry-intensive Cities: Case Study of Alexandria, Egypt[7].**

Industrial development in Alexandria Metropolitan Area AMA in Egypt, has grown significantly during the last three decades to benefit from inter-industry linkages and the supporting infrastructure in this prime industrial centre. Whilst industrialization is encouraged to advance economic growth and to improve standards of living in AMA, the rate of change accentuates the impacts on public health and water resources.

Manufacturing industry in AMA accounts for about 40 percent of Egypt's industrial activities. Environmental degradation is manifested in deteriorated water resources, unsightly over-growth of weeds, decreased fish catches and adverse public health conditions. The estimated flow of untreated industrial effluents discharged into the city sewer system, or directly in the sea, drainage canals or Lake Maruit is 1.7 million $m^3$ per day; pollutants include chromium wastes from tanneries, mercury from chloralkali and electronics industries, oil from petroleum and edible oil refining, black liquor from pulp and paper mills, and hazardous chemicals from dyestuffs and textile finishing plants. Solid wastes of various industrial activities amount to about 1.63 million tons per year. Despite successful reclamation schemes for some industrial residues; several recyclable materials are being disposed of incorrectly giving rise to serious environmental problems, in addition to loss of potentially marketable products.

In a drive to overcome unemployment problems, the local government is encouraging development of labour-intensive industries, which generate considerable pollution. At the same time, there is a high growth of small-scale industries due to adoption of policies promoting small enterprises to increase private investment in industry. This sector has proved to be even more problematic in terms of environmental protection.

Hazardous residues from manufacturing industries in AMA are discharged into the air, water and on or into the soil cause severe environmental degradation. The short and long-term effects are far more serious than those caused by municipal wastes. While the latter is more readily biodegradable, most synthesized industrial residues are toxic, persistent, biomagnifiable and tend to accumulate in the receiving environments. The prevailing malnutrition, inferior socio-economic standards and hypersensitivity of city dwellers in AMA lessen the tolerance exposure limits of most toxic substances; a grim fact which adds to the misery of most industrial workers inhabiting the squatter areas around the city.

Problems of hazardous wastes in AMA are compounded by: (a) the vast increase of industrial emissions owing to the steady expansion of existing plants and the establishment of new industries; (b) improper end-of-pipe treatment of liquid wastes and unacceptable disposal practices regarding hazardous residues; (c) difficulties in monitoring industrial emissions owing to the lack of instruments and trained personnel and (d) reluctance on the part of most dischargers to invest money in pollution abatement.

Liquid effluents from industrial sources are theoretically handled through on-site pre-treatment systems before discharge to public sewers. Since more than 75 percent of industrial establishments in AMA are still state-owned, it is difficult to enforce the emission laws due to mounting economic, and political constraints.

## 4. ROLE OF INDUSTRY IN IMPROVING SUPPLY AND DEMAND MANAGEMENT OF WATER RESOURCES IN THE ARAB REGION.

### 4.1. Opportunities for Supply Management of Water Resources in the Arab Region.

#### 4.1.1. Harvesting of rain and storm water.

Water harvesting in the Arab region depends on soil characteristics, rainfall quantity, distribution and intensity as well as the intended water use, and site topography. Water harvesting in farming is essential when additional water is needed to stabilizes and improves yield, particularly in areas where water is a scarce resource and rainfall is erratic. Water harvesting is also useful for regulating the salt balance where wadis could be developed with storage ponds, the stored water is used in this case to control salt build-up.

Harvested water is usually stored in aquifers, reservoirs, or cisterns for deferred use in periods of water shortage. In the Arab region, about one third of the agricultural land is suitable for the development of some type of water harvesting to supplement conventional water supplies.

Integrated systems combine a number of water harvesting techniques. Land alteration techniques ( i.e. desert contour strips and conservation bench terraces ) may be combined with soil treatment and provided with a backup compartmented reservoir in an integrative fashion.

Vegetation management may be incorporated in an integrated system, despite the fact that grass cover is not generally as effective as other methods of inducing runoff. Land alteration is subject to variable yields and crop loss during poor rainfall years. Soil erosion is also a potential danger in land alteration schemes. With regard to soil treatment, cost represents a serious constraint. In a well-designed integrated system, the advantages of one component may offset the constraints of another.

Groundwater recharge is practiced in some areas of the Arab region. However, storage loss from silting, evaporative loss, danger of overtopping, and breaching may render this method unsuitable in the Arab region. Percolation tanks are suitable in undulating terrain where the soil is porous or rocky, so that the water percolates underground through fissures in the rock or soil pores.

Contour terraces and silt traps have been effective in combating erosion and desertification in this region. However, construction of silt traps and floodwater fields depends on the suitability of topographic and hydrologic characteristics of the area under consideration. With the exception of contour terraces, all mentioned water harvesting systems are small-scale, suitable only for serving the needs of individual households or small rural settlements. In drought years neither of these harvesting techniques can be relied upon for steady crop irrigation. Hence, they must be supplemented with other forms of water supply.

An advantage inherent in all harvesting systems, is that they can be constructed and extended in an incremental fashion so that efforts and investments can be conveniently spread over long time periods. Overall, water harvesting technologies which rely on local resources, material and labour should receive priority over imported technologies and complex machinery. The following are pilot demonstrations proposed to improve harvesting efficiency, conserve soil and augment agricultural yield (8):

- Suitable and inexpensive materials for roofing and ground catchments for domestic water supply;
- Endogenous soils and plants in the purification of rainwater through flocculation and settling,
- Appropriate designs for manually operated, simple low cost pumping devices for drawing water from underground rainwater storage containers;
- Dew and mist harvesting as potential source of water supply;
- Minimization of evaporation losses by digging deeper excavations and by using compartmented reservoirs to reduce exposed surface area;
- Optimization of storage capacities of bunded tanks in relation to evaporation, depth, storage and agricultural requirements;
- Use of microcatchments in relation to water needs for plants' growth and their potential yields; and
- Diversion of stormwater for use on farmland ( warping )

#### 4.1.2. Desalination in the Arab region: the expensive alternative

As pressures of the ever increasing water demand are forcing Governments to secure supplies from non-conventional and inevitably expensive sources, arid countries of the region have resorted to desalination to meet the rising water demands.

As early as 1938, Saudi Arabia constructed two condensers for the desalination of sea water, to supply the city of Jeddah with drinking water . Kuwait commissioned the first multi-stage flash distillation MSF unit in 1958. One of the first large scale sea water reverse osmosis RO plants was built in Jeddah in 1977. At present, the largest desalination center in the world is situated in Al Jubail in the Eastern Province of Saudi Arabia, where more than 30 percent of Saudi Arabian desalinated water, and 7.6 percent of the total world capacity is produced. In addition, in this center lies the world's largest desalination facility in operation, consisting of 40 MSF units producing close to one million cubic meters per day. In Yanbu, a huge RO plant is presently under construction.

Out of 15.58 million $m^3$ per day worldwide installed desalination capacity, the Gulf countries contribute almost half of the total. Saudi Arabia alone houses about a quarter of the world desalination capacity. Desalination capacity in the Arab countries are given in Table 2.

**Table (2): Desalination Capacity in the Arab Region**

| COUNTRY | TOTAL CAPACITY $m^3$ per day |
|---|---|
| *Algeria* | 204,312 |
| *Bahrain* | 315,197 |
| *Djibouti* | 404 |
| *Egypt* | 87,044 |
| *Iraq* | 333,093 |
| *Jordan* | 8,445 |
| *Kuwait* | 1,523,210 |
| *Libya* | 677,750 |
| *Morocco* | 15,325 |
| *Mauritania* | 4,654 |
| *Oman* | 162,096 |
| *Qatar* | 562,074 |
| *Saudi Arabia* | 5,020,324 |
| *Somalia* | 408 |
| *Sudan* | 1,776 |
| *Syria* | 7,703 |
| *Tunisia* | 50,914 |
| *United Arab Emirates* | 2,081,091 |
| *Yemen* | 37,188 |

Source: IDA Desalting Plants Inventory, Wangnick Consulting, 1994

The primary aim of desalination is to reduce the concentration of total dissolved solids TDS. Fresh water typically contains less than 1,000 mg/l TDS, while most drinking water standards prescribe a maximum of 500 mg/l. Critical industrial applications require low TDS levels; boiler feed water in particular, should not contain more than 5 mg/l TDS.

Sea water typically has 33,000 mg/l TDS, while brackish water usually contains 1000 to 3,000 mg/l TDS. Desalination technologies are mostly based on distillation, membranes, and ion exchange. All distillation plants operate on the principle that vapours boiled off or evaporated from dilate water are salt-free and that purified water can be produced by condensing these vapours. The distillation technologies are therefore, energy-intensive.

The following describes the salient features of major desalination technologies used in the Arab region [9]:

- Multi-stage flash distillation MSF, is the most common evaporative process used in the region. It is applicable to sea water with very high salt content, and can yield a final product with as little as 25 mg/l TDS. MSF, typically achieves cost-effectiveness when used to process more than approximately 1,000 $m^3$/day.

- Multi-effect distillation MED, is a highly efficient evaporative process which typically yields a high-purity water of about 20 mg/l TDS In MED, evaporation occurs on a heat exchange surface made either of horizontal or vertical tubes; therefore, the two process variants are termed horizontal tube evaporation HTE and vertical tube evaporation VTE, respectively.

- Vapour compression VC, is a new technology which still undergoing development. VC differs greatly from the two processes discussed above because it is a single-stage compact system and the least energy-consumptive of all the evaporative processes. The process is used only in smaller operations because it is economically favoured at nominal capacities of less than 4000 $m^3$/day. Its operating temperatures are quite low, 55 $^oC$ to 70 $^oC$. Thus, the primary energy is not heat, but the electricity needed to operate the compressor. The low operating temperature also minimizes scaling and corrosion, and pretreatment for scale prevention usually consists solely of polyphosphate addition.

- Reverse Osmoses RO was developed in the late 1960s, primarily to desalt brackish water. The initial testing and development for sea water desalination began in the mid-1970s. Today, it is the second most widely used desalination process, behind only MSF in global installed capacity.

- Electrodialysis ED technology, consists of alternating anion and cation exchange membranes with the feed water flowing between them. Direct current voltage is applied so that the anions one stream and concentrates another. Membrane fouling is a recurrent problem that can only be solved by stopping the process and flushing the membranes with cleaning chemicals.

- Electrodialysis reversal EDR operates on the principle of periodically reversing the direction of the DC field. When the reversal occurs, automatic valves interchange the concentrated and dilute streams to permit self-cleansing as films and scale are carried away with waste when the flow is reversed.

- Ion exchange occurs when ions in solution are exchanged for other ions on a solid surface. Water to be desalinated, is passed through a bed of ion exchange synthetic resins. There are both anionic resins with exchangeable anion and cationic resins with exchangeable cations. In desalination, both an anionic and a cationic resin would generally be used.

- Hybrid systems involve a combinations of processes to meet the particular needs of an individual situation. Increasing attention is being paid to hybrids of RO and distillation. Very high recoveries have been shown to be possible using a hybrid system incorporating RO and VC distillation . The actual process train included pellet softening for the removal of calcium and RO operating at 90 percent recovery, followed by distillation of the RO brine using VC. The RO/VC combination is promising for remote areas or for small communities since process may be the way for distillation to compete with membrane processes in single-purpose.

The type of desalination technique appropriate for a given situation depends largely on the raw water and the desired product TDS levels. The distillation-based processes can be used to achieve very high-purity water, whereas the membrane-based processes can achieve TDS levels in the range of several hundred mg/1. Other comparison factors include:

- Energy requirements for distillation processes are substantial because of the change of state of water. The energy is mostly supplied in this region by the combustion of fossil fuels as the cost of such fuels is relatively low. Alternatively, desalination may be combined with the generation of electricity in such a way that lower-temperature. i.e., partly expanded, steam is used to drive the distillation process.

- Cost is a major factor in selecting desalination technologies . In the early 1980s, the economic situation was such that membrane processes were favoured over distillation for the treatment of brackish water and for sea water desalination for small-scale operations and for sites where energy costs were high. Today, even for large-scale sea water applications, the membrane-based technologies have become competitive. The major reason for the increased competitiveness of RO is a reduction in the costs associated with it resulting from operation at higher pressures, increased energy recovery, and decreased chemical and membrane replacement costs.

### 4.1.3. Water reuse in the Arab region: the untapped resource

To overcome water shortage in the region , efforts are being directed to development of additional sources through recycling of used water. Several Arab countries, most notably Egypt and the Gulf states, have integrated water reuse into their national water schemes with emphasis on recycling industrial cooling water, reuse of treated municipal wastewater for irrigation purposes, and partial mixing of irrigation drainage water with fresh water resources. Other alternatives will receive attention as the cost of water continues to rise, and wastewater treatment techniques become more economically viable.

Efficient wastewater treatment not only protects the quality of water resources, but sets the stage for water recycling and reuse. By using water several times, its productive use can be increased, thereby lessening the need to develop new water supplies.

## A. Water recycling in industry

Despite its great potential, water recycling in the regions' manufacturing industry has barely been tapped. As processing wastewaters must be treated to an acceptable quality to meet environmental regulations, recycling treated effluents within an industrial plant becomes in most instances, more economical than paying the high surcharges imposed on polluted effluents. In the future, pollution control standards will be more stringent, which offer more opportunity for on-site reclamation and recycling.

In deciding how much to recycle, the industry has to compare the costs of getting water and treating it prior to disposal with those of treating wastewater for reuse within the plant. In most instances, recycling offsets its costs by recovering valuable materials, such as nickel and chrome from plating operations, silver from photographic processing, and fiber from paper-making. As water and wastewater treatment costs rise, recycling will become more attractive.

In the water-scarce Arab countries, expansion of in-plant water recycling have been motivated by the shortage of adequate water supplies, rising costs of municipal water, and enforcement of stringent industrial effluent discharge standards. In some instances, where water shortage is acute, the industry has resorted to use of effluents from wastewater treatment plants for non-contact processes. This trend, has received acceptance, particularly when the treated effluent water quality is meeting industry specifications. To promote reuse in such cases, the regulatory agencies in some Arab cities are initiating credit scheme to permit industry to deduct the mass loading of pollutants in the received reclaimed water from their total discharge waste loading.

While there are a range of industrial water uses, most manufacturing facilities in the region, are still limiting water reuse to closed-system cooling make-up, wash down operations, site irrigation, fire protection, and dust control.. The following are the salient features of quality requirements of reclaimed water in the manufacturing industry.

[ I ] **Cooling Water.** Cooling tower make-up water represents a significant water use for industries such as power generation, oil refining, chemicals and metal manufacturing. In these industries, one-quarter to more than one-half of a facility's water use may be cooling tower make-up. Because a cooling tower normally operates as a closed-loop system isolated from the process, it is commonly regarded as a separate water system with its own specific quality requirements which are largely independent of the process water requirements.

The buildup of impurities such as calcium, magnesium, sodium, chlorine, phosphate, and organics in a cooling system is controlled by bleeding of a portion of the cooling water and replenishment by make-up reclaimed water. If the concentration of impurities are too high, scale deposits will form on heat-exchanger surfaces. This lowers the heat transfer capacity of the equipment and eventually requires shutdown and cleaning.

While scaling is the most prevalent problem in cooling systems, excessive impurity concentrations may cause accelerated corrosion, sliming, or plugging problems from accumulated suspended matter. Chemical additives are used in cooling water systems to control scale, slime, and corrosion. The chemical additives needed depend on the character of the make-up water. Chemical additives have definite limitations and cannot eliminate the need for blowdown.

**[ II ] Process Water**[10]. Quality requirements for water used in industrial processes are highly dependent on the particular industry involved. Even within a single industry, process water quality requirements vary form plant to plant depending on the particular products involved. For this reason, it is not possible to generalize on the quality requirements for industrial process water.

Water quality requirements for paper and allied products are quite variable, depending on the process involved and the desired quality of the finished product. Generally, it is desirable to minimize suspended solids in the water since they may adversely affect both the colour and brightness of the product. Other constituents that must be controlled, include Silica, Aluminum, hardness ( to prevent corrosion or scaling of process equipment), and microorganisms to avoid slime growths, and paper staining.

Water quality requirements in the chemical industry vary according to the nature of the process and the type of products. In general, water which is moderately soft and relatively low in silica, suspended solids and colour is required. The TDS and chloride content of the water is not too critical.

Water quality requirements for petroleum and coal products are moderate. The process water should be in the pH range of 6 to 9 and be fairly low in suspended solids. However, many constituents, such as $SiO_2$, Sodium, Potassium, and bicarbonates, are acceptable as received and will not cause processing difficulties.

Non-staining water is mandatory in most textile mill operations. Hence, the water should be as free as possible of turbidity, colour, Iron, and Manganese Hardness can adversely affect the soaps used in various operations. Hardness may also increase the breakage of silk during reeling and throwing operations, as well as cause the deposit of curds on the textiles. Nitrites and nitrates may cause problems in wool and silk dyeing.

## B. Municipal water reuse

Reusing municipal supplies can reduce demands for high-quality water. Most cities in the Arab region have opted for centralized sewer systems that collect household and industrial wastewater for combined treatment followed by discharge via an extensive piping system to the sea, a bay, or a nearby rivc. Treatment progresses in stages, starting with physical processes that remove solids, followed by biological methods that reduce organic matter, and then by chemical treatment for further upgrading. The level of treatment given usually depends on the intended reuse or the quality requirements of the receiving water body.

While reclamation projects the Arab region, particularly in the Gulf countries, make use of highly sophisticated treatment technologies. Yet these methods are not necessarily the most desirable approach to water reuse. The physical, biological, and chemical treatments that are being used to purify water are replicating what can be achieved in the natural environment. Many soils are excellent filters, straining from water unwanted particles and contaminants. Micro-organisms in the soil's upper layers thrive by decomposing organic matter, performing the biological treatment given sewage at most modern facilities.

In Egypt, where virtually no freshwater supplies remain untapped, all new demands will be met by primary treating and reusing wastewater. Reclaimed water will replace by time more of the fresh water currently used in agriculture, releasing high-quality supplies for growing cities and industries.

The Gulf states have ambitious plans for full utilization of treated municipal wastewater. However, at present the total volume of reused wastewater is about 25 percent of the available treated wastewater or 10 percent of the estimated volume of municipal wastewater generated in this sub-region. The reclaimed wastewater is used for irrigation of non-cash crops, landscape irrigation, and for industrial cooling. The volume of water reuse by country is given in Table 3.

**Table (3): Volume of Wastewater Reuse in the Gulf Countries [11].**

| Country | Annual volume (million $m^3$) |
|---|---|
| *Saudi Arabia* | 217 |
| *Kuwait* | 83 |
| *UAE* | 62 |
| *Bahrain* | 32 |
| *Qatar* | 23 |
| *Oman* | 10 |
| Total | 427 |

An obstacle to expanding municipal wastewater reuse in the low-income countries of the region, is the high investment needed for building wastewater treatment plants, extending networks of the existing sewerage, and constructing new ones for distribution of the treated effluent. The future growth of wastewater reuse in these countries depends on the development of inexpensive schemes for effluent treatment and reuse to serve the needs of particular communities. Such schemes have proved their success in the industrial estates of Saudi Arabia and the new cities of Egypt. It is also important for the Governments of the region to employ regulatory instruments and economic incentive to encourage major water consumers to install facilities for on-site treatment and recycling of their generated wastewaters.

Factors affecting the quality of the reclaimed municipal wastewater include: type of treatment system, quality of raw wastewater, and the intended uses of the reclaimed water. Residential use of water typically adds about 300 mg/l of dissolved inorganic solids, 5 to 7 mg/l of phosphorus, and both dissolved and suspended organic material.

In addition to the obvious quantity considerations, the more important parameters that impact on the viability of using domestic wastewater as a reuse source are the organic constituents in the wastewater; and its microbiological characteristics. Chemical clarification and addition of chlorine, ozone, or potassium permanganate can effectively remove some organics in wastewaters and can reduce viruses by five orders of magnitude.

Although health regulations allow use of properly treated wastewater for irrigation of food crops, the cost of such water is not always competitive with other subsidized irrigation water in most countries of the region.. At present, the bulk of reclaimed water used is for irrigation of fodder, fiber, and seed crops where health concerns are minimum and where lower levels of water quality are adequate [12].

Graywater generated from domestic uses is an important source, which deserves special attention due to its diverse reuse opportunities. The reuse of graywater has proven effective in certain circumstances for the minimization of demand placed on water resources and the imposition of treatment requirements where a water supply of high purity is not necessary. Graywater is generally available for a variety of non-consumptive domestic and industrial purposes However, the cost-effectiveness of such applications involves the requisite installation of dual distribution piping networks, which would frequently parallel potable water supply systems. In order to become a viable option, capital and operating costs must be evaluated, along with the overall volume of water to be saved and reused.

Sources and uses of graywater vary as greatly as the potential application allows. For example, sink and shower wastewaters from households may be used to flush toilets or for irrigation purposes. Rinse waters in commercial/institutional laundry facilities may be applied in countercurrent system where final rinse water is used as sources for initial washing in the cleaning sequence. Graywater may be also used for material transport in the mining industry.

Direct potable reuse which involves the incorporation of reclaimed water into a potable water supply system, is prohibited due to its potential health risks. However, indirect potable reuse through planned discharging of reclaimed wastewaters into a fresh water body ( aquifer, impoundment, or receiving stream ) is practiced throughout the region.

Indirect potable reuse is acceptable practice as the time lag and physical separation of the wastewater discharge from its subsequent beneficial use allows the wastewater effluent to receive natural treatment through stream self-purification. Examples of this natural treatment include reducing microorganism populations by natural die-off, and the loss of volatile organic compounds by surface evaporation. For some persistent constituents, however, they tend to accumulate in water and sediments [12].

### C. Reuse of irrigation drainage water

In order to assess the suitability of using drainage returnflow in agriculture, several factors related to water quality and its effect on soil, crops and public health must be carefully considered. The basic concerns are: salinity accumulation and the subsequent effect on land productivity, effect of drainage water on soil permeability, nutrients, and the potential water toxicity to plants and consumers of agriculture produce. Information on long-term health and environmental effects due to intensive reuse of irrigation returnflow in some locations in the region is limited and unreliable.

At present, land constraint in the region is exacerbated by rapid urban encroachment into farm land and by falling productivity due to waterlogging. Since extensive land reclamation projects are presently underway in desert areas of the region, use of irrigation returnflow in various mixes with fresh water, would enable further expansion of these land reclamation projects.

**Box (2)**
**Environmental Concerns of Sinai Agricultural Development Project (13)**

El Salam Canal in Egypt involves mixing Nile water with irrigation return flow in a 1:1 ratio to provide water for 595,000 fadden of the reclaimed land. The first phase of the project which constituted construction of the canal over a distance of 86.4 km west of Suez Canal and multiple mixing points from Serw and Baher Hadous drains is being used to feed 195,000 fadden south of Port Said City. The second phase involves construction of a siphon crossing Suez Canal and a net work of water distribution east of Suez canal to feed The North Sinai Agricultural Development Project NSADP ( 400,000 fadden ).

Recent studies indicate that the decreased drainage water flow at present, will only support NSADP irrigation in winter , while the shortage during May/July period will not be enough for irrigation of summer crops. The decreased flow of drainage water is attributed to: (i) increased efficiency of Nile water use and the subsequent decrease in tail-end losses, (ii) improved hydraulic operations of the Nile for navigation which results in further decrease of tail-end losses, and (iii) alternative water use for the new land reclamation schemes in the eastern and western fringes of the Delta which reduces return flow to El Salam canal .

In addition, monitoring studies confirmed the increase of salinity in the canal water to 950 mg/l, which is significantly higher than the calculated equilibrium level of 780 mg/l. This increase in salinity coupled with water shortage will reduce crop production in NSADP. The canal is expected to have other negative impacts including, diminishing flow of Nile water into Lake Manzala, increased seepage of contaminated groundwater in Lake Bardawil, and increased health hazards to the local population in Sinai..

## 4.2. Improving Demand Management of Water Resources.

### 4.2.1. Perspective on demand management of water in industry

### A. Constraints of management of water and waste in industry

A formidable problem facing the mature but aging industries in most countries of the region, is to allocate significant investments for modernization of exiting facilities or their replacement with newer ones. This move, is at present coming up against numerous technological, social and financial difficulties, and cannot be expected to gain a large momentum soon.

In this regard, some Governments are still inclined to extend protection to the state-owned industries while not being able to provide sufficient resources for retrofitting their out-dated facilities, or adding new cleaner technologies. Moreover, it has proven difficult to adopt measures to improve productivity and reduce water in public enterprises, particularly if they affect employment or cause drastic changes in the traditional management practices.

However, it is expected that the new drive towards free-market economy in the region will soon dictate careful husbandry and utilization of natural resources, reduction of manufacturing wastes, and recycling of water and energy. As economic considerations influence industrial decisions, the proper solution in one country may not be necessarily suitable in another country, particularly in this region which constitutes diverse countries with the highest and lowest incomes in the world.

Unfortunately, little consistent information is available in the region regarding management of water and waste in industry and their cost-effectiveness. This is attributed to: (i) absence of reliable data-base on production technologies used in manufacturing industries, (ii) lack of unified procedures for assessing intangible benefits when comparing various technology alternatives; and (iii) the dynamic nature of costs as new technologies are continuously developed to improve production processes and to enhance environmental-compatibility of products.

In a drive to boost private investment in industry, Governments are providing unrestricted access to water, and offering hefty subsides to raw materials and energy. Such policies encourage resources wastage and apathy towards polluting technologies. In the few instances, where subsides are lifted or when manufacturers are charged the actual water and energy costs, the industry promptly responded by introducing measures to reduce consumption of water and other production inputs through adoption of cleaner technologies or by improving production efficiency.

## B. Impacts of water-saving technologies and process changes on water conservation in industry.

Introducing water-saving technologies in existing large industrial establishments often requires process modifications with little return on investment In addition, these technologies mostly involve imported machinery. Unfortunately, countries of the region (with the exception of the oil-producers), suffer from cash-shortage and overvalued exchange rate. This, rendered securing foreign exchange to finance modern imported technologies a difficult task.

While large investments may be required for retrofitting aging industry or for acquiring imported machinery, this does not necessarily imply that conserving water in manufacturing industry is always costly. Amble evidence demonstrates that remarkable reductions in water use can be achieved by no-cost measures such as changing workers attitude towards housekeeping, maintaining effective operational controls, and introducing minor modifications to maximize use of feed stocks and to enable recycling of process waters. Such profitable management options are liable, in most instances, to immediate implementation without causing negative effects on the productivity and product quality.

To strengthen existing management system for industrial pollution control, the following actions should be considered: (i) improving management and operational capabilities for in-plant waste minimization and on-site emissions' treatment; (ii) where appropriate, centralized waste treatment facilities must be installed to reduce investments and to improve efficiency, and (iii) monitoring of waste emissions, and adequate enforcement of pollution control legislation.

Effective implementation of these actions, requires the establishment of an environmental protection unit (similar to that in Kuwait and Saudi Arabia), in major industrial areas. The proposed unit may be entrusted with the following responsibilities: (i) development of master policies to promote the quality of the environment through implementation of interim and long-range plans for water saving and abatement of industrial pollution; (ii) supervising and financing research and monitoring programme for pollution control; (iii) reviewing and assessing major industrial activities within the scope of national guidelines for environmental protection and (d) proposing remedies for existing deficiencies in the waste management system and implementing practical schemes for handling hazardous residues [14].

**Box (3)**

**Experience of Water-saving in the Oil-based Industries in the Gulf States [15]**

Oil refining and downstream industries have expanded rapidly in the Gulf states during the past two decades. At the same time, there has been a strong tendency towards integration of production facilities and introduction of low-water technologies. This trend was dictated by the increasing water scarcity in this sub-region, and the economic pressures to improve cost-effectiveness of all sectors of the oil industry. The growing public demand to reduce pollution emanating from oil processing has also promoted the industry to invest heavily in retrofitting older production facilities to improve water efficiency and minimize generation of polluted effluents.

The oil industry has to cope with another unique problem in the Gulf region, as advanced and costly wastewater treatment is mandated before discharge to the sea in order to maintain proper quality of water intakes to the desalination plants. This and the rising desalination costs, has shifted emphasis from end-of-pipe treatment to preventive solutions involving reducing water consumption and minimizing wastewater generation to the maximum practical extent.

At present, most refineries in the Gulf employ total recirculating systems for cooling applications and multiple-reuse of process water; this reduced water intakes to makeup for process and evaporation losses, and discharges to blow-downs.

Other water-saving technology measures which have been adopted as standard practice include replacing barometric condensers with surface ones; increasing the efficiency of drying, sweetening and finishing processes to minimize generation of spent caustic, acids, and clays; installation of sour water strippers to reduce the sulphide, ammonia, and phenolic concentrations and recycling of stripped condensate to the desalter.

### 4.2.2. Demand Management in domestic water supplies.

#### A. Constraints of potable water supply and sanitation in the region (16)

In the Arab region, water supply and sanitation are affected by socio-economic constraints, such as poor planning of public utilities, haphazard growth of urban settlements, the prevailing drought conditions, and adoption of alien water and sanitation technologies unfit for the region. This often results in over design of treatment systems and locking up of scarce capital in construction of treatment works while limiting investment in distribution networks. The majority of peoples living in fringe settlements do not benefit from these expensive systems as they cannot afford the connection cost.

In most Arab cities, water supply and sanitation programmes are managed and operated by public authorities. A number of factors encourage the establishment of public monopolies for these essential community services. Firstly, most piped water supply systems are not big enough to accommodate more than one producer. Secondly, the drinking water and sanitation services are social goods which benefit the health and well-being of the community. Lastly, the provision of these services is traditionally considered the responsibility of the Government for strategic and humanitarian reasons.

However, recently the monopoly of the Governments on water utilities tended to lessen. The success of the private sector in operating water utilities in some governorates in Egypt, and the sewerage system in Kuwait suggests that private companies may be more effective than the public sector in running water supply and sanitation projects. The potentialities of the private sector in operating and maintaining water supply systems may also be explored in rural areas. In few cases, co-operatives have shown promise in operating water supply systems efficiently.

Present constraints which impede provision of adequate water and sanitation services in the region include:

- Management regards projects for water supply and sanitation as engineering endeavors which deal with reservoirs, treatment works, transmission mains, and distribution networks. Investment in these hardware items usually receives priority while investment in software items ( manpower development, environmental management, effectiveness of water transport and usage, and water conservation ), do not receive similar attention. In many Arab cities water and sanitation authorities, tend to favour investment in new structural facilities to the detriment of operation, maintenance and monitoring of the existing ones. At the same time, excessive reliance on financial support from the central government has limited the role of local administration and discouraged private investment in water supply and sanitation projects.

- In water-scarce areas, the use of high quality water for down-graded purposes should be discouraged. Such improper practices reduce water supplies to low-income areas where people are not provided with safe and adequate potable water. The way to overcome this is to provide facilities which do not require flushing or to use low-quality water for flushing or watering lawns. Otherwise, high tariffs should be charged to households and institutions which use excessive amounts of the drinking water in non-potable uses. This may generate additional funds which can be used to extend distribution networks to the unserviced areas.

- In most Arab cities and towns, excessive amount of loss in distribution networks exist. Very often 30 to 50 per cent of water supplied in urban areas cannot be accounted for. Typically, half of the water loss may be attributed to improper metering; the other half is attributed to physical leaks in the distribution system and in house connection. In addition, the virtual independence of householders and absence of agencies' supervision in the construction and use of internal plumbing systems, contribute to exorbitant wastage of water in the house connections.

- While metering is necessary to reduce municipal uses, the consumption of water tends to be lower in areas where people are poorer and do not have water-using appliances or do not have adequate means of disposing of wastewater. Under such circumstances, savings from metering would not be substantial. Evidence in the region supports this argument as costs of metering in some areas or for some categories of consumers may be significantly greater than the benefits derived from metering the water used by these consumers.

- In view of the strict family traditions and religious beliefs in the Arab region, it is unlikely that water and sanitation projects can succeed unless they are acceptable to the local communities. It is also important to recognize the scattered nature of water and sanitation projects in countries like Sudan and Yemen which are often located in remote or inaccessible areas. The operation and maintenance of these dominantly rural systems can not be provided by central agencies without active participation of the local communities.

- While water supply projects are expanding in rural areas, the maintenance of these facilities has been badly neglected. This is due to lack of adequate funds for maintenance, and because of lack of suitable machinery for their maintenance. In view of budgetary constraints on funding of rural water supply projects, the investment spent for provision of such vital services should not wasted due to improper operation and maintenance practices.

### B. Improving demand management for municipal water supplies.

The provision of water supply and sanitation services in Arab cities requires a judicious balance of technological, organizational and managerial measures. Programmes should be designed according to the economic and technical capabilities of various localities. Over designed projects and restrictions on coverage of low-income areas should be foregone, while low-cost, multiple-user technologies must be pursued.

Operational function of water and sanitation services and technical capabilities should be upgraded through appropriate monitoring, rehabilitation and special training. Adequate operation, maintenance and rehabilitation will reduce investment needs. However, if the services are to achieve acceptable levels of financial soundness and self-reliance, tariffs should be based as much as possible on marginal pricing; however, allowance for social concerns must be accounted for by using binomial tariff structures.

Losses through the distribution system can be substantially reduced by rigorously enforcing standards for facilities, equipment and domestic fittings. Better detection of physical leaks in the distribution systems are essential for the efficient functioning of water supply systems.

Oman, is a case in point. Muscat, which relies heavily on costly desalination for provision of municipal water, is using new techniques and equipment for leak detection which led to substantial savings in the water supply system. The leak detection equipment includes pressure transducers and level transducers linked to electronic data loggers, insertion flowmeters, metallic and non-metallic pipe locators and portable leak noise correlator (17).

A recent study in Egypt (18) indicated that metering contributes to substantial reductions in the quantity of potable water used. However, two supplementary policies are needed to realize the full economic benefits of metering: (i) metering must be introduced in conjunction with discriminatory pricing policy, so that wastage of water is penalized, and (ii) universal metering reveals the inefficiencies of the water system by exposing the discrepancies between the quantity of water going into the supply and that actually received at the consumer's end. Leak detection in such cases, should be implemented.

In remote rural areas, where supply of spare parts is difficult, long-lasting pumps, though more expensive, should be used. Standard designs based on local materials and technology should be prescribed, and whenever possible local manufacturing of equipment for rural water supply should be encouraged. In the design, there should also be alternative arrangements for voltage fluctuations and possible supply outages in electricity.

While extending coverage in rural settlements, adequate measures should be undertaken to encourage water conservation. These include: (i) inspection of physical leaks in the distribution system and stern dealing with vandalism; (ii) illegal connections should be detected and severed; and (iii) standards for plumbing in the houses should be prescribed .

### 4.2..3. Demand management in agriculture.

### A. Implications of agricultural practices on water resources.

Poor management of irrigation water is attributed to seepage from unlined irrigation canals, and excessive watering of fields. This causes groundwater levels to rise which eventually water log the root zone of soils. In dry climates, water near the surface evaporates, leaving soils laden with a damaging layer of salts. Presently, water logging and salinization cause sterilization of sizable areas of cropland in the Arab region.

Pervasive depletion and overuse of water supplies, the high capita cost of new large irrigation schemes, rising pumping costs, and worsening ecological damage necessitate a shift in the way water is valued, used, and managed in agriculture. If food production is to keep pace with expanding food needs, attention must turn to increasing water *productivity* in agriculture. Sustaining economic growth and supplying growing water demand will require, reusing, and conserving water to get more production out of existing supplies.

So far, however, little attention has been paid to the efficiency with which irrigation systems operate. Much water is lost as it is conveyed from reservoirs to farmlands, distributed among farmers, and applied to fields. The overall efficiency of irrigation systems is estimated to average only 30 percent in the Arab region. Some of this "lost" water returns to a stream or aquifer where it can be tapped again, provided the necessary infrastructure is available. But much is rendered unproductive or becomes severely degraded in quality as it picks up salts, pesticides, and toxic elements from the land [19].

While 90 percent or more of the water supplied to industries and homes is available for reuse, return flows from agriculture are often only half the initial withdrawal. The rest is consumed through evaporation and transpiration, which depletes the local water supply. Though water can be saved only by reducing consumption, reducing withdrawals-whether they are consumed or not, can make a given reservoir or aquifer supply last longer or serve a larger area.

The gravity irrigation system is still widely used in the Arab region as they are inexpensive and simple to operate. However, these systems are the least efficient. Farmers typically apply an excessive amount of water to ensure that enough reaches plants situated on higher ground. This results in more water use than actual crop needs while the excess percolates out of the root zone or runs off through the drainage system.

Because of these problems, many gravity systems used in the region are less than 50 percent efficient; yet a number of practices can greatly improve their performance. The most appropriate is leveling the land so that water gets distributed more evenly. Precise leveling can drastically reduce water needs, besides alleviating waterlogging, curbing erosion, and raising crop yields. However, leveling is still done with traditional equipment such as tractors or soil scrapers.

As an alternative, modern irrigation technologies are gaining interest in the region. However, expansion of these water-efficient technologies is being hampered by: (i) low financial returns for the farmers as accessing export markets is hampered by inadequacy of agricultural marketing systems, (ii) the ineffective interface between public irrigation distribution systems and on-farm irrigation systems for large scale irrigation schemes; (iii) inappropriatence of some applied on-farm irrigation technologies to the prevailing sociocultural conditions n the Arab villages, and (iv) lack of support services for selection, design and training in the operation and maintenance of the systems. Modern on-farm irrigation technologies require a reliable water supply at the farm-turnout, and micro-irrigation requires an almost continuous water supply.

The excessive use of agrochemicals, a phenomenal problem in the Arab region, significantly contributes to diffuse contamination of soil, and water bodies. The use of manure and fertilizers lead to emission of phosphate, potassium and nitrate into groundwater and surface waters.

However, under the prevailing water stress conditions in the region, fertilizer application and plant density should be reduced in order to prevent unwanted vegetative growth, which consume all available water before flowering. When fertilizer application is not adapted to water availability, excessive fertilizer remains in the soil, increasing the nutrient leaching potential.

Pesticides pollute water bodies by three route, movement it the vapour phase, surface runoff, and leaching. Vapour phase movement can lead to transport via spray drift during application or through volatilization from plant surface, soil, or water. While the major impact is likely to be phototoxicity to nearby crops, vapour phase movement followed by redeposition has been implicated as a cause of contamination of water bodies. However, atmospheric dilution and degradation processes attenuate the impact of such residues.

Surface runoff and leaching appear to be more significant processes for water contamination. Factors that increase the potential for runoff loss include: (i)steep slopes, (ii) surface application, (iii) use of wettable powder formulation, (iv) intense rainfall, (v) crop and surface litter coverage, (vi) pesticide water solubility and (vii) soil adsorption characteristics.

**B. Improving demand management in irrigation.**

Strategies which may reduce the risk of surface or groundwater contamination by pesticides involve multiple approaches including new formulation to reduce pesticide leaching, developing new pesticides with reduced mobility and persistence, improving techniques of pesticide application ( See Section 5.3. ), and production of selective pesticides with reduced non-target organism toxicity.

It is important, however, to recognize that the feasibility, of these approaches to improve water quality are sometimes site-specific. From the standpoint of sustainable agriculture, pest-control strategies should balance both objectives of maximizing cost effectiveness and minimizing environmental risks. Weed control by mechanical means as being practiced in countries like Egypt where the labour supply is abundant, may be inefficient in other countries which experience labour shortage..

Non-conventional approaches for pest control have emerged in the region recently. While these approaches are essential to ensure environmental compatibly of agricultural development in the long term, it is anticipated that agrochemicals will continue to play an important role in the future, but to a lesser degree with the development of biologically intensive pest control systems that place emphasis on host plant resistance biotechnology, biological control, and cultural manipulation.

At present, few Arab countries are conducting field experiments using biological controls for crop protection. However, as biological controls are used along with pest resistant cultivators, the impact of these new methods should be carefully considered in light of existing or potential natural enemies. In this connection, weeds present a particular problem owing to the diversity of species that simultaneously compete with crops. Biological control agents, whether they be insects, nematodes or microbial weed pathogens, are highly specific to individual weed species.

To ameliorate possible negative impacts of biological controls, a fuller understanding of their environmental interactions, nutrient cycles, and management systems geared toward optimizing use of water resources, is a prerequisite for a wider application of these controls. Commercial farms in some Gulf countries, are using less pesticides, fertilizers, and antibiotics per unit of production than comparable conventional farms. Reduced use of these inputs lowers production costs and lessens agriculture's potential for adverse impacts on water and other natural resources without necessarily decreasing per acre crop yields.

Turning to the vital issue of water conservation in agriculture, farmers can reduce irrigation losses by capturing and recycling water that would otherwise run off the field. This has been successfully achieved in large farming areas by constructing a pond to collect and store the runoff, and installing pumps to return the water to the head of the field.

To ensure wide application of water-saving techniques in this water-scarce region, the selected technologies must be affordable and appropriate for local farming conditions. A case in point, is the use of pitcher irrigation which incorporates properties somewhat akin to drip systems. Vegetable or fruit seeds are planted around a baked earthen pitcher buried in the soil. Farmers fill the pitcher with water, which then gradually seeps through the porous walls into the root zone. As with drip systems, evaporation and water losses remain very low. The locally manufactured pitchers offer an inexpensive, efficient and simple water-delivery method.

Among modern irrigation technologies, micro-irrigation has a potential to conserve 50 percent of water on the farm compared to surface irrigation. The potential yield increases per unit of water are often two to three-fold. However, the technology's suitability for small farming units depends on the local terrain, the socio-economic environment, and potential marketability of profitable crops which may in turn encourage investments in new water-saving technologies.

The share of micro-irrigation in selected Arab countries is given in Table 4 [20].

**Table (4): Modern Irrigation Technologies Areas in the Arab Region**

| Country | Total irrigated | Sprinkler and/or micro-irrigation | |
|---|---|---|---|
| | ('000 ha) | ('000 ha) | Percent |
| *Algeria* | 400 | NA | NA |
| *Egypt* | 2.920 | 680 | 23 |
| *Iraq* | 4.750 | NA | NA |
| *Jordan* | 50 | 43 | 86 |
| *Morocco* | 853 | 135 | 16 |
| *Oman* | 40 | NA | NA |
| *Saudi* | 420 | NA | NA |
| *Syria* | 700 | NA | NA |
| *Tunisia* | 394 | 45 | 11 |
| *Yemen* | 495 | NA | NA |

Periodic monitoring of soil moisture results in appreciable water saving as irrigation only takes place just before crops would become stressed due to lack of water. In this regard, many cheap devices are available to measure soil moisture, of which gypsum blocks are probably the least costly and simplest to use. When buried in the root zone, the blocks acquire a moisture content roughly equal to that of the surrounding soil. Electrodes embedded inside them are connected to a meter that measures electrical conductivity. The wetter the gypsum block, the wetter the soil; this can indicate to the farmer when to stop irrigation.

In sum, improved water demand management often increases crop yields, reduces soil erosion, and decreases waterlogging. Encouraging more widespread adoption of the above mentioned water-saving methods would help sustain irrigation agriculture where water supplies are diminishing, and curb soil damage due to over-irrigation.

**Box (4)**

**Experience and Constraints of Modern Irrigation Technologies in the Arab Region** [22].

Drip irrigation was introduced in the region since 1960's. In **Jordan**, farmers in the Jordan Valley was encouraged to employ drip irrigation through a loan from an NGO. The hardware components include: (i) small, earth-built water reservoirs with capacities of 1,000 to 5,000 $m^3$ to permit continuous flow for the drip systems; (ii) modular portable drip systems that did not require investments in land; (iii) peripheral components, including pumps, fertilizer application units, filtration system, fittings, and valves; and (iv) plastic sheets for mulching, farm machinery, and agrochemicals. Within seven years, yields increased three to four times, water use declined from 12,000 to 6,000 $m^3$ per hectare and the area under irrigation doubled.

In **Morocco**, an impact evaluation on the Doukkala Irrigation Projects revealed that field application efficiencies provided with sprinkler equipment on the farm, were only marginally higher than for the gravity systems ( 67 percent compared with 58 percent). The performance of the sprinkler systems was low and equipment maintenance was poor.. The sprinkler system designs did not fit ownership pattern since farm sizes had decreased considerably through inheritance. Individual plots had become long and narrow, therefore, irrigation overlapped from sprinklers in adjacent plots. These problems could be corrected by rearranging the plots, adopting more appropriate sprinkler technology (including part-circle sprinklers), stricter controls, imposing sanctions for vandalism, and better field services for maintenance and repair.

In **Tunisia**, several sprinkler irrigation schemes have been implemented, however, some schemes suffer from low uniformities in water applications. Sprinkler equipment has surpassed its technical and economic life. Often, the equipment is not replaced because farmers perceive the costs to be too high because farmers have problems with access to agricultural credit. Problems have also been experienced with drip irrigation. For example, uniform specifications were adopted for a 2,000 hectare scheme in Cap Bon, but performance was poor because soil conditions were not uniform. Other deficiencies include omission of filters, the lack of pressure control, and inappropriate capacity in the emitters. These problems could be avoided with quality control during design and installation.

In Egypt, about 68,000 hectares were under micro-irrigation in 1986. However, almost 20 percent of the systems had been abandoned because of maintenance problems, clogging, insufficient pressures and power failures. Although the "new lands" cover about 25 percent of the total irrigated area, their contribution to total agricultural production is only 7 percent. Many problems have been observed in the new lands located east and west of the Nile Delta:. These include: poorly planned and designed irrigation systems with insufficient in-system storage and inadequate water control; poorly constructed and maintained booster pumping stations with frequent breakdowns and unreliable power supplies; and inadequate quality control in the design and installation of the on-farm equipment..

Precision land leveling has been introduced in Egypt in the early 1970's but proved to be difficult due to year-round cropping. Alternative meska (water course) improvements were also made; an unlined, low-level meska was transformed and farmers pumped individually into a lined saqia above field-level served by one communal pumping station. However, such a system had several disadvantages; (i) the switch from on-demand system to a rotational system, resulted in management problems; (ii) a considerable loss of night storage capacity occurred; and (iii) difficulties in maintenance of the pumping stations, which were owned by groups of farmers [21].

In another field experiment in Egypt, a distribution system in a public groundwater scheme with individual wells irrigating about 50 to 100 hectares, has been installed in the Western Desert and has proved to be operationally efficient and less costly. The well water is pumped into an elevated tank, which provides working pressure and is equipped with sensors to automatically regulate the pumped water. A looped, buried system of PVC pipes provided with hydrants distributes the water to individual farms.

## 5. CONTRIBUTION OF INDUSTRY TO WATER INFRASTRUCTURE AND DEVELOPMENT OF INNOVATIVE TECHNOLOGIES TO IMPROVE WATER EFFICIENCY AND REDUCE POLLUTION.

### 5.1. Clean Technology and water conservation in Industry(21).

Considerations of water conservation, economic efficiency and environmental protection in industry warrant the adoption, as far as possible, of a preventive strategy. Waste treatment technologies, commonly transfer pollutants from one environmental medium to another and consume resources out of proportion to the accrued benefits. Moreover, conventional controls only deal with the problem of first-generation pollution, which is created in the manufacturing process and regulated by legislation, while ignoring the problem of second-generation pollution emanating from waste treatment such as sludge handling or containment of concentrated hazardous effluents. Therefore, clean technology CT which comprises both preventive and resources conserving measures is usually preferable to corrective measures from both economic and environmental perspectives.

Few major industrial facilities in the region have either initiated or already implemented a broad range of reuse, beneficial recycling, energy conservation and waste recovery measures within a comprehensive programme on pollution prevention. Further expansion of CT activities in all industrial sectors depends to a large extent on proper identification of economically feasible approaches liable to implementation in manufacturing industries, especially those modifications incorporating alternative technologies that exhibit significant recycling of process water, reclamation, energy recovery, or revenue generating potentials.

Process alteration represents the most prominent component of a CT programme. The diaphragm process which has been widely employed in the region for producing chlorine and caustic soda, generates considerably less waste than the alternative mercury cell process. Unfortunately, switching to this low-waste technology requires large capital investment, The chloralkali plant in Alexandria will invest over US $ 180 million to replace existing mercury cells with the diaphragm system.

Inefficient chemical reactions in manufacturing processes represent the major source of increased waste generation. Improving the efficiency of the process through modification of catalysts, reactor design, and operating parameters has been shown to reduce significantly the quantity of waste generated. For example, in the production of acrylonitrile by the catalytic ammoxidation of propylene, switching from an antimony-uranium catalyst to a ferrobismuth phosphomoylbdate catalyst has boosted the conversion of acrylonitrile by 35 percent. Modification of equipment is another way to reduce waste generation. The invention of mechanical wipers to scrape the sides of paint tanks, for example, reduces the exposed volume of waste paint that would otherwise produce fugitive volatile organic compounds VOC's emissions.

Similarly, process automation, which helps optimize product yields by automatically adjusting process parameters, has in many cases minimized operator error, reduced the likelihood of spills, and discouraged the production of off-specification materials. These off-specification materials can be highly toxic, albeit, their generation in small amounts.

In addition to water-saving potentials of these CT options, water conservation can also result in significant waste reduction. An example, is the efficient product washing in the canning industry, which results in reduced sludge generation by minimizing the amount of product lost to the wash water and the quantity of wastewater that is generated.

Technology modification and development of low-waste production systems is currently a central focus of CT activities in the industry-intensive countries of the region. Generally these changes are most cost-effective when implemented during a plant's planning or design period or when a plant is retooling and replacing worn out equipment. Retrofitting plants that have already been in operation is often expensive but are usually inevitable to achieve enhancement of environmental quality ( the Jeddah cement plant in Saudi Arabia has ceased operation as cost of retooling was higher than constructing a new plant ). Substation of less toxic solvents, such as petroleum solvents for more toxic solvents such as perchloroethylene or trichloroethylene, generates a spent solvent waste that is less toxic. These environmentally-friendly solvents have been recently introduced in modern commercial printing facilities in Egypt and Saudi Arabia.

Good operating and housekeeping practices present no-cost opportunities for significant reduction in waste generation. Improving existing practices involve the alteration of conventional procedural, organizational or institutional aspects of a manufacturing process The goal is to limit unnecessary generation of waste attributable to human intervention. Employee training, inventory control, waste stream segregation, improvements in materials handling, spill and leak prevention, and preventive maintenance are all examples of good operating practices. Others include the scheduling of batch operations to limit the frequency of equipment cleaning and, consequently, waste generation; the segregation of hazardous wastes from non- hazardous wastes to minimize the volume of contaminated wastes; and the reduction of overspray and runoff from spraying by the paint booth operator during paint application.

Despite its obvious advantages, CT has not reached the desired level in the Arab region due to lack of research and development, inadequacy of information on opportunities for waste minimization and their costs and benefits, and lack of innovative policy measures for implementation. Neither the pollution control policies, legislation and administrative structures, presently prevailing in the region are conductive to waste minimization. Effective implementation of CT will require informational, legal, economic and institutional measures that are substantially different from those currently in effect.

Box (5)

## Cleaner Technology in the Arab Region: Selected Examples[22]

**Integrating Cleaner Production in the Industrial Estates of Saudi Arabia**

Saudi Arabia was aware of the need to relocate industrial activities away from residential neighborhoods to avoid adverse health and environmental impacts of the generated wastes and to enable better industrial environmental management of manufacturing establishments.

Due to the intense competition among investors to benefit from the incentives offered by these industrial estates, the Government is basing selection among manufacturing activities on the extent of employing cleaner technologies in their processes; and most importantly, the degree to which plants can conserve water through recycling or internal multiple-reuse systems.

Innovative approaches to conserve water have been successfully employed in the Saudi industrial estates. Effluents from the individual plants are subjected to on-site preliminary treatment to remove any deleterious constituents; a periodic external monitoring has ensured compatibility for biochemical treatment in a centralized facility as violators are promptly disconnected from the central wastewater collection network. The centralized treatment serves two important purposes: (a) eliminating environmental risks associated with discharge of polluted industrial effluents, and (b) enabling reuse of the treated water in developing green areas within the industrial estates and providing a valuable source of secondary water for down-graded industrial uses. Since desalinated water is extremely expensive, most industries are striving to get their share of the recycled free-of-charge water for use in operations which do not require high quality process water.

**Cooperation Among Industry, Government and International Donors to Adopt Cleaner Technology : The Egyptian Model**

The Miser Chemical Industries MCI chloralkali plant in Alexandria, is Egypt's primary source of caustic soda and chlorine. The plant was built in the 1950's and comprises two mercury-amalgam electrolysis units. The release to the sea of about 12 ton mercury per year with the process effluents (7.5 mg/l compared to a maximum allowable limit of 0.05 mg/l) has caused serious human and environmental risks. As a result of over 40 years of operation, mercury contamination has reached alarming levels with hot-spots around the distillation/recovery unit, all over the cell houses, in soil and wastewater trenches with levels 10 to 100 folds higher than the maximum allowable mercury levels.

MCI has launched, in cooperation with international donors, a major pollution prevention programme comprising two undertakings: the mercury decontamination and demolition of the existing electrolysis facilities, to be implemented in conjunction with construction on the existing premises of new electrolysis units using mercury-free membrane technology. MCI has been recently privatized and will share the cost of shifting to the cleaner production diaphragm process with the German Bank KfW.

Desilication of RAKTA black liquor would allow recovery and reuse of over 10,000 ton per year caustic soda and elimination of a major source of pollution to the sea. The IE/UNEP is leading an international effort to solicit financial assistance of about US $ 40 million to build a full-scale Desilication facility. An extensive cleaner production plan is presently underway to shift to save-all system for white water, replacing chlorine with oxygen bleaching, and recycling water in straw washing. These self-financed efforts, will eventually lead to 10 fold reduction in water consumption, significant recovery of lost fibers, and reduction of a chronic industrial pollution problem in Egypt.

## 5.2. New Technology Approaches for Potable Water Supplies and Sanitation.

Unfortunately, most water treatment plants in the region are designed for provision of safe drinking water only when raw intakes are of reasonably good quality. When raw water quality deteriorates, the corresponding quality of drinking water may become unacceptable due to presence of high concentrations of dissolved inorganics which pass through water treatment units with a low level of removal, and accumulation of hazardous micropollutants as a result of chlorine reaction with soluble organic pollutants.

The following are proposed measures to upgrade water treatment technologies in the region (23):

- Better treatment can be achieved through optimization of the existing operations. Rigorous clarification of the water with a maximum reduction of suspended solids can be attained, by proper settlement and slower filtration. However, a noticeable deterioration in water quality occurs, because of the practice of increasing the throughput of the plant by accelerating process flow rates at the expense of treatment time; this in turn reduces pollutants' removal.

- Specific pollutants may be removed, to some extent, together with suspended matter; the chemical reagents used as either coagulants or flocculents in this step play a critical role. Numerous new products are being marketed, but for some of these (such as synthetic organic polymers) there are doubts about their biological properties and their heath effects. Other newer coagulants, which appear more appropriate, include polyhalogenated aluminum compounds and other mineral complexes.

- Provision of additional stages of treatment by powdered activated carbon PAC has been already considered in some water treatment works in the region; the current candidate is Borg El-Arab treatment plant in Egypt The PAC has an extremely high surface area to volume ratio giving a powerful adsorptive capacity and resulting in the rapid removal of micropollutants especially non-polar ones such as aromatics and saturated aliphatic. Inorganic substances by contrast, are poorly removed. If used after chlorination, the PAC may be quickly saturated by organochlorines and their efficiency reduced. Carbon adsorption should be used at the final stage of treatment to eliminate residual organic compounds just before disinfection. The systems known as "biological filtration on carbon" is will proven and very effective technique which should be considered in cases where raw intakes are substantially deteriorated.

- Use of alternative chemicals available in the market, requires thorough experimentation in order to determine: the efficiency and reliability of the chemical in full-scale operation; its cost-effectiveness; and, the potential health or nuisance effects. Modern technology has enabled a great number of new adsorbents, and coagulant aids. Many of these adsorbents can be made chemically specific, such as the scavenging resins or, they can be specific through biological effects.

- Re-location of water abstraction points. This is becoming a viable alternative in some locations in the region, most notably in Alexandria Egypt, where abstraction points for potable water are situated in urban and suburban areas which dispose of various domestic, institutional and industrial effluents in closeby waterways. A necessary measure is to move the abstraction points upstream of the polluted water sources in the urbanized zones. For this to be fully effective, several conditions must be satisfied: (i) the displacement should be sufficient so that it need not be repeated within a few years; (ii) the catchment upstream of the new abstraction site must be protected against polluted discharges from industry and municipalities); and (iii) raw water transported must be sufficiently pure. Transporting untreated water over long distances may sometimes lead to side effects such as deposits of mud and proliferation of microbial contaminants.

- Chlorine is used library in most water treatment plants in the region, as a method to control pollution of water intakes. This practice results in early formation of organochlorines which cannot be easily removed later, and should therefore, be replaced by safer pre-treatment alternatives. A rational solution is to have sufficient clarification of the raw water at the upstream abstraction point together with a final treatment at the water plant, which can be much simpler.

- Pre-ozonation in conjunction with existing post-chlorination should be given due consideration. Optimum application should be carefully controlled in order not to interfere with other operations. A light application can also replace post-chlorination, and could be usefully associated with filtration on activated granulated carbon. The light application of a "remnant" bacteriostatic agent" (chlorine dioxide, chloramine chlorine) is essential in this case to protect the distribution network.

- On-line sensor inputs for monitoring water quality parameters such as pH, dissolved oxygen DO, and specific ions (i.e. $NH_4^+$, $NO_3^-$, ... etc. ) are expected to develop in importance as the feedback potential of the advanced process controllers is expanded. Current on-line applications of these latter sensor mechanisms still encounter problems in reliability and maintenance, particularly in the harsh industrial and water environments of the Arab region. Despite these problems, the rationale of water quality conservation fostered through such monitoring devices should be promoted in the region.

- Recent technology advances have significantly extended the scope for ion exchange techniques including development of new (synthetic or natural) materials, easily regenerated and highly selective for obnoxious ions such as ammonia, and nitrates. Ion exchange also seems promising for removing organics and may become complementary to activated carbon adsorption. However, the comparatively high cost of these techniques may be a limiting factor in the foreseeable future.

- The control of wastes from water treatment plants should be given due consideration. Most plants in the region dispose of their sludges back in same water source, but at locations downstream of their intakes. Logic dictates that reclamation of the wasted chemicals, or at least sludge drying and landfilling, should be employed to eliminate further pollution of potable water resources. Reclamation of waste chemicals should be based on techno-economic studies, and whenever feasible must be promoted in new and old water treatment plants.

Appropriate household water conservation measures should be easily managed by their users, result in appreciable water conservation, encourage individual responsiveness, and consider local cultures and traditions. Technologies designed to suit householders can be maintained and operated in a sustainable manner. The relative advantage of a new technology may depend upon a reduction of capital cost, operations and maintenance costs, or both.

A variety of locally produced household fixtures, can greatly reduce domestic water uses. Substituting these water-saving fixtures for conventional models can achieve substantial reduction in water use. The extremely low-water-using fixtures may reduce existing levels by as much as 50-70 percent. Since conserving water indoors also translates into reduced sewage flows, plans to expand wastewater treatment facilities can be delayed or scaled down in size, again reducing investment needs. Saving water also saves energy since less water needs to be pumped through the urban system-from source, to treatment plant, to homes, and finally to the wastewater plant.

Many intermediate technologies for urban sanitation range from the simple pit latrine to the water-borne piped sewage system. Ventilated and lined pit latrines, toilets that use less water for flushing, multi-house septic tanks, and waste stabilization ponds combined with systems for reusing treated wastewater are all being in operation in demonstration projects in the region. Egypt, Yemen, and Jordan are also implementing low-cost urban sanitation programmes; some are aided by bilateral and multilateral lending agencies. Such projects can greatly contribute to adoption of new and affordable technologies for sanitation services.

Equipment and processes for conservation of potable water in rural areas must be simple to operate with nominal operator interaction, either for routine performance control or system maintenance. Advanced control techniques are, therefore, unnecessary and undesirable. Superior performance represents a minor consideration in this case, as compared to basic ability to consistently operate with minimum supervision. Such technology is presently available in the Arab markets, however, its effective adaptation to conditions in the region may require further efforts. Specific information regarding process design, equipment selection, control measures and operating methods should be developed based on field testing in the region. Size limitations should also be explored to determine whether the small-scale rural system has any characteristic limiting design factors [(26)].

A case in point, is the package rural water and wastewater treatment units, which have been installed in some villages in Egypt. Most of these units were originally provided with electro-mechanical control mechanisms unfamiliar to the operators in rural areas;

these control instruments were rendered inoperable because of lack of proper maintenance. The manufacturers of water and wastewater treatment units intended for use in rural areas, must therefore, provide a simplistic and reliable control mechanism which has a low demand for maintenance and/or operator interaction.

Alternative systems for sanitation in rural communities which involve use of waterless or low-water toilet facilities should be promoted and adapted to the local customs; new designs based on field research may be developed to ensure adequacy and acceptability of such systems in the rural areas of the region. Such systems include: recycling oil flush where oil is separated from sewage by flotation and filtered before recycling, composting, and in-situ chemically treated and recycled flushing water.

### 5.3. Impact of New Agricultural Technologies on Reduction of Pollution of Water Resources(25).

Despite the growing contribution of alternative pest and vector control measures, chemicals will continue to play a significant role for a considerable time to come, particularly when immediate effects are needed in case of emergency situations. Efforts, therefore, should aim to ensure that pesticides are applied in the most judicious manner, using appropriate equipment. Manufacturers need to develop equipment made of materials that are less subject to corrosion, with less need for sophisticated maintenance, and that can be readily adapted for community use in rural areas.

New equipment, with improved atomization and spray deposition characteristics, is needed to increase the efficacy of ultra low volume ULV applications, and reduce energy requirements. Agricultural spray equipment that uses electrostatic forces to deliver droplets of uniform size is already commercially available in the region. Such equipment should be developed further to determine its potential for ground and aerial use programmes of pest control.

The following are some suggested design modifications to improve applications of chemicals for crop protection and environmental control in rural areas, which would also reduce their pollution of air and water resources:

- Development of effective rotary atomizer installed on lightweight equipment suitable for use by farmers in a safe and convenient way. Electronic sensor control of application equipment, should also be designed to minimize the impact on off-target organisms and to reduce pollution of the receiving water bodies, air and soil.

- Advanced and safer systems for pesticide mixing and loading to reduce worker exposure should be emphasized. This requires development of small hand-operated compression sprayers constructed of lightweight, high-strength plastic materials. Although these sprayers may not be as durable as the stainless-steel sprayers in current use, their initial cost and depreciation would be less.

- Portable hand-carried, shoulder-slung, or wheel-mounted aerosol generators are widely use in the region; though efforts should be directed to development of more efficient and quieter equipment than existing ones. The development of engines with reduced noise and less harmful exhaust emissions is necessary; one possibility might be to use an electric motor powered by rechargeable batteries, for convenience in use and to avoid pollution of homes.

- Plastic nozzle tips have been tested in some pesticide applications but their performance was poor, with a decrease in discharge rate and increase in the swath width. Insecticide deposits around the edges of the tip orifice commonly caused blockage of the nozzles. As improvements in engineering plastics continues to take place, testing should continue to evaluate nozzle tips made of new materials that are resistant to chemicals.

- Abrasive particles present in water commonly result in accelerated erosion of the orifice which cause distortion of the spray pattern and an excessive increase in the discharge rate. Due to increasing costs of pesticides, and growing environmental concerns, research is needed to determine the performance of different nozzle tips to achieve maximum spraying efficiency. New designs should be based on economic considerations that relate the cost of nozzle tip replacement to the cost of pesticide that might be wasted with an increased flow rate.

- Motorized knapsack mist blowers, powered by a small two-stroke internal combustion engine, producing a high velocity airstrip are widely used in mosquito control in the Arab region. These are the only portable equipment that can project spray into the eaves of houses or thickets around villages where exophilic vectors can occur. When these sprayers are used without full air output, poor atomization of the spray liquid occurs. The resulting droplets are generally far too large to be effective for vector operations, and there is increased fall-out of spray which contaminates both the environment and water streams. Testing the effect of the different nozzle designs used on motorized mist blowers is needed; nozzles designed for ULV application, with fixed restrictors, are better than most presently used in rural areas.

- The taps on most mist blowers not easily operated with one hand, and often leaks after a period of use. Manufacturers are encouraged to fit a trigger valve to allow easier operation and permit intermittent spraying.

- ULV applications, in which the minimum volume of liquid insecticide formulation is applied per unit area, provide maximum effectiveness against target vectors. Most organophosphorus insecticides can be applied as " ready-made non-volatile " formulations, but other insecticides, such as carbamates and pyrethroids, must be formulated with compatible solvents for ULV application. Use of non-volatile formulations in the Arab region should be encouraged as they permit improved control of droplet size and limit pollution of the receiving environments.

## 6. PRIORITY ACTIONS TO CONSERVE WATER IN THE ARAB REGION.

### 6.1. Strengthening Institutional Mechanisms [23].

One major handicap in the Arab region has been the fragmentation of decisions on management of water resources in terms of both geographic boundaries and allocation among various uses. To overcome this problem, a greater control of water resources is needed to restrict irrational use in the longer term. The underlying conditions for effective management include: (a) coordination of activities of public agencies involved; (b) an increased role in decision-making for those most affected by water development (private concerns, NGO's and local communities); (c) enactment of a unified water permit system to enable efficiency in allocation and resolution of use conflicts; and (d) determination of the threshold level of water damage which is unacceptable to society regardless of the short-term benefits which may accrue.

The weakening and erosion of exiting legislation is contributed by several inter-related factors including: (i) dynamic evolution of polluting activities, industry in particular; (ii) increased complexity of developmental activities; (iii) loop-holes and vagueness in regulations which enable violations; (iv) transfer and evasion of pollution via other form or media (discharge of polluted water in drainage canals and its ultimate disposal in fresh waterways); and (v) inflation and monetary erosion which render charges ludicrous.

It is, therefore, recommended to revise and amend the existing national legislation at reasonable periods of time. Permits issued for discharge to water bodies should be also subjected to periodic review to ensure continued compliance with the conditions granted in the initial permits. Fairness and firmness in enforcing regulations should be imposed on all concerns to ensure equity and respect for the law.

Financial sanctions may be used as an effective tool to support enforcement of water quality legislation. The imposition of water taxes, fees and other financial sanctions may constitute a dis-incentive for existing wasteful uses. However, the relevant Government actions ought to be flexible in adapting to the local circumstances and time. A recent trend in some Arab countries to tax pollution emissions of industrial facilities in proportion to their water consumption is a right move in this direction.

Decisions concerning management of water resources are made, in most instances, with imperfect knowledge of the behaviour and characteristics of the water supply systems. Information is essential, particularly for identifying trends of water quality changes due to increased reuse of drainage water and accumulation of pollutants in water bodies; and for assessing the effect of practices of wastewater treatment on the quality of water streams and approaches to remedy existing deficiencies.

Skilled manpower is short in various areas including management and administration of water utilities, operation of industrial and municipal water treatment systems, and monitoring of pollution and water quality. Responding to this problem, it is obvious that personnel rules, salary structures, and promotion potentials are critical aspects of staffing. Of the cases examined in the region, water institutions tied to the civil system structure are less able to recruit the needed professional cadre, compared to the privately managed entities which exercise more freedom in hiring and are usually in better position to offer attractive salary and other employment incentives.

### 6.2. Cost-recovery and Cost-containment of Water Resources.

The high level of non-revenue water, either incurred by delinquency or the substantial non-accounted for losses in the networks, creates chronic deficit between the expenditures and the cash income for water utilities. The ensuing shortage of money limits spending on maintenance and improvements, which in turn affect the continuity and reliability of water supplies.

On the other hand, the region has the highest cost of municipal water production in the world. This is attributed to: (i) heavy reliance on expensive non-conventional water supplies; (ii) absence of adequate auditing of construction and rehabilitation costs; (iii) high operational and maintenance costs; (iv) cost-recovery is hampered by inadequate metering, billing, and collection systems, (v) inefficient management of both expenditure and income due to lack of internal control mechanism; and (vi) low level of tariff and high percentage of non-revenue water.

The recommended measures to improve cost-recovery and cost-containment of water utilities include:

- Project planning, design and construction alternatives should be evaluated and appraised to select effective option at the least cost. To achieve this, proper planning, design criteria, and appraisal guidelines should be developed.

- Cost-effective technologies must be used. The selection of machinery and equipment must be based on the principle of optimum cost benefit, simplicity and effectiveness for treatment of raw waters of particular quality.

- There should be a commercial-type management structure which links authority with responsibility. Utilities should lend themselves to the dynamic situation of the water industry.

- Customers should be encouraged to use water rationally, by instituting stiff tariff to discourage wasteful uses and to bring per capita demand to a reasonable level. Imposing heavy penalties for illegal use and pollution abuse, encouraging reuse of industrial water, and raising community awareness can lead to substantial reduction in municipal water needs, and hence reduce existing financial constraints placed on the water industry.

- Metering should be used to the maximum extent, not only to generate revenue but to discourage waste. Adequate staffing is necessary for reading, repairing, billing, and collection.

- Modern leak detection technologies should be employed. Technicians should be trained on use of new computer recording and analysis systems for continuous leak monitoring.

- An efficient accounting system can produce the necessary information to enable sector managers to take appropriate cost-cutting measures. Costs of materials can be controlled by an efficient purchasing and inventory systems. In addition, quality control may result in substantial savings in cost of water production.

### 6.3. Opportunities for Water-saving Equipment and Consulting Services[26].

Market opportunities in the water field are expected to grow at a rapid pace throughout the region; estimates range from 15 to 20 percent per year to the year 2000. Market growth is attributed to increasing enforcement of restrictive environmental legislation, growing interest in the economic potentials of cleaner technology in industry, and the significant investments in developing municipal infrastructure.

The following represents the scope of marketing pollution control equipment, water quality monitoring instruments, and consulting services:

- Environmental monitoring and testing devices are needed to test air, water and soil. Instruments for testing conventional contaminants and micropollutants in water and soil, are in great demand to monitor constituents harmful to the environment and toxic residues which pose health risks, such as trace metals, pesticides, and toxic organic matter. The majority of testing and monitoring instruments are presently imported. However, the potential exists for local manufacturing of non-sophisticated analytical devices.

- Municipal water and wastewater treatment, including engineering, construction, manufacturing, and operation is an attractive market which is steadily expanding.. The market size in Egypt alone is US $ 375 million per year with a growth rate of 15 percent per year. Foreign competition is stiff, particularly in the oil-producing countries. Countries which procure these facilities through foreign financial assistance programmes are obliged to restrict their purchases to suppliers from the donor' countries. As the region's water and wastewater treatment needs will continue to expand in the foreseeable future, their is a potential for developing sound local manufacturing and marketing capabilities in these fields.

- The need for industrial wastewater treatment equipment in the region is tremendous. The markets of industrial pollution control in most countries are still in their infancy, the potential for developing local manufacturing capability for biological and physico-chemical treatment systems is virtually untapped.. In limited instances, manufacturing under licenses from foreign companies enabled acquiring the necessary technical capabilities for local production of advanced wastewater treatment systems Developing business relation with potential customers early on may provide the necessary investments for the design, manufacturing and operation of treatment systems appropriate to local conditions.

- Consulting services are in great demand in the region. Major services are needed in the fields of environmental audits, devising specialized pollution control programmes, offering professional advise on cleaner technology, and means of incorporating environmental management practices in existing and new industries. Local environmental consulting firms, exist in some countries, but much more will be required in the future. To ensure competitiveness, firms should employ interdisciplinary professional staff with wide-range qualifications including environmental engineering, industrial engineering, environmental chemistry, economists, policy planners and specialists in environmental laws and regulations.

- Waste recycling opportunities in the region are considerable. The market will expand as new technologies are introduced to upgrade the quality of recyclable products and adding new range of marketable goods. Also, more efficient waste collection ( waste newspapers, plastics, glass, textiles, ...etc ), and a growing urban population will increase the demand for recyclable products, and hence the reprocessing equipment. The potential market for large-scale recycling of wastes has spurred some national companies to seek foreign recycling equipment manufacturers to form joint ventures.

### 6.4. Strengthening Cooperation Among International and Regional Organizations Concerned with Conservation of Water Resources.

United Nations inter-agency cooperation for water resources conservation is perceived as responding, *inter alai* to the following objectives:

- Stimulating coordinated, multilateral attacks on problems which cannot be addressed by one country acting alone;

- Enabling adjacent countries to deal effectively and amicably on transboundary and shared water resources problems;

- Assisting countries to solve more rapidly and efficiently problems of a common nature (e.g. waste disposal, depletion of resources through co-operative research, technology transfer and management);

- Sharing the financial and technology burdens when costs of problem-solving exceed the capacity of a single country, or small group of countries; and

- Harmonizing regulatory practices and standards and promoting efficient control of their observance through unified monitoring systems.

The United Nations organizations, and international and regional bodies which provide assistance to countries of the region in the field of water resource include: include:

- **UNIDO** has adopted in 1991 a policy of ecologically sustainable industrial development ESID to protect the biosphere, make the most efficient use of man-made and natural capital, and to promote equity. ESID focuses on introduction of cleaner production processes and strengthening of the domestic technical and scientific capacity for such processes. In this regard, UNIDO endeavors to assist member states in developing techniques for identifying and measuring environmental impacts; design, operate, and monitor cleaner production technologies; preparing guidelines for environmentally sound industrial practices in selected sectors; transferring technology and managerial know-how through establishing demonstration centres for ESID and creation of endogenous research and development capacity; and education, training, and dissemination of relevant information. Many of these activities are planned in cooperation with other organizations of the United Nations system. UNIDO is cooperating with UNEP for establishing National Cleaner Production Centres in some Member States and arrangements are underway to establish more centres in Asia, Africa, and Latin America. UNIDO places special emphasis on developing local capability for manufacturing of equipment related to water development and use, including domestic water supplies, irrigation, mini-hydro plants, industrial water reuse, and end-of-pipe treatment of industrial effluents. Assistance is also provided for development of systems for abatement of industrial pollution; establishment of wastewater monitoring schemes, instituting environmental legislation and emission limitations; and advising on technologies for waste recycling (27).

- **UNEP** activities cover broad assessment of environmental consequences of changes in water quantity and quality. A programme for the Environmental Management of Inland water Resources EMINWR has been launched in 1986 to provide guidelines on sound management of inland water systems, make regular global assessment of the state of inland waters and increase public awareness of the need for environmentally sound water development. Other activities include monitoring of water-related health parameters, rain and storm water harvesting, eutrophication, and provision of support related to the Euphrates and the Nile basins on environmental aspects.

- **WHO** interest in water stems from the fact that water and sanitation have a far-reaching impact on human health. WHO has a mandates for promoting urban and rural sanitation, manpower development, preparing of drinking water guidelines and criteria, procedures of pollution monitoring, and environmental health criteria (International programme on chemical safety, WHO/UNEP/ILO). Through the

Global Environmental Monitoring System (GEMS), WHO has been actively involved in health-related monitoring of environmental quality for almost ten years. The objectives of this project are to: collaborate with countries in the establishment of new water monitor systems and the strengthening of existing ones; improve the validity and comparability of water quality data within and between countries; and assess the incidence and long-term trends of water pollution by conventional contaminants and hazardous substances.

- **UNESCO** focuses on improving capacity of the member states to assess, plan, and manage their water resources through utilization of scientific knowledge concerning the relation of water resources to human activities and the natural environment. The council of the international hydrological decade IHD (WHO/UNESCO/FAO/ and the International Association for Hydrological Sciences IAHS) has carried out extensive studies to: (i) identify and define the hydrological processes and phenomena directly concerned with the means of entry, distribution and self-purification of pollutants in surface and ground water; and (ii) review the known effects of such pollutants on any aspect of these processes and phenomena.

- **The World Bank** has placed major emphasis on assisting countries of the Middle East and North Africa MENA to tackle their water resources problems. But emerging pressures felt more in MENA than other parts of the world, have led the Bank to reconsider the way it approaches water issues. The new water resources management policy approved in 1993, requires a shift in focus from the needs of individual water-using sectors to an integrated management approach. Water is to be explicitly regarded as a key resource for socio-economic development, with emphasis placed on demand management and conserving water quality. The Bank lending for water projects in the MENA region during the period 1960-92 amounted to US $ 23.13 billion. Assessment of the physical impact of land and water projects of the environments has received steadily increasing attention by the Bank.

- **The Economic and Social Commission for Western Asia ESCWA**, plays a key role toward promoting regional cooperation in order to conserve, develop, and use water resources in an economic manner. Appropriate emphasis has been also placed on developing non-conventional water resources, and in setting up institutions for this purpose. The means of implementation include: dissemination of information to and among countries of the region; promotion of technical cooperation; and carrying out field surveys on the availability of water resources and developing guidelines for their efficient use.

- **FAO** is a major water use sector agency with activities in most aspects of water resources development and conservation. Research on irrigation and drainage receive particular attention as well as operational activities related to development of forestry, inland fisheries, and protection against soil erosion in agricultural areas. A special emphasis is placed on impacts of agriculture and agrochemicals on the quality of water resources and development of means of low-water irrigation.

- **ILO** assists Governments to procure fund and get technical assistance for labour-intensive water technologies such as irrigation, water supply, sanitation, flood control, and soil/water conservation projects.

- **UNICEF** promotes low-cost water and sanitation technologies to serve low-income rural and peri-urban communities. Special attention is given to linking sanitation and health education to water supply. Another important aim of the fund is to establish basis for guidelines to strengthen water supply, community motivation, and educational components of primary health care.

- **UNCHS** has several activities related to appropriate water supply and sanitation, and standards and technologies for the upgrading of squatter and rural communities within the context of human settlements development. In the field of building infrastructure technology, the centre has operational activities related to waste disposal, sanitation, and community water supply. .

- **UNDRO** main activities in the field of water are centered on the mobilization and coordination of international relief assistance in case of disasters such as storm surges, floods, landslides, and mudflows. In addition, the office provides technical assistance in disaster preparedness and prevention at the request of the Governments of disaster-prone countries.

- **WMO** is active in areas related to collection, processing, and dissemination of hydrological data. The organization plays a leading role with regard to water-related hazards of meteorological origin such as floods, droughts, and tropical cyclones.

- **UNDP** is promoting sound management of water resources and strengthening co-operation and information exchange in areas related to water resources development. UNDP has a particular interest in analyzing environmental aspects of water resources development in the developing world and in incorporating environmental considerations in the water development planning process.

- **IAEA** is interested in uses related to water resources and atomic energy, and assessment of natural and artificial sources of radioactive contamination of water bodies. The agency has operational activities related to use of radio-isotopes as tracers in hydrology, crop water use, and nuclear desalination, as well as protection of water resources from radioactive pollution.

Environmental components of the following agencies also contribute to the overall efforts for sound management of water resources in the region: Centre for Environment and Development in the Arab Region and Europe (**CEDARE**), International Centre for Agricultural Research in Dry Lands (**ICARDA**), Arab Centre for Semi-arid and Dry Lands (**ACSAD**), Arab League Educational, Cultural and Scientific Organization (**ALECSO**), Arab League Agriculture Development Organization (**ALADO**), Inter-Islamic Network on

Water Resources Development and Management (IINWRDM), World Resources Institute (WRI), World Environment Center (WEC), and Water and Sanitation for Health (WASH).

## 7. A PROPOSED ACTION PROGRAMME FOR DEVELOPMENT AND RATIONAL USE OF WATER RESOURCES IN THE ARAB REGION

### 7.1. Concept and Approaches.

Rapid population growth, and continued industrial and agricultural development exert pressures on both the quality and quantity of water resources in the region. The escalating demand coupled with continued pollution of waterways, has exceeded the carrying capacity of water bodies in most countries of the region, causing imperceptible damages to water quality and emergence of serious human health risks. This may eventually diminish the sustainability of this vital resource base, and render some water bodies unfit for beneficial uses.

The impending water crisis in the region requires development of multi-faceted regional programme to alleviate the impact of development activities on water resources and to identify means for to reconcile the competing demands for water among beneficial uses.

The basic premise of the programme is that sector-specific management interventions should be always planned and developed within the broader context of a multi-sectoral, integrated plans. This is necessary, to ensure that development activities can ultimately have a positive impact on management of water resources.

To achieve this goal, the programme may promote coordination among the concerned institutions to conserve the quality of water resources and to ensure their availability in the long-term. During formulation of the programme, economic and environmental improvement returns, as well as potential impacts of sectoral activities on the sustainability of water resources should be given due consideration. In this regard, activities needed to reverse or control the damage to water supplies must be prioritized.

The development of the action programme may embody numerous structural and non-structural factors. These include among other things, governments' policy regarding allocations among uses, conservation programmes, recycling and reuse polices, water quality standards and enforcement mechanisms, effectiveness of pollution control from point and non-point sources, economic controls, and rights to use among public and private properties. In entirety, the action programme should embrace the following principles:

A. *The action programme should not only emphasize how demand can meet supply, but how countries of the region can achieve this goal in a cost-effective manner with maximum reliance on endogenous capabilities for design, construction and operation of water supply systems. This will enable coping with new and expanded water projects,* *providing expertise for operation and maintenance, and upgrading performance of existing water delivery systems;*

B. *In addition to identifying the necessary physical measures and their costs, the programme of action should account for the need to strengthen organizational, and administrative mechanisms to enable implementing these non-structural activities in harmony with physical structures.*

C. *While the action programme on water conservation is indispensable for achieving sustainable development in the region, it should also account for the special economic, social and political goals of the individual countries. The action programme should, therefore, be flexible to allow for periodic updating to account for changes in regional and national development targets, adjustment of population and investment projections, and alterations in socio-economic conditions.*

Consequently, it is advisable in view of the dynamic changes in the region to develop a long-term water conservation action programme with a time horizon of 30 years (to the year 2025), and to account for new or evolving circumstances, through devising medium-term action programmes for a time horizon of 5 years, possibly in coordination with the set targets and sectoral programmes of the 5-years national development plans of

### 7.2. Incorporating Sub-regional Concerns in the Regional Action Programme.

The prime objective of the action programme at the sub-regional level, is to strengthen the planning and management of water resources in shared water basins. To satisfy this objective, the programme should pay special attention to the following:

- Advocating cooperation in implementing inter-country measures to provide water of suitable quality, including research on innovative technologies to conserve water and reduce the risk of hazardous contaminants;
- Promoting development of appropriate infrastructures to foster joint management of shared water basins and to create business opportunity for material recovery, pollution control equipment, and related environmental services;.
- Improving water monitoring of shared water bodies, with particular emphasis on surveillance of micropollutants in water streams;
- Strengthening information exchange on subjects related to water resources management including successful practices for solving problems of common nature; and
- Ensuring adequate capabilities at the sub-regional levels to respond to emergency situations involving shared water resources.

### 7.3. Promotion of Action at the National Level.

Countries of the Arab region may be encouraged to develop national programmes on water conservation which would take stock of current and prospective issues and constraints, and set out sectoral activities in concert with the scope and activities of the regional action programme. This will nct only enable effective utilization of national resources, but consistency in implementing in-country and sub-regional projects, and coordination of donor support.

To attain this goal, it is recommended to incorporate the following principles in the national water conservation programmes:

- Planning new water-intensive activities must infuse an understanding of the burdened assimilative capacity of water resources. Improper planning and development of projects may result in devastating effects on the quality and sustainability of water bodies. If planning is based on economic and/or strategic considerations without due regard to their negative impacts on waterways, future corrective interventions may be costly and difficult to implement;

- Improving *demand management* of water resources should be given utmost attention in implementing sectoral-activities. Future development, particularly in industry and agriculture, should result in water uses which are both sustainable and geared towards a multiple use strategy. This means that single, exclusive, use of water resources should be discouraged in favour of multiplicity of use to achieve compatibility between conservation objectives and long-term development goals;

- Land and water uses must be jointly planned and managed. Planning should be based on the premise that land, and water resources constitute, from the national policy perspective, an indivisible unit;

- The complexity of the existing water problems and the fragility of resources, particularly groundwater aquifers, require the application of rigorous environmental impact assessment to determine the repercussions of proposed developmental activities on water resources, and to guide the selection of measures to manage and mitigate potential adverse effects;

- Action responsibilities should be gradually decentralized to local enterprises to stimulate community-initiatives and to harmonize, and liberalize management systems;

- Building adequate community capacity is essential to control pollution of water resources and to conserve available supplies. Such capacity includes developing mechanisms for communication, and enhancing public awareness of the problems and their proper solutions;

- Cooperation among public agencies and local communities should also involve private organizations, clienteles, and others that have vested interest in use of water resources; cooperation should not be only limited to soliciting views on specific actions but extended to defining issues and priorities, evaluating alternatives and helping in programme implementation;

- Scientific knowledge and experience regarding appropriate water treatment technologies should be freely shared and disseminated among concerned entities within the country so as to foster upgrading existing technologies and procedures;

- The success of the water conservation action programme will be also contingent upon the establishment of an information system for new developments in conservation technology, monitoring quality of water resources, and development of models for estimating available annual yields from surface and ground reserves;

**Box (6)**

**Guidelines for Developing National Programme on Water Conservation**

- A succinct statement of goals and objectives should be included, with a clear description of how the national programme will meet these goals;
- The programme should cover a rational allocation for water use in industry and should provide the basis for interaction with other water uses;
- The programme should identify alternatives for a specific action, with the disadvantages and advantages of each;
- The programme should specify the implementation resources and how they will be used. It should also embody a proper balance between short-term needs and sufficient flexibility to meet long-term demands. Irrevocable water allocations should be avoid to the extent possible;
- Political, technical, legal and financial constraints should be carefully considered to ensure effective implementation of the proposed actions;
- Public involvement should be secured. The proposed alternative should be subject to discussion among concerned groups throughout the planning process;
- The programme should be sound, comprehensive and functional. It should be based on reliable data, sound technical and economic assessment and procedures that are functional;
- Information should be collected on population projections, geographic distribution, per capita consumption, water quality, cost of water production, tariffs, human resources, development plans of other sectors, organizational structures, rules and regulations, system deficiencies, inter-agency coordination mechanisms, fiscal structure of water utilities, problems of water conservation, water treatment technologies, water delivery and distribution networks, and any other pertinent information Current situation must be analyzed in order to understand systems and their constraints which may influence management of water supplies; problems such as scarcity of personnel, organizational shortcomings, economic and financial constraints, legal and procedural gaps, training needs, and absence or inadequacy of specific information[28];
- Interactions between major water sectors ( industry, municipal, irrigation, navigation, power supply ) and other sectors of production and services must be delineated. Sources of polluting waterways , such as irrigation drainage, industrial and domestic effluents, diffuse pollutants must be identified and if possible quantified to enable assessment of their impacts on potable water-quality and the associated health-risks;
- Goals and targets must be clearly defined, delineating the geographical boundaries and description of the development projects which involve intensive water use, defining scenarios for assessing economic viability of new and expansion projects, determining horizon for the programme of action in intermediate and long-terms;
- Environmental impacts of water development projects must be assessed in general terms, including the anticipated positive and negative impacts on water quality, community health, standards of living, other beneficial uses of water bodies, and development activities. An early recognition of these effects, and consideration of proper mitigation measures, may serve considerable time and effort during programme implementation;
- Estimation of surface and groundwater supplies including projected changes in quality and quantity in the long-term; other potential sources such as desalination of brackish water, rain-water harvesting, recycling of industrial water, and by the improved management and conservation measures in urban and industrial systems;
- Specific projects should be identified, subject to availability of financing and potential constraints, and their priorities assigned within and among the various water use sectors; and
- Programme-support activities such as water research, training, information systems, administrative and organizational procedures, and technical exchange should be identified, as deemed pertinent to the programme activities;

### 7.4. Broad Activities of the Programme of Action.

Broad actions in concert with the basic regional, sub-regional and national requirements stated above, may cover wide-ranging activities, with emphasis on the mutually reinforcing ones. This essentially requires new modalities of cooperation and coordination among the concerned national agencies, regional organizations, international entities, private businesses, and the public. To this end, the programme should have provision for the following activities:

- Providing advice on industry least-cost solutions for development of water resources;

- Providing technical support to the concerned national agencies for conservation and protection of water resources through information exchange on water-saving technologies, and potential reuse of industrial, irrigation and municipal wastewaters;

- Establishing an inter-agency mechanism for implementing joint national programmes that protect water quality and enhance local capabilities for improved management of water resources in the member States;

- Developing procedures for disaster preparedness in industry -intensive localities and training workers on containment of spills involving release of toxic chemicals ; d

- Providing assistance to public and private industries on new cleaner production technologies and on water-saving techniques, and development of guidance for water demand and consumption in various industrial sectors.

- Assisting concerned Government bodies in instituting proper legislation and regulations, backed by proper financial penalties, and instituting enforcement mechanisms to protect and conserve water resources. Technical assistance may be provided for the development of guidance on acceptable levels of water use for various manufacturing industries. New water regulations must be based on scientific knowledge, and embody the principles of practicality, acceptability and affordability. Status and ordinances should delineate responsibilities of the enforcing agencies, basic rights of citizens to have access to dependable and safe water supplies, and proper sanctions on violators;

- Setting up procedure for community participation in water resources management through mobilization of industry workforce and fostering sense of belonging among other citizens groups.

- Providing technical assistance for the implementation of water monitoring programmes in industry in support of law enforcement;

- Establishing guidelines to influence future industrial development through identifying likely problems and proper mitigation measures for pollution control. The environmental impact assessment mechanism may produce such a prospect for sound environmental management in industry;

- Implementing training workshops for waste minimization in industry to prepare specialized cadres for management of cleaner production and water conservation in industry,

- Providing technical assistance for proper management and containment of hazardous waste arising from MSE's, including developing facilities for adequate disposal toxic residues;

- Providing assistance for the development of appropriate technologies for conservation of water in agriculture and municipal uses and commissioning feasibility studies for manufacture and marketing of pollution control equipment, water conservation devices, and environmental monitoring instruments.

### 7.5. Proposed Collaborative Activities of the United Nations Agencies, and International and Regional Organizations.

Collaboration should be pursued to implement joint activities within the framework of the mandate and operational programmes of the United Nations specialized organizations, international bodies, and regional development funds. UNIDO may play a catalytic role in mobilizing inter-agency resources for such an important endeavor. The following are potential activities candidate for implementation through cooperative inter-agency mechanism:

◆ **Appropriate water conservation technology**

- Alternative production methods for effective utilization of water resources without prejudice to the environment ( **UNEP, WHO, FAO, UNCHS** ).

- New clean technologies adaptable to the techno-economic conditions of the Arab region ( **UNIDO, UNEP, ALIDMO, WB** ).

- Innovative approaches for maximum recycling of water, and material inputs in manufacturing processes ( **UNEP, IAEA, UNIDO** ).

- Renewable and non-polluting material inputs in the pollution-intensive industries ( **UNIDO, UNDP, UNESCWA, UNEP, WB** ).

♦ **Abatement of pollution**

- Devising simple, effective package wastewater treatment units for small-scale industries and small communities, that require minimum skills for operation and maintenance [29] ( **UNEP, WHO, ILO, UNCHS, UNIDO** ).

- Developing guidance on handling and containment of hazardous residues (**WHO, UNEP, ILO, CEDARE** ).

- Developing emergency response plans for accidental release of toxic chemicals in industry ( **UNDRO, ILO, WHO, WEC, UNEP** ).

- Assist in design and operation of centralized schemes for wastewater treatment in industrial estates ( **UNEP, WHO, UNIDO** ).

- Assist in establishing simple and reliable methods for internal and external monitoring of pollution including sampling, and field analysis ( **UNEP, ILO, WHO** ).

♦ **Institutional Mechanisms**

- Assist national authorities in devising practicable, enforceable and flexible legislative instruments to control industrial emissions ( **WHO, UNEP, WASH, UNESCO, ALECSO, ILO** ).

- Implement awareness programmes on water-saving for industrial managers and workers ( **ILO, UNESCWA., WHO, UNEP , UNIDO** ).

- Provide advise on appropriate cost recovery schemes suitable for industries with limited financial resources ( **WASH, CEDARE, WEC, UNDP** ).

- Support national efforts for infusing environmental impact assessment in industrial development plans with particular emphasis on measures to mitigate impacts on water resources (**UNEP, WHO, UNESCO, FAO**).

- Develop practical guidance on cost-benefit and cost-effectiveness analyses applicable to local conditions of industry and environment in the Arab region ( **WB, UNEP, UNDP** ).

- Promote strengthening self-reliance and local initiatives to solve pollution problems (**UNICEF, WASH, CEDARE, WHO, FAO**).

♦ **Research on water conservation**

- Provide support to encourage indigenous research capabilities ( **UNESCO, ALECSO, UNEP, WHO** ).

- Assist in local studies on environmental stresses in industry-intensive locations, and urban settlements with emphasis on impact on water resources (**ILO, UNCHS, WHO**)

- Support national surveys on human perceptions and socio-economic implications of industrial polarization in metropolitan centres, and their impact on water resources ( **UNESCO, ALECSO, CEDARE** ).

- Collaborate national research institutions in undertaking long-term studies on total exposure of populations and sensitive subgroups to potentially toxic substances and the effect of water pollution on human health and environmental amenities ( **WHO, UNESCO, ALECSO, UNEP, IAEA** ).

- Development of guidelines for effective auditing of the environmental impacts of existing industries ( **UNEP, WHO, UNIDO, UNESCWA** ).

- Promote field research and demonstrations on low-waste technologies, and methods for cost-effective recovery and recycling of wastes ( **UNEP, WHO, WEC** ).

- Help in establishing national information systems regarding industry and including choice of technology, industrial siting, case studies of innovative treatments, institutional mechanisms, water resources and improved procedures for handling of hazardous wastes (**UNEP, UNIDO, WHO, UNESCO**).

- Devising programmes for technical and financial assistance to help small entrepreneurs to cope with their pollution problems ( **UNDP, WB** ).

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