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MINISTRY OF PUBLIC WORKS AND WATER RESOURCES

STRENGTHENING IRRIGATION MANAGEMENT IN EGYPT:

A PROGRAM FOR THE FUTURE

NON -AGRICULTURAL COST RECOVERY

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ACRONYMS

CIDA	Canadian International Development Agency
CWERI	Climate, Water and Environment Research Institute
DGIS	Directorate General, International Cooperation, Ministry of Foreign Affairs, The Netherlands
DRI	Drainage Research Institute
EEAA	Egyptian Environmental Affairs Agency
EHD	Environmental Health Department
EIAs	Environmental Impact Assessments
EOHC	Environmental and Occupational Health Center
EPL	Environmental Protection Law
ERs	Executive Regulations
GOE	Government of Egypt
GOFI	General Organization for Industry
HAD	High Aswan Dam
MALR	Ministry of Agriculture and Land Reclamation
MEE	Ministry of Electricity and Energy
MHPU	Ministry of Housing and Public Utilities
MOH	Ministry of Health
MOI	Ministry of Industry
MOT	Ministry of Tourism
MPWWR	Ministry of Public Works and Water Resources
MRNC	Ministry of Reconstruction and New Communities
MSR	Ministry of Scientific Research
NOPWSD	National Organization for Potable Water and Sanitary Drainage
NRC	National Research Center
NRI	Nile Research Institute
NWQCU	National Water Quality Conservation Unit
NWRC	National Water Research Center
PRIDE	Project in Development and the Environment
RIGW	Research Institute for Groundwater
SWRI	Soil and Water Resources Institute
UFW	Unaccounted For Water
USAID	United States Agency for International Development

ABBREVIATIONS

BCM	Billion cubic meters
BOD	Biological Oxygen Demand
g/l	Grams per liter
g/m^3	Grams per cubic meter
GWh	Gigowatt hour
kg	Kilogram
KWh	Kilowatt hour
lcd	Liters per capita per day
m^3/day	Cubic meters per day
MCM	Million cubic meters
SS	Suspended solids
TDS	Total dissolved solids
TSS	Total suspended solids

NON-AGRICULTURAL COST RECOVERY STUDY

I. INTRODUCTION

In the analysis and establishment of a Water Service Cost Recovery Scheme, it is important to look at all beneficiaries from the system. In the Nile System, some water demands involve at least partial consumption, such as agriculture, municipal[1], and industrial demands. Other demands involve little or no physical consumption, such as navigation, hydropower generation, recreation, waste assimilation, and environmental demands. Disaggregating the various impacts of these demands, particularly in a closed system such as the Nile, where "losses" in one location are "sources" elsewhere, is complex and presents a challenge in the rational allocation of costs among beneficiaries.

The purpose of this report is threefold. First, the report provides a brief review of the existing non-agricultural users of the Nile system, giving special attention to the municipal and industrial sectors in terms of both future water demands and wastewater flows. Although at present, municipal water supply and industrial demands represent only a small percentage of the total water diversion in Egypt, they will steadily increase in the near future due to the rapid population growth, better standards of living, industrialization and urbanization[2]. Second, the report presents the initial results of water service cost allocation among beneficiaries of the Nile System. Third, the report describes how current policies affect the municipal water supply and industrial sectors, and speculates on alternative mechanisms for charging for water services.

Apart from this introductory section, the report consists of the following five: Section II describes the non-agricultural water users in Egypt. Section III provides a review of the current studies to date on municipal and industrial demand projections, and proposes a methodology to assess future municipal water demand and wastewater discharges. Annex I presents the results from a spreadsheet developed under this task to assess future municipal water demand and production. Section IV describes a framework for assessing cost recovery policies and presents initial results. Section V discusses several mechanisms for charging for water services. Finally, Section VI provides an overview of the current institutional framework for water quality management in Egypt.

This report has drawn on several consultant reports and from other available reports on the water resources sector in Egypt prepared by the Ministry of Public Works and Water Resources. The bulk of the analytical work in this report is based on data provided by government agencies supplemented by field visits. Annexes II and III present the findings of field visits to the household sector and the industrial sector, respectively. Annex IV addresses

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1 The term municipal water demand includes urban and rural villages demand. Urban demand, in turn, refers to domestic, commercial, institutional, and industrial demands supplied by a piped public system.

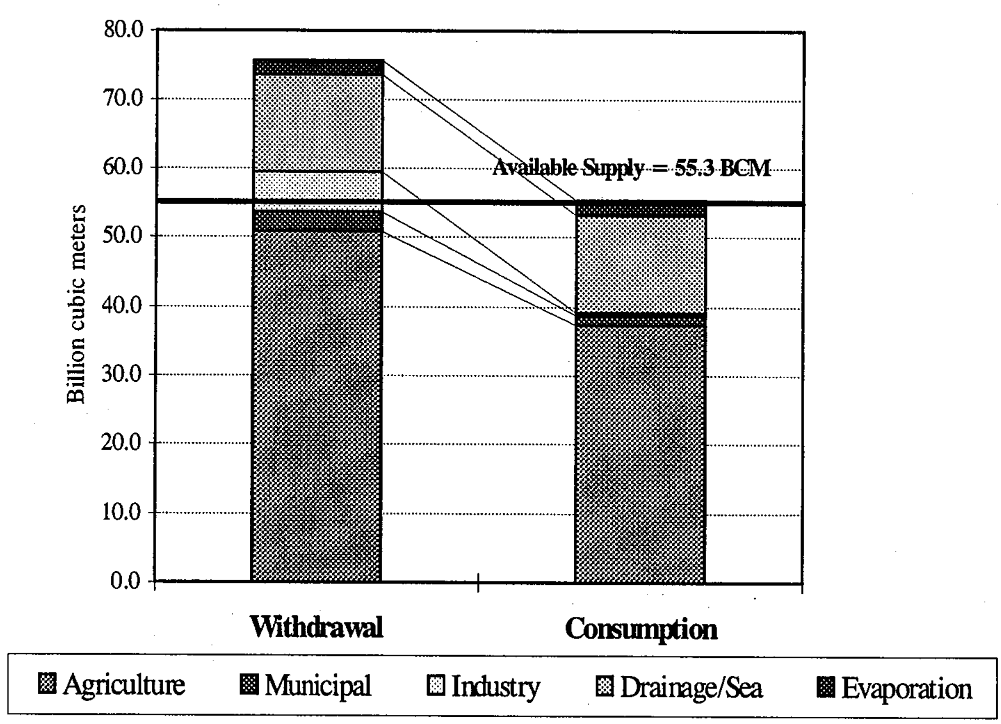
2 According to the most recent water balance, in 1992/93 the total water diversion in Egypt was 62.8 billion cubic meters (BCM), out of which the irrigation diversion was about 88 percent, and municipal and industrial diversion was about 12 percent [NWRC (1994)]. This figure includes reuse of drainage water. Total inflow in 1992/93 was 55.3 BCM.

cost to the economy of water pollution on the basis of representative examples. Annex shows the water treatment cost for different quality levels of the intake water. Finally, Annex VI compares cost of saving water in the industrial and agricultural sector.

II. CURRENT USERS OF THE NILE SYSTEM

This section describes the main water users of the Nile System, including irrigation, municipal water supply, industrial water supply, navigation, hydropower generation, and environmental consideration. The Egyptian Water Balance for year 1992/93 is shown in Figure 1. In a system such as the Nile River in Egypt, the reuse of return flows complicates water accounting, and total *diversions* significantly exceed *consumption*. Water demands[3] for the latest year for which data are available were as follows:

Figure 1
Water Balance of the Nile System, 1992/93



Source: Irrigation Sector, Ministry of Public Works and Water Resources, 1995.

A. Irrigation Sector

The irrigation sector is by far the largest water user. In 1992/93, water demand for was about 50.7 BCM, out of which 3.2 BCM came from groundwater sources and about 3.9 BCM came from recycling drainage water. Thus, surface water diversion for irrigation

3 Throughout this report, the terms supply and demand for water indicate diversion requirements; consumptive use, or net demand, is separately identified.

purpose was about 43.6 BCM, while water consumption was found to be 37.3 BCM. Total irrigated area was about 7.4 million feddan, and the cropping intensity was estimated at almost 200 percent.

B. Municipal Water Supply Sector

Municipal water demand, which includes water supply for major urban areas and rural villages, was estimated at 2.9 BCM. According to the records of both the National Organization of Drinking Water and Sanitary Drainage and the MPWWR, about 1.8 BCM came from the Nile system, either through canals or direct intakes, and about 1.1 BCM came from groundwater sources. Total water consumption was estimated at 1.5 BCM, while about 1.4 BCM were returned to the Nile system in polluted form.

C. Industrial Sector

Industrial water demand was estimated at 5.9 BCM, out of which about 3.1 BCM came from the canal system and about 2.8 BCM were direct withdrawals along the Nile river. Non-recoverable consumption by the industrial sector was estimated at only 0.6 BCM. Thus, a huge volume of partially treated effluent was returned to the system.

D. Navigation Sector

Water demand specifically for navigation occurs only during the winter closure period (about 2-3 weeks between January and February), when Nile discharges to meet other non-agricultural demands are too low to provide the minimum depth for Navigation. For example, the section between Aswan and Luxor requires a minimum draft of 1.5 m[4], which is hardly obtained with releases for municipal and industrial purpose. Without the extra release for navigation of about 2.1 BCM, navigation would suffer serious constraints during this period. For the rest of the year water releases for irrigation, municipal, and industrial purposes are sufficient to provide the minimum safe depth, fulfilling navigation demand.

E. Hydropower Generation Sector

Since 1990, irrigation has had priority over hydropower in order to maximize the water available for agriculture and new lands development. Thus at present there are no special releases for hydropower, and only releases for irrigation, municipal, industrial, and navigation purposes are available to pass through the turbines at the High Aswan Dam. Releases for hydropower generation range from a maximum of 230 Mm^3/day during the irrigation season to 80 Mm^3/day during the winter closure season. Average daily release is estimated at 155 Mm^3/day [K&M Engineering and Consulting Engineering (1993)]. The equivalent daily hydropower generations are 42.3 GWh, 14.8 GWh, and 28.5 GWh, respectively. Prior to 1990, hydropower water demand during the winter season was satisfied by special releases at the HAD to satisfy the planned power generation

F. Waste Assimilation Use

At present there are no official figures on the demand of water for waste assimilation. It seems that even during the low flow season there is enough capacity in the Nile system to assimilate and dilute wastes. Nonetheless, several cases have been reported, where municipalities have to require additional releases from HAD because the quality of the Nile water at the point of intake does not meet the national standards. It can be concluded that the situation is marginal, and local concentrations or unusual events quickly result in problems.

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4 *Water Resources Present and Future,* MPWWR, 1990 (quoted in ISPAN, page A 22)

III. MUNICIPAL AND INDUSTRIAL WATER-RELATED SERVICES

This section reviews the municipal and industrial water-related services. It starts with the description of customers and services. Then, it continues with a review of the major studies to date of present and projected municipal and industrial demands, and concludes with a proposed methodology to assess future demand.

A. Definition of Customers and Services

Most cities and towns in Egypt provide access to potable water supply systems either through house connections or public standpipes. In 1992, the water supply coverage in urban areas was estimated at 90 percent. More details on water supply and sanitation coverage are provided in Table 1. Although this is a relatively high coverage rate, the quality of service does not meet standards specified by the World Health Organization [Nicholson (1993)]. The deficiencies of the service are as follows: less than 24-hours service, temporary rationing, low pressure, frequent breakdowns, and deficient water quality. Within Egypt, cities in the Nile Delta seem to have better quality of service in terms of coverage, regularity of supply, and water quality.

Table 1

Water Supply and Sanitation Coverage, 1992

	Population		Coverage	
	Million	**Percentage**	**Water**	**Sanitation**
Urban Areas				
Cairo	11.1	20%	95%	70%
Alexandria	3.3	6%	98%	40%
Canal Cities	1.1	2%	96%	35%
Others	8.5	15%	80%	30%
** Overall	24	44%	90%	50%
Rural Areas	31	56%	45%	5%
Total	55	100%	65%	34%

Source: NOPWSD, 1995.

Due to the rapid expansion of major cities, agencies responsible for the provision of water supply have not been able to keep pace with the increasing demand for water connections. The situation is most acute for those living in poorer neighborhoods, since they have to rely on other sources than piped water (canals, the river, shallow groundwater, or street water vendors). Those who rely on either pump wells or street vendors paid as much as 20 times more per unit of water than a household connected to the public system. Annex II provides more details on the interviews carried out in two settlements of Cairo.

Regarding groundwater, recent studies have indicated that about 99 percent of total shallow wells are chemically and biologically polluted [Egyptian Environmental Affairs Agency (1995), Chapter on Municipal Water Supply and Wastewater, p. 2]. The condition of shallow groundwater has forced many households to dig wells to 35-meter depth, increasing the cost of water to about three times the rate for piped supply (LE 0.31 per cubic meter compared to LE 0.11 per cubic meter). A household of 5-members in Cairo with piped water

house connection pays a flat rate of LE 5 per month for a total estimated consumption of about 45 cubic meters or 300 lcd.

In rural areas the water situation is quite different. In 1992, only 45 percent of households in rural villages were reported to have access to piped water supply systems, either through in-house connections, standpipes or neighbors with house connection. A USAID report ("Assessment of Village Water Supply in Egypt") has shown that households in rural areas rely on five water sources: in-house or yard connection (30%); public standpipe (15%); private handpump (28%); neighbor's connection (22%); and river or canal (5%). As with urban water service, the quality of rural water service is less than WHO standards. In addition, water networks in rural areas are very often not operational.

Table 2 shows the sources of supply to meet municipal water demands. In 1990, the distribution of municipal water by sources was as follows: direct intakes from the Nile (13%), canal system (51%), and groundwater (35%).

Table 2
Municipal and Industrial Water Withdrawal per Region and per Source, 1990
(In liters per capita per day)

	Municipal				Industry			
Regions	**Direct Intakes**	**Canal**	**GW**	**Total**	**Direct Intakes**	**Canal**	**GW**	**Total**
Upper Egypt	0	6	84	90	110	0	0	110
Middle Egypt	56	67	63	186	275	71	0	346
East Delta	0	99	39	138	6	254	0	260
Middle Delta	0	59	70	129	3	4	0	7
West Delta	0	278	30	308	0	389	0	389
All System (share)	21 12%	92 54%	57 34%	171 100%	118 48%	130 52%	0 0%	248 100%

Sources: RIGW (1992), CAPMAS (1994), and PS (1990).

Wastewater and sanitation are the other two water-related services provided at the municipal level. On average, as shown in Table 1, 34 percent of the total population have sewerage systems. In urban and rural areas, sewerage coverage rates are 50 percent and 5 percent, respectively. Those without access to sewerage systems use on-site wastewater and sewage facilities, mainly latrines and septic tanks, which are regularly emptied into canal or drainage systems. Out of the total volume of wastewater that is generated (about 7 BCM) only 3 BCM receives adequate secondary treatment, corresponding to the present capacity of wastewater treatment plants.

Regarding the industrial sector, as shown in Table 2, water is withdrawn directly from the Nile river or from the canal system. There are no records on groundwater extraction for industrial purposes. In 1990, average intakes on a per capita basis were as follows: direct intakes about 118 lcd and canal intakes about 130 lcd. The average shares were therefore 48 percent and 52 percent, respectively. It is worth noting that East Delta and Middle Egypt are the major water-using regions, with per capita water supply for industrial purpose of 389 lcd and 346 lcd, respectively. The above figures correspond to industrial water coming from self-

supplied water sources only. They do not include the water that comes from piped water supply systems, which represents 30 lcd on average. This volume is accounted for under water requirements for the municipal sector.

The industrial sector consists of 20,000 large- and small-size industrial units, of which 650 large establishments are state-owned. The Law 48 of 1984 stipulates that industrial wastewater effluents have to be treated according to certain water quality standards prior to their discharge into water bodies. However, this Law is rarely enforced, and untreated industrial effluents (both sanitary and industrial wastes) are dumped directly into the Nile river and other water bodies.

B. Review of Studies to Date

To date, there are three major studies dealing with projections of future municipal and industrial water demands: (i) the Water Master Plan; (ii) the Planning Sector Study on Water Demands Present and Future Estimates; and (iii) the Water Security Project. This section briefly comments on the approach followed by each study and summarizes their results.

It is important to note that the above-listed three studies have adopted in one way or another the traditional demand forecasting approach, which ignores important determinants of water demand, especially water price, extent of metering, household income, industrial growth, investments in the water supply and sanitation sector, and distribution of demand between connected and non-connected households. Another observation has to do with the inclusion of allowances for unaccounted-for water (UFW). The three studies included UFW. Therefore, the reported future "demands" are indeed future requirements.

Since consideration is presently being given to progressively increasing the water tariff aiming to reach marginal cost of supply, and introduction of water metering in some important areas, projections of future water demand should not ignore the effects of water price increases on consumption. Similarly, the introduction of market-based instruments for pollution abatement (effluent charges) as envisaged under the New Environmental Protection Law may have substantial effects on industrial water demand as well as effluent discharge.

1. Water Master Plan

The base year for this study is 1976. The approach followed consisted mainly of estimating future populations for each Governorate and the six existing major cities, assessing current and future water use on a per capita basis, and analyzing alternative scenarios with different population growth rates. The basic scenario, for example, assumes that urban population would grow at 4 percent per year, while rural population would growth at 1 percent per year. Regarding future water use, the basic scenario assumed that water use coefficients in urban and rural areas in the year 2000 would be 40 percent and 60 percent higher than those prevailing in 1976, respectively. The results for the year 2000 are presented in Table 3.

Table 3
Municipal Water Requirement by Year 2000
(In million cubic meters)

Scenario	Urban	Rural	Total
Basic	4,416	730	5,147
Revised	4,052	730	4,782
Alternative 1	3,833	657	4,490
Alternative 2	3,869	730	4,599
Alternative 3	3,139	478	3,617
Alternative 4	3,723	478	4,201
Alternative 5	3,833	949	4,782
Alternative 6	4,052	730	4,782

Notes:

1. Basic Scenario: Urban and rural population would grow at annual rates of 4% and 1%. Unit water use coefficients for urban and rural areas would be 40% and 60% higher than 1976 levels.
2. Revised Scenario: Same as Basic Scenario, except that water use coefficients for Cairo, Alexandria and Suez would reach 350 lcd.
3. Alternative 1: Same as Basic Scenario except that water use coefficients for urban and rural areas would be 25% and 40% higher than 1976 levels. Water use levels for Cairo and Alexandria would reach 350 lcd and 300 lcd, respectively.
3. Alternative 2: Same as Basic Scenario except that after 1990 annual growth rates for urban and rural population would be 3.5% and 0.75%, respectively.
4. Scenario 3: Same as Basic Scenario except that water use coefficients would not experience increase.
5. Scenario 4: Same as Basic Scenario except no increase in water use coefficients. Cairo and Alexandria, however, would reach levels of 350 lcd.
6. Scenario 5: Same as Basic Scenario except that water use coefficients for urban and rural areas would be 25% and 100% higher than 1976 level.
7. Scenario 6: Same as Basic Scenario except that urban and rural population would grow at 4.3% and 0.9% between 1976 and 1990, and at 3.6% and 0.8% between 1990 and 2000. Water use coefficients for Cairo and Alexandria would reach 350 lcd.

Source: "Water and Wastewater Studies Municipal and Industrial Sectors," Master Plan for Water Resources Development and Use, March 1981.

Regarding industrial demand projections, the study assumed a direct correlation between industrial output and water use (that is, constant demand in cubic meters per ton of production). Unitary coefficients per unit of output were obtained for the different industrial sub-sectors through an industrial survey covering about 100 industrial units. Future water requirements were obtained by applying these unitary water use coefficients to the expected industrial output growths. This approach ignored the possibilities for reducing the coefficients by means of improved technologies, internal reuse or recycling, except for the cement industrial sub-sector, where a 75 percent reduction was assumed due to a shifting from a wet-process system to a dry-process system. The results of the study are shown in Table 4.

Table 4
Industrial Water Requirements by Year 2000
(In million cubic meters per year)

Category	Water Use
All except power generation	2,985
Power generation	6,745
Total	9,730
Consumptive use	437 (4.5%)

Source: "Industrial Water Use and Wastewater Production," Master Plan for Water Resource Development and Use, March 1981

2. Planning Sector Study

In the municipal sector, the study assumed that the future municipal water demand would depend on the following factors: (i) population and population growth rates; (ii) consumption per capita per day; (iii) living standards of the population; and (iv) level of water efficiency in the piped water supply system. The base year for this estimate was 1990. The study considered two scenarios, based on different combinations of the last listed factor. The results of the study are presented in Table 5.

Table 5
Municipal Water Requirements by Years 2000, 2010, 2020, and 2030
(In million cubic meters per year)

Scenario	2000	2010	2020	2030
Scenario 1	2,916	2,923	4,295	5,225
Scenario 2	3,652	4,398	5,332	6,492

Notes:
1. Scenario 1: Losses would reduce to 25% by year 2000, 20% by year 2010, 15% by year 2020, and to 10% by year 2030.
2. Scenario 2: Losses would reduce to 40% by year 2000, 35% by year 2010, 30% by year 2020, and to 25% by year 2030.

Source: "Water Demands Present and Future Estimates," MPWWR, September 1990.

For the industrial sector, this study extended the Water Master Plan's projections. Future water requirements were estimated by taking into account expected output growth rates for the various industrial sub-sectors, and the unitary water use coefficients obtained under the Water Master Plan. Table 6 presents the results of the study.

Table 6
Industrial Water Requirements by Years 2000, 2010, 2020, and 2030
(In million cubic meters per year)

Category	2000	2010	2020	2030
Industrial water demand	5,248	6,213	8,074	11,763
Consumptive use	503	932	1,813	3,668
Water lost from system because of quality deterioration	2,177	2,896	4,262	7,218

Source: "Water Demands Present and Future Estimates," MPWWR, September 1990.

One important finding of the study is the net impact of the industrial sector on the Nile system. As shown in Table 6, a huge volume of water can effectively be lost from the system because of quality deterioration. This volume can be made available for other users if investments in wastewater treatment and reuse take place. A case in point is the water savings in the pulp and paper industrial sub-sector that can be made available by introducing cleaner technologies. The Rakta Pulp and Paper Mill in Alexandria, for example, could save about 85 percent of water and reduce pollution loads by 95 percent by practicing recovery of pulping chemical at a cost of LE 0.54 per cubic meter of water treated.

3. Water Security Project

At the time this report was being prepared, the Annex of the Water Security Project dealing with industrial water demand estimates was not available. Thus, only comments on the municipal water estimates can be presented here [Mankarious (1992)]. The analysis disaggregates Egypt into Cairo, Alexandria and the other governorates. The approach used in the analysis consists of deriving population growth rates and consumption per capita growth rate between 1990 and 1992, and using those values as the basis for future demand. Since data were available for 1952, 1977, 1987, 1989, 1990, and 1992, average growth rates could have been obtained. Population growth was found to grow at a 2.36 percent per year and it is expected to remain at such level for the next 15 years. On average, the consumption level is expected to increase by 5.7 percent per year from an initial value of 207 lcd in 1992. This implies that by year 2010, average consumption per capita nationwide would reach a value of 565 lcd, which is extremely high compared with current levels prevailing in developed countries.

Two scenarios were analyzed. The first scenario considered that population will grow at an annual rate of 2.36 percent per year. Consumption levels during the base year, i.e., 1992, were 609 lcd, 480 lcd, and 112 lcd, for Alexandria, Cairo and other governorates, respectively. The second scenario makes the same assumption regarding population growth, but the rate of water consumption will increase (or decrease) at annual rates varying from -0.4 percent for Alexandria, 8.79 percent for Cairo, and 5.75 percent for other governorates. (The overall consumption per capita level is expected to rise from 207 lcd in 1992 to 565 lcd in 2010.) The results of the analyses are shown in Table 7.

Table 7
Municipal Water Requirements by Years 1995, 2000, 2005, and 2010
(In million cubic meters per year)

Scenario	1995	2000	2005	2010
Scenario 1	4,556	5,120	5,753	6,465
Scenario 2	5,390	8,000	11,881	17,640

Source: "Municipal Water Demand in Egypt up to the Year 2010," MPWWR, 1992

C. Proposed Methodology to Assess Future Water Demand and Production

1. Water Demand in the Municipal Sector

As stated earlier, municipal water demand, especially urban water demand for residential and industrial use, depends on a number of factors including population, household income, water price, industrial growth, and climate. An adequate analysis of water demand involves predicting how demand will respond to changes in these variables. Econometric forecasting methods can be used to estimate future water demands by residential and industrial users. However, lack of reliable historical data often precludes an analysis of this nature.

In this case, instead of waiting for data from specific sites where water metering exists (Cairo or Alexandria) it was decided to use the results of a similar analysis done by the World Bank in Algeria in 1994. Making use of available data, water price elasticities for the residential and industrial sectors were estimated as -0.16 and -0.30, respectively: That is, a 10 percent increase in piped water price would decrease demand for the residential and industrial consumers by 1.6 percent and 3 percent, respectively Similarly, residential income and industrial investment elasticities were estimated at +0.37 and +0.41, respectively. Residential users not connected to the piped water supply system, as well as institutional and public users were assumed to be price inelastic (that is, demand was unaffected by price increases).

The above water price and income elasticities are consistent with values reported in other developing countries: a recent review of urban water demand studies carried out by the World Bank reveals that residential (or domestic) water price elasticity ranges between -0.12 and -0.75, with an average value of -0.45. Similarly, in the case of household income elasticity, the review finds values ranging between +0.04 and +0.60, with an average value of +0.30. In the revised projections, the following assumptions have been made: real increases in income per capita of 4 percent per year between 1995 and 2025; industrial investment increases of 5 percent between 1995 and 2000, 5.5 percent between 2000 and 2015, and 6 percent between 2015 and 2025. Population projections to the year 2025 are shown in Table 8.

Apart from considering the effects of these macro-economic variables, the present analysis also examines the impact of water price, and the extension of coverage in piped water supply in urban and rural areas.

Three scenarios are analyzed: the first reflects the highest likely rate of demand increase, based on: no increase in water prices; increased coverage of urban (to 100%) and rural (to 75%) populations with water services, and no improvement in UFW losses. Scenario 2 indicates the lowest likely pattern of future demand: prices of water increase at 2% (residential) and 4% (industrial) per year, coverage remains at a constant percentage of the

population, and UFW losses are cut by 30%. Scenario 3 is a "most likely" projection including increased prices and coverage, and reduction in UFW by only 15%[5].

The results of the econometric forecasting are presented in Table 10 and Figure 3. More details are shown in Annex I. Consistent with the assumed elasticities, Scenario 1 produces the highest estimate of municipal demand, while Scenario 2 produces the lowest estimate.

Table 8
Present and Projected Population
(In million inhabitants)

Area	Actual 1986	Projected 1995	2000	2015	2025
Urban					
Cairo	8.80	10.73	11.98	16.19	19.40
Alexandria	2.92	3.61	4.06	5.62	6.84
Port Said	0.40	0.49	0.56	0.77	0.94
Suez	0.33	0.41	0.46	0.63	0.77
Other urban	6.97	8.79	10.00	14.31	17.82
Rural	26.52	32.83	36.96	51.23	62.44
Total	45.93	56.86	64.02	88.75	108.22

Source: Central Agency for Public Mobilization and Statistics, June 1994.

Table 9
Assumptions Regarding the Economic Parameters

Economic Variables	Elasticity	Assumed Annual Increase in Real Terms 1995-86	2000-95	2015-00	2015-15
Domestic water price	-0.16	0-2%	0-2%	0-2%	0-2%
Income growth	0.37	3.0%	4.0%	4.0%	4.0%
Industrial water price	-0.31	0-4%	0-4%	0-4%	0-4%
Industrial output growth	0.41	3.0%	5.0%	5.5%	6.0%

Notes:
1. The elasticity values used here were estimated from a casual econometric forecast in Algeria.
2. Lack of data precluded the determination of price elasticity, income elasticity and industrial output elasticity for Egypt.

5 Reduction of unaccounted-for water is not an easy task. World Bank projects aiming to reduce UFW have largely been unsuccessful mainly because they have tried to address this problem in isolation, without considering institutional strengthening programs and, more important, without setting appropriate water pricing policies. If the GOE hopes to reduce the high level of UFW (45%) major efforts would have to be directed to improve the overall performance of the institutions working in the sector, charges introduced for raw water, and water prices increased. The present system lacks incentives for water utilities to become more efficient.

Figure 3
Future Annual Municipal Demand

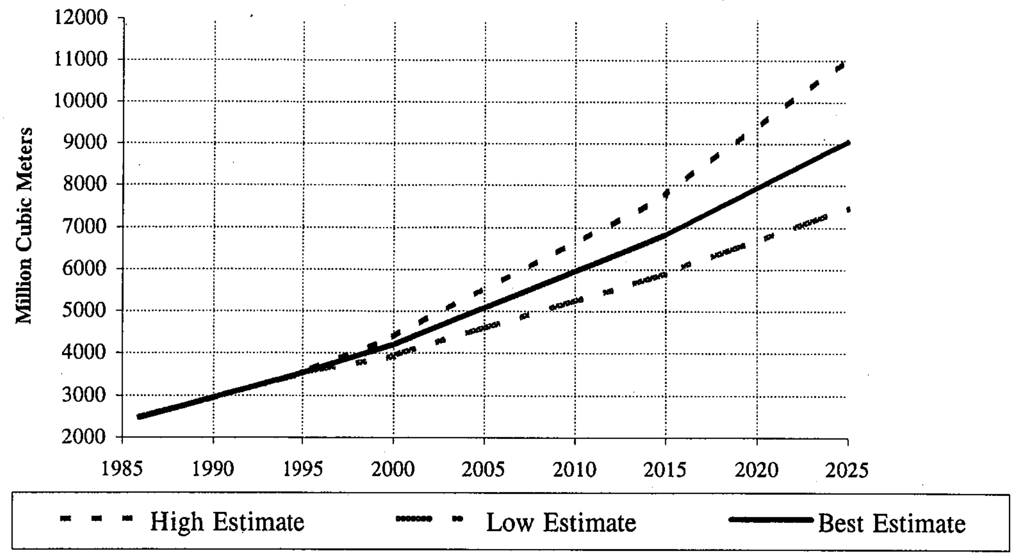
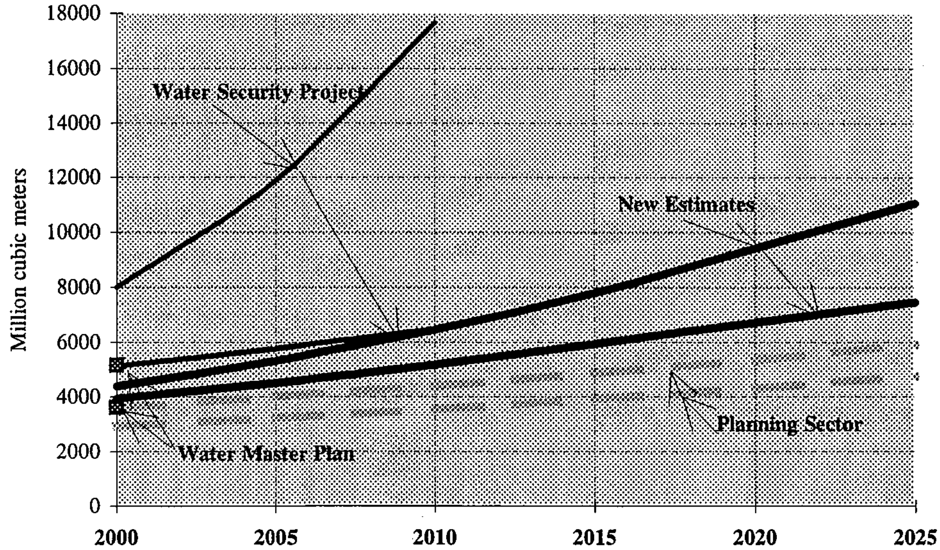


Figure 4 compares the results of the three revised studies on water demand projections with the results of this analysis. Two remarks are in order. First, the lowest and highest estimates for year 2000 made under the present study are within the projections made under the Water Master Plan. Second, this analysis reveals that between year 1995 and 2025, per capita municipal water requirement will increase from 170 lcd to 190-280 lcd. In the case of Cairo and Alexandria, per capita demand levels will increase from 317 lcd and 422 lcd in 1986 to 512 lcd and 712 lcd by year 2025, respectively.

Figure 4
Projections of Future Municipal Requirements



2. Wastewater Discharge in the Municipal Sector

To assess the stress on the Nile system in the near future due to urbanization and increasing population, it is interesting to estimate both the future sewerage volume and quality.

In general, the volume of sewerage flow depends on the total population connected to the sewerage system, the population connected to the piped water supply system, and the return flow factors applied to water consumption. The criteria adopted in the basic estimate are as follows:

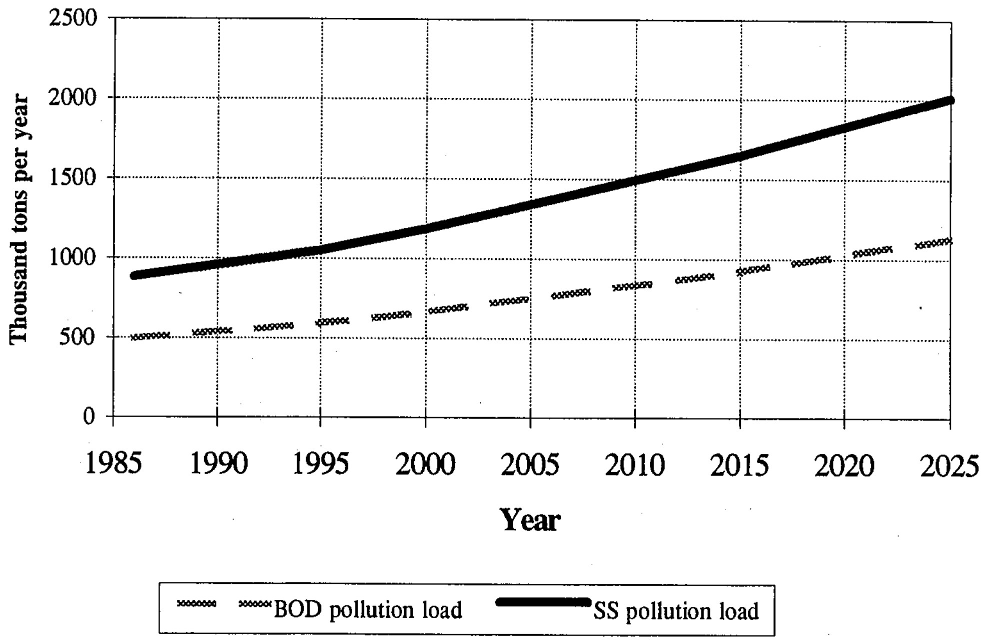
- Sewerage coverage will remain at 1995 levels.
- 90 percent of non-industrial effluent discharge will return back to sewerage system.
- 50 percent of unaccounted for water will get its way into sewerage systems[6].
- 75 percent of wastewater discharge will find its way into the Nile system.

The quality of the sewage, in turn, depends on wastewater loads as well as the types of treatment processes. In this particular case, the following assumptions were made:

- All collected sewerage will be treated to secondary level. This treatment process reduces about 70 percent of biological oxygen demand (BOD) content and 70 percent of suspended solids (SS) content.
- Daily municipal per capita pollution loads are assumed to be 45 grams BOD and 80 grams of SS.

The results of the analysis reveal that if sewerage coverage levels remain constant at 1995 levels, pollution loads to the Nile system will almost double between 1995 and 2025. As shown in Figure 5, the amount of BOD and SS will increase by 80 percent from 592,000 ton and 1,053,000 ton to 1,130,000 ton and 2,000,000 ton, respectively.

Figure 5
Municipal Pollution Load in Terms of BOD and SS
(Constant levels of Sewerage Treatment Coverage)



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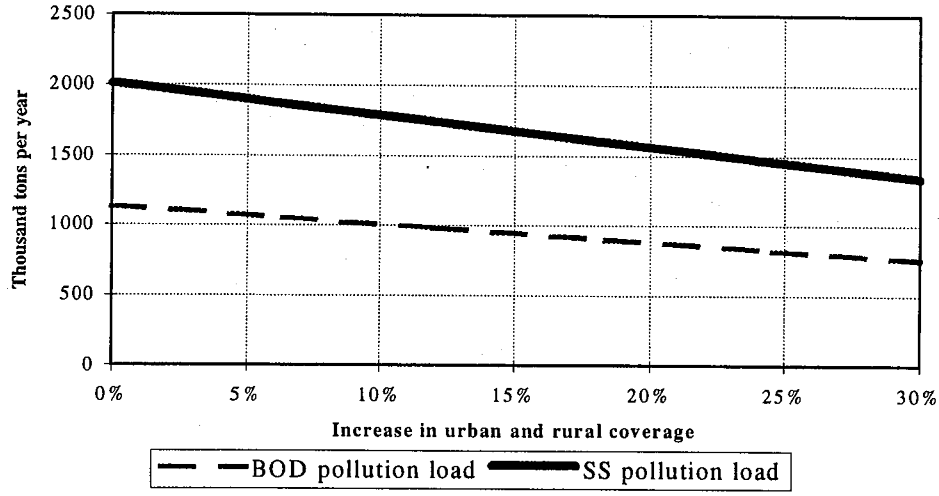
6 It must be recalled that UFW includes both physical and non-physical losses. Physical losses do not benefit anybody and are associated with leakage, hydrants, and overflows. Non-physical losses are associated with consumption not metered or paid as a result of fraudulent or unbilled consumption and faulty meters. In this case it is assumed that 50% of UFW corresponds to non-physical losses.

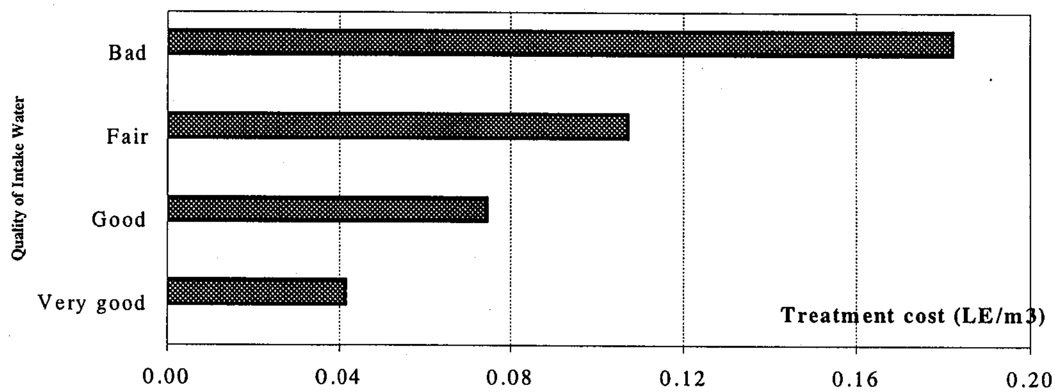
However, if additional efforts are directed to improve sanitation conditions in Egypt, pollution loads can be further reduced (See Figure 6). Increasing urban and rural sewerage coverage levels from 54 and 5 percent to 84 percent and 65 percent by year 2025, respectively, will cause a 33 decrease in BOD and SS pollution loads.

Figure 6
Municipal Pollution Load by Year 2025
(Increasing levels of Sewerage Treatment)



The main benefit of reducing municipal pollution loads is that water quality from the Nile system would not be further deteriorated. Water not consumed re-enters either the Nile river or groundwater aquifers in polluted form. Greater pollution of surface sources means a much higher cost of treatment for producing potable water or suitable water for industrial purpose. Figure 7 illustrates the variable costs of water treatments as quality of the water source deteriorates. In the case of groundwater sources, pollution means complex and often expensive treatment processes. Some forms of pollution can cause irreversible damage to the aquifer.

Figure 7
Water Treatment Cost



Source: See Annex V.

3. Industrial Water Demand

Projection of industrial water demand is more complicated than projecting municipal water demand, and is influenced by many factors. The most important determinants are: technology, product mix, industrial processes, employment level, capital availability, input quality and prices, water price, effluent charges, pollution control policies, and management attitude. In the case of Egypt, as in many developing countries, very little is known about the relative importance of the above mentioned variables.

Except for the two comprehensive industrial surveys carried out during the 1970s and mid-1980s, no additional work has been done to correlate industrial productivity, production cost, water cost, and employment levels with water demand in various industrial sub-sectors. The initial intention of the author was to update the correlation factors between water and the parameters indicated on the basis of the large amount of data collected by EEAA and GOFI. Although a database on industrial water use and effluent discharge was made available to the author, data on industrial production are still lacking. Considering the increasing importance of the industrial sector in Egypt, it is recommended to develop such a comprehensive database and to better investigate industrial water use.

According to EEAA's records, government-owned enterprises used about 1.3 BCM of water during 1990/91. The breakdown of industrial water use by sub-sector is shown in Table 10. Since the private sector was responsible for about 40 percent of the industrial output, 1990/91 industrial water use was about 1.8 BCM, if one assumes direct correlation between industrial output and water use.

Evidence indicates that some industrial sectors have increased water use coefficients per unit of output. The Misr Helwan Spinning and Weaving Company and the National Metal Industries Company, which were visited and interviewed as part of this study, have increased their water use per unit of output from 400 cubic meter per ton of weaving products and 122 cubic meters per ton of finished product (estimated during the 1978 industrial use survey) to about 550 cubic meter and 155 cubic meter, respectively. Similarly, a recent report dealing with the Rakta Pulp and Paper Mill in Alexandria indicates that the company currently uses about 360 cubic meter per ton of paper, while the 1978 figure was only 194 cubic meter. One reason for having a much higher water use per unit of output could be that some industrial sectors are using dilution as a means of conforming to pollution control regulations.

Table 10
Industrial Water Use, 1990/91
(In million cubic meters per year)

Sub-sector	Water Withdrawal	Effluent Discharge	Consumptive Use
Chemical	137	41	96
Food	253	76	177
Textile	189	57	132
Metals	100	30	70
Mining	163	49	114
Engineering	461	138	323
Total	**1,303**	**391**	**912**

Source: Industrial Water Use Survey, EEAA, 1995.
Note: The survey covers only 200 government-owned enterprises using more than 300 cubic meters of water per day.

IV. FRAMEWORK FOR ASSESSING COST RECOVERY POLICIES

As pointed out by Adrian O. Hutchens (1995), there are several methods of cost allocation. The most common ones are: (i) Use-of-Facilities method, (ii) Alternative Justifiable Expenditure method, and (iii) Separable Cost-Remaining Benefits method. Availability of data is a key variable in deciding about which method one can use. Among the three methods, the latter one is the most demanding of data, but at the same time it yields the most equitable distribution of cost among the beneficiaries of the system. The second method, which is a modified version of the third, is recommended for situations where derivation of separable costs is not possible. The first method is the simplest and is recommended for situations where derivation of project benefits is not possible.

Since the third approach has already been applied to the Nile System, through the ISPAN study, and a substantial effort devoted to deriving the benefits accruing to each user as well as to estimate the total cost of the system, a decision was made to update the ISPAN study to 1994 cost levels while correcting a number of its major shortfalls, as pointed out by Hutchens (1995). A further reason for this decision was the absence of detailed cost information required for a Use of Facilities analysis (Lewis and Hilal, 1995). This section summarizes the cost allocation process followed under the ISPAN study. (See ISPAN, 1993, for a full explanation of the approach.)

On the cost side, two types of costs are to be allocated. The first set includes those costs incurred for a specific, identifiable, and separable purpose or function (a navigation lock, or power house, for example). Such costs are allocated directly and fully to that particular purpose. The second set includes costs which cannot be separated by specific purpose or function (a canal delivering irrigation and municipal supplies, and serving as a navigation channel, for example). Such costs are allocated in proportion to the lesser of remaining net benefits, or the costs of the alternative single purpose project

In the case of the Nile system, joint costs were identified at three levels: regional costs such as pumping cost, navigable canals, and non-navigable canals, main stem costs such as barrage costs; and High Aswan Dam complex cost. Table 11 presents the type of joint cost to be allocated at each level, and the respective beneficiaries.

Once these joint costs are identified, the next step consists of distributing the joint costs among the different beneficiaries of the system according to the benefits received. In this particular case, the benefits were assessed as follows:

- *Agriculture of Old and New Land*: Agricultural net primary return from the region is based on the residual imputation method assuming that all factors of production except water and land are valued at their market prices. (Market prices are assumed to be equal to shadow prices, since most of the agricultural inputs and output prices are no longer controlled by administrative processes). This is the method followed under ISPAN, and it includes provision for returns to family labor, management, fixed assets, and land.

- *Canal Intakes for Municipal and Industrial Purposes*: The benefit for each cubic meter of water is assumed to be equal to the marginal cost of developing the next best alternative. In this case, the alternative schemes are either pumping water from deep aquifers (LE 0.18 per cubic meter in 1994 prices) or developing surface sources in

Upper Egypt (LE 0.36 - 0.42 per cubic meter)[7]. If extraction from deep aquifers were banned for industrial purpose, then the alternative scheme would be to treat and reuse water already being used in the industrial process (for example, for the pulp and paper sub-sector, this cost has been assessed at LE 0.54 per cubic meter).

Table 11
Distribution of Joint Cost Among Beneficiaries

Level	Associated OM&R Costs	Beneficiary
High Aswan Dam	HAD Headquarters MPWWR (only O&M cost for the Nile system)	A, NL, DM&I, CM&I, GWM&I, H, N, GT, T, F, FC
Main Steam	Barrages and reservoirs without Esna	A, NL, DM&I, CM&I, GWM&I, N, GT, T, F
	Esna Barrage	A, NL, DM&I, CM&I, GWM&I, H, N, GT, T, F
Region Upper Egypt	Main irrigation system and drainage system Pumping stations	A, DM&I, N A, DM&I
Region Middle Egypt	Main irrigation system and drainage system Pumping stations	A, NL, DM&I, N A, NL, D&MI
Region East Delta	Main irrigation system and drainage system Pumping stations	A, NL (Sinai), DM&I, N A, DM&I
Region Middle Delta	Main irrigation system and drainage system Pumping stations	A, DM&I, N A, DM&I
Region West Delta	Main irrigation system and drainage system Pumping stations	A, NL, DM&I, N A, NL, DM&I

Legend:

OM&R: Operation, maintenance and replacement costs;
A: Agriculture old land
NL: Agriculture new land
DM&I: Direct intakes for municipal and industry purpose
CM&I: Canal intakes for municipal and industry purposes
GWM&I: Groundwater intakes for municipal and industrial purposes
H: Hydropower
N: Navigation
GT: Ground transport
T: Tourism
F: Fishing
FC: Flood control.

Notes:

1. It is assumed that the reader is familiar with the ISPAN Study.
2. In the case of agriculture in new lands, it has been assumed that irrigation schemes in Upper Egypt, East Delta and West Delta will use deep aquifer water sources. Thus, they do not benefit from the Nile system. Agriculture in Sinai, however, will benefit from the Nile system, but there will no be pumping cost associated with delivering water.

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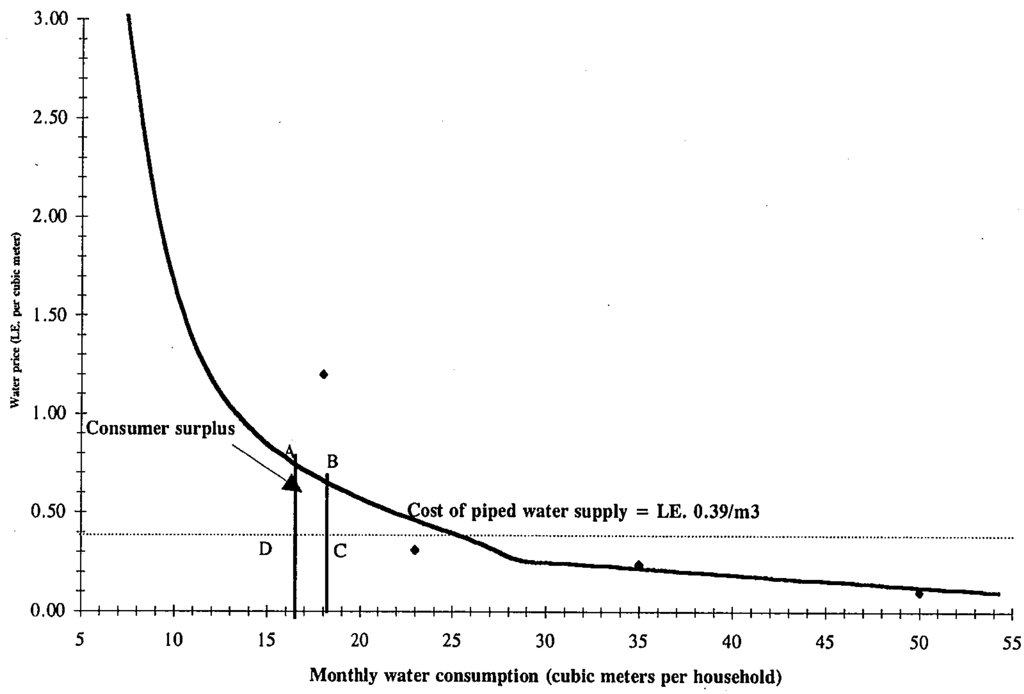
[7] Alternative schemes from surface sources, with yields to be divided equally between Sudan and Egypt, are: the Jonglei Canal I (4 BCM), the Jonglei Canal II (3 BCM) the Machar Marshes Conservation Schemes (4 BCM at Aswan), and the Bahr El-Ghazal (7 BCM at Aswan). Average cost of obtaining an increment of one cubic meter is estimated ranging between LE 0.30-0.35 (1992 prices).

Another approach to estimate benefits in the municipal sector, more specifically in the domestic sector, is to assess the willingness to pay for a given level of service, based on derived demand curves. The findings of the field interviews provide the basis for the demand curve in Figure 8 for Cairo. The reduction in consumer surplus due to a 10 percent reduction in water consumption from a moderate level of 18 cubic meters per month per 5-member household (120 lcd) to 16.2 cubic meters (108 lcd) is about LE 1.2 per month [(0.60+0.74)*1.8/2] or LE 0.67 per cubic meter. Since the subsidized cost of piped water supply is on average LE 0.39 per cubic meter (assuming 30 percent subsidy), then the willingness to pay for raw water is about LE 0.28 per cubic meter (LE 0.67 - 0.39).

Figure 8
Water Demand Curve for Cairo



Source: Field interviews, Annex II.

- *Groundwater and direct Intakes for Municipal and Industrial Purposes*: As stated by A. Hutchens (1995), it is difficult to estimate municipal and industrial benefits from direct and groundwater intakes. Nonetheless, the lower bound can be assumed to be the opportunity cost of water in agriculture. Hazel et al. (1994) have estimated that agricultural water has a shadow price of LE 0.056 per cubic meter (1990 prices).

- *Ground transport, Navigation and Hydropower*: A good proxy for benefits is the single-*purpose* alternative cost. In the case of ground transport, the single purpose alternative is building a bridge. In the case of navigation and hydropower, the most likely alternatives are shipping by rail and thermal power, respectively.

- *Tourism*: Benefits are assessed on the basis of the net primary revenues from the *Nile* river tourism industry (floating and dinner boats).

- *Fisheries*: Benefits are assessed on the basis of output-market value of the fish harvest.

- *Flood Control*: Its based on an estimated percentage (4 points) of the total Nile system benefits excluding benefits for agriculture.

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- *Tourism*: Benefits are assessed on the basis of the net primary revenues from the Nile river tourism industry (floating and dinner boats).

- *Fishery*: Benefits are assessed on the basis of output-market value of the fish harvest.

- *Flood Control*: The estimate follows the ISPAN approach, and is based on an estimated percentage (4 points) of the total Nile system benefits excluding benefits for agriculture.

V. ALLOCATION OF WATER DELIVERY COST AMONG BENEFICIARIES

This Section presents a revised version of the allocation of OM&R costs, based on a revised and updated identification of benefits accruing the to beneficiaries of the system, an updated and more accurate assessment of the OM&R costs of the Nile System, and a new rule to allocate joint costs on the basis of benefits. The cost allocation was done with a help of a spreadsheet version of the ISPAN Cost Recovery Model[8].

A. Updated Operation and Maintenance Costs of the Nile System

The analysis of OM&R cost of the Nile system was estimated from the GOE budgets detailing the proposed 1994 annual costs for the MPWWR. Only the planned expenditures for operation (Chapter 1), maintenance (Chapter 2), investment costs for rehabilitation and replacement (part of Chapter 3) were considered for the total OM&R of the Nile system (thus specifically excluding the investment costs associated with system improvements). The following department and authorities where included: the Irrigation Department, the Aswan Dam Authority, the Drainage Authority, and the Mechanical and Electrical Department. As shown in Table 12, the total OM&R cost of the Nile system is about LE 652[9] million (in December 1994 prices), broken down as follows: High Aswan Dam LE 55 million, barrages and main stem LE 110 million, drainage system LE 63 millions, main irrigation system LE 240 million, and pumping stations LE 184 millions.

Regarding the above estimate of the OM&R cost of the Nile system, two remarks are in order. First, this task of updating OM&R costs was the most time-consuming task, mainly because there is lack of an overall accounting system for the Ministry of Public Works and Water Resources[10]. Second, Chapter 1 (or the operation budget) for each department and authority is not disaggregated into labor for the pure operation and maintenance of the system and labor associated with new construction and investment. Thus, total costs may be over-estimated.

An interesting observation is that the 1994 OM&R cost of the Nile system represents about 0.6 percent of GDP, which compares well with the OM&R level calculated under the ISPAN study (See Table 13). This level of current expenditure, including replacement and rehabilitation seems to be relatively high compared to the level devoted to fixed agriculture and irrigation investments (net of investments in new land) of about 5 percent of GDP.

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8 With the purpose of assisting the Ministry of Public Works and Water Resources of Egypt, the author, with the assistance of Professor Ibrahim Elassiouti and Dr. Samir El Zaher, developed a spreadsheet to perform allocation of O&M costs of the Nile System, which builds on the ISPAN model.

9 Since the first draft of this report, small revisions (in total about 3%) to costs have been identified. These will be introduced, and all tables updates, at the time of finalizing the report.

10 This issue is addressed directly in a separate report: *Financial Management Systems in the MPPWWR*, Charles B. Lewis and Mohammed Hilal, Cairo, 1995

Table 12
FY1994 OM&R Cost of the Nile System
(In December 1994 prices)

Item	Operation and Maintenance Cost			Capital Cost	Total Cost	
	Personnel	Non-Personnel	Total		Million LE.	Share
High Aswan Dam						
Headquarters Irrigation Department	2,934,418	16,677,629	19,612,047			
Design Department	175,372	26,154	201,526			
MPWWR - HAD	9,541,000	1,894,000	11,435,000			
Replacement of equipment's HAD				4,083,000		
Strengthening structure for HAD				18,301,000		
Tushka Canal rehabilitation				1,296,000		
** Sub-Total	12,650,790	18,597,783	31,248,573	23,680,000	54,928,573	8%
Barrages and Stem						
Delta Barrages	3,570,429	604,837	4,175,266			
Researvoirs	655,348	4,934,524	5,589,872			
Esna Barrage and power station				53,724,000		
Development of the Nile Basin				2,341,000		
Nag Hammadi lock				4,525,000		
Dammiata Regulator and lock				0		
Reh.Nag Hammadi barrage				3,596,000		
Protection of the Nile river				1,895,000		
New methods weed control				25,468,000		
Strengthening Delta Nile				4,987,000		
Prevention of floods				3,261,000		
** Sub-Total	4,225,777	5,539,361	9,765,138	99,797,000	109,562,138	17%
Pump Stations						
Upper Egypt			45,111,000	11,402,080		
Middle Egypt			39,066,000	9,874,169		
East Delta			16,246,000	4,106,275		
Middle Delta			14,789,000	3,738,010		
West Delta			31,554,000	7,975,466		
** Sub-total	51,368,100	95,397,900	146,766,000	37,096,000	183,862,000	28%
Drainage System						
Upper Egypt	3,089,000	60,099	3,149,099	2,285,143		
Middle Egypt	8,019,000	34,080	8,053,080	5,843,716		
East Delta	10,071,000	49,184	10,120,184	7,343,710		
Middle Delta	9,426,000	147,165	9,573,165	6,946,765		
West Delta	5,688,000	47,089	5,735,089	4,161,666		
** Sub-total	36,293,000	337,617	36,630,617	26,581,000	63,211,617	10%
Main Irrigation System						
Upper Egypt	12,599,600	16,998,609	29,598,209	16,415,885		
Middle Egypt	14,955,674	30,131,498	45,087,172	25,006,439		
East Delta	14,506,165	17,374,637	31,880,802	17,681,866		
Middle Delta	12,642,785	6,774,399	19,417,184	10,769,241		
West Delta	5,298,296	22,195,694	27,493,990	15,248,834		
Sinai (ED)	627,443	273,590	901,033	499,735		
** Sub-total	60,629,963	93,748,427	154,378,390	85,622,000	240,000,390	37%
** Total Cost (OM&R)	165,167,630	213,621,088	378,788,718	272,776,000	651,564,718	100%
(Shares)	25%	33%	58%	42%	100%	

Sources: "Achievements of the Investment Plan for FY1993/94 up to June 1994," MPWWE, Planning Public Department Mechanical and Electrical Department, 1995; Irrigation Department, 1995; and Drainage Authority.

Table 13
Actual Annual Expenditure, FY1987-FY1991
(In December 1991 prices)

Item	FY86/87	FY87/88	FY88/89	FY89/90	FY90/91	Average	Share
Operation and Maintenance Cost	255.64	297.20	347.54	337.15	318.99	311.30	58%
- Personnel	69.40	79.87	91.31	103.29	114.47	91.67	17%
- Non-Personnel	186.24	217.33	256.23	233.86	204.52	219.64	41%
Capital Cost	222.59	246.43	230.86	203.09	201.48	220.89	42%
- Structural Replacement	72.59	90.56	87.60	90.03	98.57	87.87	17%
- Pump Station Rehabilitation	55.67	62.68	60.37	29.20	30.58	47.70	9%
- General Improvements	94.33	93.19	82.89	83.86	72.33	85.32	16%
** Total	478.23	543.63	578.40	540.24	520.47	532.19	100%
GDP (in million LE. 1991 prices)	86,837	89,641	92,722	95,276	97,568	92,409	
Annual Expenditures as % GDP	0.55%	0.61%	0.62%	0.57%	0.53%	0.58%	

B. Updated Benefits Accruing to Each Beneficiary

Following the approaches listed in Section IV, estimates of benefits accruing to each beneficiary of the system were assessed as follows for 1994:

Benefits in Old Land Agriculture

Region	Benefits (million LE)	Irrigated Area (million feddan)	Water Req. (m3/feddan)
Region 1 - UE	884	0.762	7023
Region 2 - ME	1158	1.524	8195
Region 3 - ED	1685	1.581	5078
Region 4 - MD	1304	1.439	3831
Region 5 - WD	1246	1.293	8189
Region 5A (Sinai)			
Total (HAD & Steam)	6276	6.599	

Benefits in New Land Agriculture

Region	Benefits (million LE)	Irrigated Area (million feddan)	Irrigated by Nile System	Water Req. m3/feddan[1]
Region 1 - UE	271	0.195	0.000	7023
Region 2 - ME	168	0.184	0.184	8195
Region 3 - ED	783	0.612	0.000	5078
Region 4 - MD	64	0.059	0.000	3831
Region 5 - WD	305	0.264	0.264	8189
Region 5A (Sinai)	271	0.212	0.212	6463
Total	1862	1.526	0.660	6463

*Water requirements per hectare are assumed similar in old and new lands in the same region (ISPAN, page F5)

Municipal and Industrial Benefits from Canal Intakes

Region	Population in 1994	M&I Canals	
		Per Capita Use* (lcd)	Total Benefits (LE millions)
Upper Egypt	6.55	6	2.41
Middle Egypt	21.64	138	193.26
East Delta	11.92	353	272.68
Middle Delta	9.78	63	39.54
West Delta	7.32	667	316.16
Steam/HAD	57.21		824.05
Population growth	2.4%		

* These data are derived from Table 2

Municipal Benefits from Direct Intakes and Groundwater Sources

Region	Population in 1994	Per Capita Use (lcd)	Total Benefits (LE millions)
Upper Egypt	6.55	84	27
Middle Egypt	21.64	63	106
East Delta	11.92	39	20
Middle Delta	9.78	70	28
West Delta	7.32	30	9
Steam/HAD	57.21		185
Population growth	2.4%		

Industrial Benefits for Direct Intakes and Groundwater Sources

Region	Population in 1994	Per Capita Use (lcd)	Total Benefits (LE millions)
Upper Egypt	6.55	110	43
Middle Egypt	21.64	331	354
East Delta	11.92	6	6
Middle Delta	9.78	3	2
West Delta	7.32	0	0
Steam/HAD	57.21		403
Population growth	2.4%		

Navigation Benefits

Cost of railroads 0.057 LE per ton-km

Annual growth rate: 2.00%

Level	Traffic Flow		Benefits	
Only Stem	2511	Million ton-km per year	143	LE million per year
Region 1	0	Million ton-km per year	0	LE million per year
Region 2	99	Million ton-km per year	6	LE million per year
Region 3	507	Million ton-km per year	29	LE million per year
Region 4	797	Million ton-km per year	45	LE million per year
Region 5	434	Million ton-km per year	25	LE million per year
At Stem and HAD			248	LE million per year

Benefits in Hydropower

Thermal power cost:	0.147	LE per KWh	
Average generated capacity at HAD:	10400	million KWh	HAD and old Aswan Plants
Total benefit HAD:	1533	million LE per year	
Total generated capacity at Esna:	540	million KWh	
Total benefit at Esna:	80	million LE per year	

Benefits in Tourist - Floating Boats

Number of floating boats:	157	
Number of cabins:	55	
Occupancy rate:	95%	Nov.-Feb.
	75%	Others
Rate per cabin:	500	LE per day
Total profits:	65.00%	of revenue
Total benefit:	837	LE million per year
Annual growth rate:	2.00%	

Benefits in Tourism - Dinner Boats

Dinner Boats:	30		
Total passenger	120		
Occupancy rate:	95%	Nov.-Feb.	
	30%	Others	
Rate per person	100	LE per day	(included 4 trips per day)
Total profits:	65.00%	of revenue	
Total benefits:	44	LE million per year	
Growth rate:	2.00%		

Benefits in Fishery

Total harvest from HAD	22034	tons
Total harvest from Nile, canals and drainage	37880	tons
Total harvest:	59914	tons
Market value:	2500	LE per ton
Total return HAD	150	million LE per year
Total return Nile	95	million LE per year

Benefits in Ground Transport

At the HAD level:		46.59 LE million	Capital cost of bridge at HAD
(Alternative scheme)		5.00%	O&M cost
At the stem level:		139.76 LE million	Esna, Nag-Hammadi and Assuit
		99.83 LE million	Delta barrages, Faraskour barrage
		53.24 LE million	Zifta and Edfina barrages
	Sub-total	292.82 LE million	
		5.00%	O&M cost

C. Allocation of Cost Among Beneficiaries

Based on the updated version of OM&R cost and the revised estimates of benefits, the following results were obtained for cost allocation among beneficiaries of the system. It must be noted that here, the time frame is 5 years instead of 30 years as considered by the ISPAN study. The rationale for this change is that here we are looking only at OM&R costs, which are expected to remain at the same level (in constant 1994 prices) in the years to come, while the ISPAN study included aspects of investment and associated changes in benefits among sectors. Results of the analysis are presented in Tables 14, 15A, and 15B.

Table 14
Cost Allocation Among Beneficiaries
(In 1994 prices)

Sector	Cost	Share
Old Agriculture	489.09	77.13%
New Agriculture	48.27	7.61%
M&I Canals	59.70	9.41%
Municipal Direct Intakes & GW	2.76	0.44%
Industry Direct Intakes & GW	6.01	0.95%
Navigation	6.33	1.00%
Tourism and Recreation	13.04	2.06%
Hydropower	5.85	0.92%
Transportation	0.94	0.15%
Flood control	0.56	0.09%
(Separable Cost)		
Fishery	1.53	0.24%
Subtotal	634.09	100.00%

Note: The above allocation does not include the LE 18.2 million allocated to flood control as a separable cost.

Table 15A
Cost of Water Services
(In December 1994 prices)

Sector	Cost (LE. million)	Volume (MCM)	Unit Cost (LE per '000 m3)
Old Agriculture	489.09	41,970	11.65
New Agriculture	48.27	4,266	11.32
M&I Canals	59.70	4,845	12.32
Municipal Direct Intakes & G	2.76	1,710	1.62
Industry Direct Intakes & GW	6.01	2,581	2.33
Navigation	6.33		
Tourism and Recreation	13.04		
Hydropower	5.85		
Transportation	0.94		
Flood control	0.56		
(Separable Cost)	0.00		
Fishery	1.53		
Subtotal	634.09	55,372	

Note: Water requirements for agriculture are based on *Irrigation System Management in Egypt Calibration of the Nile Water Resources Management Model*, Tarek Kotb, September 1992. Figures are consumptive use. Allocations for all sectors are five-year averages based on projections described in Section IV, and thus differ from 1992/3 data in Section II.

Table 15B
Cost of Agricultural Water Services

AGRICULTURAL SECTOR OLD LAND (in LE. per feddans)

Region	Irrigated Land	HAD/Stem	Irrigation/ Drainage	Pumping cost	Total Cos
Region 1 - UE	0.762	14	67	74	155
Region 2 - ME	1.524	14	42	24	80
Region 3 - ED	1.581	14	32	11	57
Region 4 - MD	1.439	14	31	12	57
Region 5 - WD	1.293	14	27	20	60
Total	6.599	14	37	23	74

AGRICULTURAL SECTOR NEW LAND (In LE. per feddan)

Region	Irrigated Land	HAD/Stem	Irrigation/ Drainage	Pumping cost	Total Cos
Region 1 - UE	0.000	0	0	0	0
Region 2 - ME	0.184	16	50	29	95
Region 3 - ED	0.000	0	0	0	0
Region 4 - MD	0.000	0	0	0	0
Region 5 - WD	0.264	16	32	24	72
Region 5A (Sinai	0.212	16	39	0	55
Total	0.660	16	39	26	82

D. Sensitivity Analysis

In order to check the robustness of the results, three different sensitivity tests were carried out. The first tested the impact on the the allocation of costs of changes in benefits in the agricultural sector of +15 percent and -15 percent, since one could expect that this is a sector subjected to more fluctuation in inputs and output prices. The results of the sensitivity test show that the costs of water services for agriculture and M&I users vary between LE 72-75 per feddan and LE 11-14 per cubic meter, respectively. Thus, the results are robust to changes in agricultural benefits.

The second test consisted on altering the benefits to new land. Instead of assuming that new land irrigation schemes are fully developed, a constant increase in the area developed, from 0.18 million feddan today to about 0.66 million feddan in year 2015 is assumed, which is the same assumption as in the ISPAN study. The results of the sensitivity test show that the cost allocated to M&I per cubic meter of water increases by 10 percent, the cost allocated to old agriculture increases by 7 percent, and the cost allocated to new land increases by 10 percent. Thus, once again the results are relatively insensitive to the pace of new land development.

Finally, since it is expected that in the future M&I will put more stress on the Nile system, the third test consisted on looking at demands from the different beneficiaries of the system in year 2015. The results of the test suggest once again that the original results of cost allocation are robust. Costs of water services in M&I, old lands, and new lands, decrease by 11 percent, 8 percent, and 12 percent respectively.

VI. PROPOSED MECHANISM FOR CHARGING FOR SERVICES

For the municipal and industrial sectors taking water directly from canals, it seems feasible to introduce water charges for raw water at the intake point of about LE 0.015 per cubic meter. Similar systems are being currently used in countries like India, Indonesia, USA, and France.

At present, the MPWWR keeps records of how much water is being delivered to each water treatment plant or to each industrial unit. Charging for raw water on a volumetric basis, apart from allowing the government to recover some of the cost of running the system, will introduce incentives for water agencies and industrial units to improve efficiency.

If the General Authority for Greater Cairo Water Utility were to pay for each cubic meter of raw water taken from the Nile system, for sure, it will be encouraged to reduce its current level of physical losses, of about 25 percent, improve metering, and increasing water prices. Before opting for passing the cost of raw water charges to the consumers impossible, the utility would seek ways to reduce its cost. Raising water rate by 15 percent to domestic users to cope with extra cost of raw water, from LE 0.10 to LE 0.12 per cubic meter, would also result in pressures from consumers on the utility to improve efficiency and reduce the cost of service.

Similarly in the industrial sector, if self-supplied firms were to bear an additional cost of about LE 0.015 per cubic meter, about 3-10 percent increase over current production cost (LE 0.15-0.50 per cubic meter), firms would have incentives to improve water use efficiency by better housekeeping, shifting from open-cooling system to a closed-cooling system, adopting cleaner technologies, and implementing wastewater reuse scheme.

Charging volumetric charges to self-supplied industries for direct water intakes from either the Nile or groundwater sources (LE 0.002 per cubic meter) may be a more difficult task, since at present there is no system in place to monitor direct water intakes. The MPWWR may think of recovering the cost of water by taxing pumping cost, e.g., increasing electricity rate by about 10 percent. Since average pumping cost is about LE 0.03 per cubic meter, a 10 percent increase on electricity rate would allow to recover about LE 0.003 per each cubic meter taken directly from the Nile system.

Fixed charges in proportion to the total OM&R costs of the Nile System should be imposed on the other non-agricultural sectors, e.g., river and ground transport 1.5 percent, tourism 2.1 percent, hydropower 1 percent, and fishery 0.3 percent.

VII. INSTITUTIONAL FRAMEWORK FOR WATER QUALITY MANAGEMENT

The purpose of this section is to provide a brief overview of three components of the current institutional framework for water quality management in Egypt: (i) organizational structure, (ii) regulatory and legislative framework, and (iii) incentives and disincentives for pollution abatement.

A. Organizational Structure

In Egypt, as in many developing countries, the organizational structure for water quality management is extremely complex mainly because of the large number of government agencies involved in one way of another with water quality management related-activities. Table 16 lists the government bodies involved in water quality management. The subsequent paragraphs describe the functional responsibilities of the most important agencies.

Table 16
Water Quality Management Organizational Structure

Level	Government Agency
Central	Ministry of Public Works and Water Resources (MPWWR) Ministry of Health (MOH) Egyptian Environmental Affairs Agency (EEAA) Ministry of Scientific Research (MSR)
Sectoral - Central	Ministry of Housing and Public Utilities (MHPU) National Organization for Potable Water and Sanitary Drainage (NOPWSD) Ministry of Local Administration (MLA) Ministry of Reconstruction and New Communities (MRNC) Ministry of Industry (MOI) Ministry of Interior (MI) Ministry of Agriculture and Land Reclamation (MALR)
Local	Ministry of Public Works and Water Resources - Regional Branches Ministry of Health - Regional Branches Egyptian Environmental Affairs Agency - Regional Branches General Organization for Greater Cairo Water Supply Cairo Waste Water Organization Alexandria Water General Authority Suez Canal Authority.

1. Ministry of Public Works and Water Resources

The Ministry of Public Works and Water Resources (MPWWR) has sole legal responsibility for the planning and management of water resources in Egypt. According to its Charter, the MPWWR is responsible for providing water of suitable quality to all users. To accomplish this goal, the Ministry has to ensure that appropriate measures are undertaken to protect both the quantity and the quality of Egypt's water resources. In practice, very little has been done. Water quality management occupies a relatively small proportion of the overall activities of MPWWR.

The Law 48 of 1982 for the protection of the Nile and its waterways assigns to MPWWR the legal responsibility over the following functions:

- Issue and cancellation of discharge permits into Egyptian waterways, which include the Nile river, canal and drainage networks, lakes, and groundwater reservoirs.
- Inspecting wastewater treatment facilities.
- Monitoring locations of intake sites for potable water treatment plants as well as municipal and industrial discharges.
- Ensuring that proper samples and analyses of discharges are carried out by the Ministry of Health.
- Levying fines for non-compliance.
- Setting regulations and specifications for discharges into water bodies.
- Issue and cancellation of licenses for new floating vessels.
- Issuing licenses for the construction of any establishment that directly discharges into waterways.

The MPWWR has delegated the water quality monitoring related tasks of both surface and groundwater to the National Water Research Center (NWRC). NWRC, in turn, consists of the following institutes:

- *The Drainage Research Institute (DRI).* In the area of water quality management, DRI is responsible for monitoring the quality and quantity of drainage water in the Nile system. At present, DRI has installed 97 monitoring water quality stations distributed along the Nile drainage system. One of DRI's functions is to provide to MPWWR with information on the availability of drainage water to be reused for agricultural purposes, predominantly in land reclamation projects. At present, DRI is preparing guidelines for the reuse of drainage water for irrigation purpose.

- *Nile Research Institute (NRI).* NRI is responsible for protecting and developing the Nile River in a sustainable and scientific manner by means of: (i) monitoring water qualify in the river channels and drainage system; (ii) assisting in the enforcement of pollution control laws related to the Nile system; (iii) evaluating and assessing the impact of new developments and interventions in water quality; and (iv) operating and maintaining a database related to water quality. NRI's total network includes 34 water quality monitoring stations along the Nile river and 60 observation stations on strategic discharge sites.

- *Research Institute for Ground Water (RIGW).* This institute is in charge of field investigations for the proper understanding of Egypt's groundwater system. Initially, RIGW's main responsibility was to provide advice to MPWWR on the development of groundwater sources for agricultural purpose. Now, RIGW is responsible for the efficient monitoring of groundwater sources in order to ensure their sustainable use by irrigation, domestic, and industrial uses. At present, RIGW has set up about 500 observation irrigation wells, and hopes to install in the near future about 150 observation drinking wells.

2. Ministry of Health

The Ministry of Health (MOH) is responsible for the public health of all Egyptian citizens. The Law 48 of 1992 assigns MOH direct responsibility for the quality of intake water for drinking and domestic purposes and the quality of municipal and industrial discharges into water bodies. The MOH performs this function through the Environmental Health Department (EHD) and the Environmental and Occupational Health Center (EOHC). The former department carries out regular sampling and analysis to ensure compliance with specifications and standards as per Law 48 of 1982. The latter department is responsible, among other things, for the monitoring of the environment, which includes the Nile River and its main canals; and for setting standards for effluent discharges, e.g., municipal, industrial, and river vessels, potable water sources, and receiving water bodies. EOHC has 10 analytical laboratory facilities for carrying out physical, chemical and bacteriological analyses.

3. Egyptian Environmental Affairs Agency

According to the New Environmental Protection Law (EPL), the Egyptian Environmental Affairs Agency (EEAA) is responsible of supporting other government bodies in implementing the Law 48 of 1982 through the design of projects and programs aiming towards capacity building on law enforcement.

The New EPL stipulates that EEAA, through the newly created Climate, Water and Environment Research Institute (CWERI), will review Environmental Impact Assessments (EIAs) of all new and expanding establishments along the banks of surface water bodies and even for new and expanding water and wastewater municipal treatment plants. It is envisaged that by means of the EIAs, the EEAA will be able to protect Egypt's water resources against further degradation since all new establishments will be required to have effective treatment of wastewater and effluent discharges.

The New EPL authorizes EEAA to establish and operate a national environment monitoring network to oversee the conditions of the environment, e.g., land, water and air. In addition, the Law gives sufficient leeway to EEAA to undertake monitoring of existing establishments, considered as high point sources of pollution. EPL also delegates authority to EEAA to supporting the implementations of alternative mechanisms for water pollution control, such as a system of water charges that reflect the scarcity value of water, and a system of sewer charges that reflect the cost of providing the service.

Another task to be fulfilled by EEAA, through CWERI, is to identifying cost-effective policies for water pollution abatement. This is a very important step towards the design of a more effective pollution control strategy.

4. Ministry of Housing and Public Utilities

The Ministry of Housing and Public Utilities (MHPU) is responsible for planning and development of the water supply and wastewater sector. The MHPU and its affiliate agencies are the sole agents for the construction of sewers and wastewater treatment facilities all over the country. Unfortunately, the planning and development of the sub-sector have not been guided by a comprehensive assessment of Egypt's environmental protection needs. Although, a relatively large share of GDP has been invested in the construction of municipal wastewater plants[11], the impacts of the investments on the environment are minimal. In the past, rural water supply and sanitation as well as industrial pollution control have not received adequate attention. Priority on investments should be guided by a comprehensive water management and pollution control strategy for the Nile basin.

The bodies affiliated to MHPU responsible for water supply and wastewater management activities are the following: the National Organization for Potable Water and Sanitary Drainage (NOPWSD) , the General Organization for Greater Cairo Water Supply, the Cairo Waste Water Organization, the Alexandria Water General Authority, and the Suez Canal Authority.

5. Ministry of Industry

Within GOFI, the Environmental Management Department is in charge of providing technical advice to industrial firms for complying with a MOI decree of 1982 that stipulates that all industrial facilities must install and operate water pollution abatement equipment to conform with Law 48 of 1982.

6. Ministry of Agriculture and Land Reclamation (MALR)

The Ministry of Agriculture and Land Reclamation (MALR), through the Soils and Water Research Institute (SWRI), is responsible for conducting research in support of the sustainable development of the agricultural sector. SWRI's main activities in the area of water quality management include the setting of policies on the use of fertilizers; the classification of water resources and soils; and the monitoring of water and soil quality for agricultural purpose. At present, SWRI relies on a modern laboratory for physical, chemical and biological analyses of both water and soil.

7. Ministry of Scientific Research

Until 1982, the Ministry of Scientific Research (MSR), through the National Research Center (NRC), was responsible for a relatively large water quality monitoring program of the Nile system. At present, due to financial constraints, NRC is responsible for monitoring only a small number of existing water and wastewater treatment plants in the Great Cairo area and a small number of pumping stations.

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11 The GOE with the support of bilateral donors has built about 50 municipal wastewater treatment plants through out the country. There are other 50 plants under construction. Future investment plans in the sector contemplate the construction of 160 plants aiming to provide "all governorates and cities in Egypt with wastewater systems" [The World Bank (1993)].

B. Legislative Framework

There are numerous laws and regulations that govern water quality management in Egypt. The most important of these laws and regulations are the following:

- *Wastewater Discharges into Sewerage System:* The Law 93 of 1962 stipulates standards for wastewater discharges into the sewerage system. It also stipulates that permits have to be obtained for the discharge of raw wastewater into public sewerage systems. It gives responsibility to both MOH and MHPU for monitoring discharges to municipal sewerage systems. This Law has been replaced by Law 48 of 1982.

- *Regulation of Water Resources and Treatment of Wastewater:* The Law 27 of 1978 regulates all public water sources for drinking purposes. It authorizes the MOH to set standards and specifications for potable water. This Law has been replaced by Law 48 of 1982.

- *Protection of the River Nile and its Waterways:* The Law 48 of 1982 regulates the discharge of waste and wastewater into the Nile and its waterways and set standards for the quality of effluents. This Law stipulates clear responsibilities on the MPWWR and the MOH in monitoring the conditions of effluents discharged into the various water bodies, including the Nile river and its associated drain system, lakes and groundwater, ensuring that the quality is within the water quality standards set by the Law. According to this Law, the MOH has the obligation of carrying out periodic sampling and analyzing of wastewater and waste discharges from establishments that are permitted to discharge to waterways and reporting back to the MPWWR. This Law is partially enforced.

- *Industrial Water Pollution Control:* The MOI decree 380 of 1982 stipulates that all industrial companies, including GOFI, have to operate and maintain water pollution equipment to meet environmental standards. This law is hardly enforced.

- *The New Environmental Protection Law:* The Law 4 of 1994 redefines the role of the EEAA, and stipulates that this agency is the highest government body responsible for the coordination and supervision of environmental affairs is Egypt. Concerning water resources, this Law specifies that the Law 48 still remains in force. It authorizes the setting of an Environmental Fund to finance EEAA's activities.

C. Incentives and Disincentives for Water Quality Control

There are two sets of instruments for water quality control: (i) command and control instruments; and (ii) market-based incentives. Although in the past the GOE has relied mainly on the former, it seems that now attention is being given to the latter approach. Next paragraphs describe the set of instruments already in use under each approach.

1. Command and Control Instruments

They include any regulation that imposes constraint regarding water use, water using technologies, and effluent discharges. Among the instruments being used at present in Egypt, there are the following:

Regulations. The Law 48 of 1982 has formulated concentration-based water quality standards for effluents and fresh and saline water bodies. The standards established in the Law are as follows:

- Fresh water bodies receiving treated industrial effluent;
- Treated industrial effluent being discharged into fresh water bodies and groundwater reservoirs. There are different standards for the Nile river, its canal system, and groundwater sources.
- Treated industrial effluents for volumes less than 100 cubic meter per day.
- Drainage water to be mixed with fresh water for irrigation purpose.
- Municipal and industrial effluents discharging into brackish or saline water bodies.
- Brackish or saline surface water bodies receiving treated municipal or industrial effluents.

Since the standards are concentration-based and not pollution load-based, many industrial firms have resorted to dilution as a means to comply with the law -- a solution which conforms to the Law without any beneficial impact on pollution levels.

Although water resources are used for different purposes (drinking, irrigation, and fishing), quality standards for receiving water bodies are similar across the border. As a result, some water courses are subjected to looser standards, while others are subjected to stricter ones. Thus, some efforts should be directed to classify water bodies according to their potential use (?).

Penalty Fees. The Law 48 of 1982 stipulates penalty fines for non-compliance with the Law, which range between small monetary sums (LE 500 to LE 2,000), to imprisonment

Environmental Impact Assessment. The New EPL proposes the implementation of a new command and control instrument for pollution abatement: requiring Environmental Impact Assessments (EIAs). The EIA will be are a pre-requisite for all new establishments applying for licenses or for existing establishments looking for expansion. According to the New EPL, Line Ministries are responsible for the preparation of the EIAs and upon completion they should be forwarded to EEAA for approval.

2. Market-Based Incentives

These include any measure that acts as an incentive for water users and polluters allowing them to determine the most efficient and effective way water use and pollution abatement pattern. The New EPL provides with a number of financial incentives aiming to control pollution of water sources.

Environmental Fund. With the establishment of this fund, money from different sources will be made available for environmental protection projects. Regarding the water sector, the fund will provide soft-loans to industrial firms for pollution abatement projects such as recycling and reuse of treated effluents as well as for setting up small-scale pilot demonstration projects.

Effluent and Sewer Charges. EEAA is already in the process of studying other economic instruments, namely effluent and sewer charges, which are suitable for the Egyptian context.

D. Evaluation of Current Institutional Framework

- *Lack of Enforcement.* At present there is lack of capacity within the MPWWR to enforce the regulations dealing with water quality. Government-owned enterprises, considered the main polluters, get special treatment on the basis that the government cannot fine them or force their closing.

- *Conflict of Responsibilities:* The Law 4/1994 stipulates that EEAA will supervise and operate the national monitoring network, for which an environmental information center will be established within EEAA. The Law 48/1984 assigns the same responsibility to the MPWWR. This also calls for the reliance on different institutions for basic data sampling, analysis, processing, and storing.

- *Initiatives Under Way to Improve Water Quality Management*: The GOE has already established: (i) the High Committee for the Nile, chaired by the Minister of MPPWR and comprised by representatives of MOI, MALR, MHPU, and MEE, is responsible for the protection of the Nile River in term of its quality and quantity; (ii) the *National Water Quality Conservation Unit (NWCU),* which responds to the need of better information on water quality, is the focal point on water quality information in Egypt and aims to serve as a bridge between generators of data and users of information; (iii) *National Water Quality Conservation Program Advisory Committee,* instituted the National Water Quality Conservation Program Advisory Committee, is supposed to guide the program of the NWCU and includes representatives of the several government bodies dealing with water quality matters, e.g., DRI, RIGW, NRC, agencies

Table 17

Planned and On-going Water Quality Management Related Projects

Project	Funded By/Status	Area of Concentration	Description
Secondary City Project	USAID Ongoing	Water supply and wastewater sector	Extension of water supply and sanitary services to 8 secondary cities through out the country.
Water Quality Monitoring System	USAID Ongoing	Monitoring of water quality	Creation of a National; Water Quality Monitoring Unit within the National Water Research Center
River Nile Protection and Development Project - Phase II	CIDA Ongoing	Monitoring of water quality in the Nile system	Development of a Nile water strategy research unit within the National Water Research Center and establishment of a Central Laboratory for environmental quality Monitoring
Environmental Management of Groundwater Resources	DGIC Ongoing	Monitoring of groundwater quality	Establishment of pilot scale projects for studying groundwater pollution and identifying interaction between surface and groundwater quality.
Strengthening Planning Sector of the Ministry of Public Works and Water Resources	DGIC Ongoing	Identifying strategies for water quality management	Development of a decision support system for the evaluation of alternative instruments for water quality control.
Monitoring and Analysis of Drainage Water Quality	DGIC Planned	Monitoring of drainage water quality	Upgrading and extension of the existing drainage water monitoring network.
Integrated National Water Quality Monitoring System	DGIC Planned	Monitoring of water quality.	Strengthening current institutional framework for monitoring of water quality.
Environmental Fund Project	World Bank Planned	Provision of financial incentives	Establishing economic incentives for industrial water pollution abatement projects.

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Annex I

Table 1: Water Supply Coverage, Population Connected and Non-Connected

Item/Area	Actual 1986	Projected 1995	2000	2015	2025
Coverage			5%	15%	10%
Cairo	87%	95%	100%	100%	100%
Alexandria	93%	98%	100%	100%	100%
Port Said	86%	96%	100%	100%	100%
Suez	86%	96%	100%	100%	100%
Other urban	70%	80%	85%	100%	100%
Rural	40%	45%	50%	65%	75%
Population Connected					
Cairo	7.66	10.19	11.98	16.19	19.40
Alexandria	2.72	3.54	4.06	5.62	6.84
Port Said	0.34	0.47	0.56	0.77	0.94
Suez	0.28	0.39	0.46	0.63	0.77
Other urban	4.88	7.03	8.50	14.31	17.82
Rural	10.61	14.77	18.48	33.30	46.83
Total	26.48	36.40	44.04	70.82	92.61
Population Non-Connected					
Cairo	1.14	0.54	0.00	0.00	0.00
Alexandria	0.20	0.07	0.00	0.00	0.00
Port Said	0.06	0.02	0.00	0.00	0.00
Suez	0.05	0.02	0.00	0.00	0.00
Other urban	2.09	1.76	1.50	0.00	0.00
Rural	15.91	18.06	18.48	17.93	15.61
Total	19.45	20.46	19.98	17.93	15.61

Note: The EXCEL spreadsheet developed under this task to simulate future municipal water demand and production is available from IIMI under request.

Table 2: Total Municipal Water Production Higest Scenario, 1986 - 2025
(In million cubic meters per year)

Item/Area	Actual 1986	Projected 1995	2000	2015	2025
Domestic					
Cairo	363	534	674	1133	1570
Alexandria	178	256	317	544	766
Port Said	18	27	34	58	82
Suez	6	9	12	20	29
Other urban	134	212	276	578	832
Rural	194	298	400	896	1458
Non-connected	320	371	389	434	437
Sub-Total	1212	1707	2102	3665	5174
Industrial					
Cairo	48	71	92	172	262
Alexandria	35	50	64	123	190
Port Said	2	2	3	6	9
Suez	2	3	5	9	13
Other urban	18	29	38	90	142
Rural	19	30	42	104	186
Non-connected	0	0	0	0	0
Sub-Total	123	185	243	503	802
Others					
Cairo	98	130	153	207	248
Alexandria	37	48	55	76	92
Port Said	4	6	7	9	11
Suez	13	18	21	30	36
Other urban	53	77	93	157	195
Rural	58	81	101	182	256
Non-connected	0	0	0	0	0
Sub-Total	263	360	430	661	839
Losses in the System					
Cairo	377	545	682	1121	1543
Alexandria	173	246	302	516	728
Port Said	17	25	32	53	75
Suez	16	23	28	43	58
Other urban	134	207	266	538	762
Rural	155	233	310	676	1086
Non-connected	0	0	0	0	0
Sub-Total	872	1280	1620	2948	4251
Total Municipal Demand	2470	3533	4395	7776	11066

Assumptions:

1. Between 1995 and 2025 there will be an annual real increase in income per capita of 2% . Similarly, industrial investment will experience a real increase of 4% between 1995 and 2000, 4.5% between 2000 and 2015, and 5% between 2015 and 2025.
2. No real increase will take place between 1995 and 2025.

Table 2: Total Municipal Water Production Higest Scenario, 1986 - 2025

(In million cubic meters per year)

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Rural	19	30	42	104	186
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Sub-Total	123	185	243	503	802
Others					
Cairo	98	130	153	207	248
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Port Said	4	6	7	9	11
Suez	13	18	21	30	36
Other urban	53	77	93	157	195
Rural	58	81	101	182	256
Non-connected	0	0	0	0	0
Sub-Total	263	360	430	661	839
Losses in the System					
Cairo	377	545	682	1121	1543
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Port Said	17	25	32	53	75
Suez	16	23	28	43	58
Other urban	134	207	266	538	762
Rural	155	233	310	676	1086
Non-connected	0	0	0	0	0
Sub-Total	872	1280	1620	2948	4251
Total Municipal Demand	2470	3533	4395	7776	11066

Assumptions:

1. Between 1995 and 2025 there will be an annual real increase in income per capita of 2% . Similarly, industrial investment will experience a real increase of 4% between 1995 and 2000, 4.5% between 2000 and 2015, and 5% between 2015 and 2025.
2. No real increase will take place between 1995 and 2025.
3. There will be no improvements in the level of unaccounted-for water.

Table 3: Total Municipal Water Production Lowest Scenario, 1986 - 2025

(In million cubic meters per year)

Item/Area	Actual 1986	Projected 1995	2000	2015	2025
Domestic					
Cairo	363	534	631	1010	1356
Alexandria	178	256	305	501	683
Port Said	18	27	32	52	72
Suez	6	9	11	18	25
Other urban	134	212	256	434	605
Rural	194	298	354	582	795
Non-connected	320	371	442	728	995
Sub-Total	1212	1707	2032	3326	4532
Industrial					
Cairo	48	71	82	128	173
Alexandria	35	50	59	94	129
Port Said	2	2	3	4	6
Suez	2	3	4	7	9
Other urban	18	29	34	56	79
Rural	19	30	35	57	77
Non-connected	0	0	0	0	0
Sub-Total	123	185	217	346	473
Others					
Cairo	98	130	145	196	235
Alexandria	37	48	54	74	90
Port Said	4	6	6	9	11
Suez	13	18	21	29	35
Other urban	53	77	88	125	156
Rural	58	81	91	126	154
Non-connected	0	0	0	0	0
Sub-Total	263	360	405	560	682
Losses in the System					
Cairo	377	545	551	723	780
Alexandria	173	246	249	331	356
Port Said	17	25	26	35	38
Suez	16	23	23	29	30
Other urban	134	207	208	278	296
Rural	155	233	227	284	279
Non-connected	0	0	0	0	0
Sub-Total	872	1280	1283	1680	1778
Total Municipal Demand	2470	3533	3936	5913	7464

Assumptions:

1. Between 1995 and 2025 there will be an annual real increase in income per capita of 2%. Similarly, industrial investment will experience a real increase of 4% between 1995 and 2000, 4.5% between 2000 and 2015, and 5% between 2015 and 2025.
2. Domestic water price will increase at an annual rate of 2%, while industrial water price will increase at an annual rate of 4% between 1995 and 2025.
3. The level of unaccounted-for water will go down from 40% in 1995 to 30% by year 2025.

Table 4: Total Municipal Water Production Best Scenario, 1986 - 2025
(In million cubic meters per year)

Item/Area	Actual 1986	Projected 1995	2000	2015	2025
Domestic					
Cairo	363	534	664	1063	1428
Alexandria	178	256	312	511	697
Port Said	18	27	33	55	74
Suez	6	9	12	19	26
Other urban	134	212	272	542	757
Rural	194	298	394	841	1325
Non-connected	320	371	383	408	398
Sub-Total	1212	1707	2069	3440	4705
Industrial					
Cairo	48	71	86	135	182
Alexandria	35	50	60	96	132
Port Said	2	2	3	5	6
Suez	2	3	4	7	9
Other urban	18	29	36	70	98
Rural	19	30	39	82	129
Non-connected	0	0	0	0	0
Sub-Total	123	185	229	395	557
Others					
Cairo	98	130	153	207	248
Alexandria	37	48	55	76	92
Port Said	4	6	7	9	11
Suez	13	18	21	30	36
Other urban	53	77	93	157	195
Rural	58	81	101	182	256
Non-connected	0	0	0	0	0
Sub-Total	263	360	430	661	839
Losses in the System					
Cairo	377	545	625	902	1099
Alexandria	173	246	275	406	501
Port Said	17	25	29	43	53
Suez	16	23	26	35	42
Other urban	134	207	241	425	527
Rural	155	233	279	521	721
Non-connected	0	0	0	0	0
Sub-Total	872	1280	1474	2332	2944
Total Municipal Demand	2470	3533	4203	6827	9045

Assumptions:

1. Between 1995 and 2025 there will be an annual real increase in income per capita of 2% . Similarly, industrial investment will experience a real increase of 4% between 1995 and 2000, 4.5% between 2000 and 2015, and 5% between 2015 and 2025.
2. Domestic and industrial water prices will increase at annual rates of 2% and 4%, respectively.
3. The level of unaccounted-for water will go down from 40% in 1995 to 35% by year 2025.

Annex II
Household Water Survey

In order to assess how much is already being paid for water by those low-income communities nearby Cairo and the nature of the service provided, two members of the Cost Recovery Task Force and the author conducted non-structured interviews in settlements of Shubra and Imbaba. This Annex reports the main findings of the field surveys.

1. Began and Menti in Shubra, El Hena

Households in these communities depend on more than one water source. A large percentage of them have piped water connections, but water service is intermittent. On average, households receive water about 4-5 hours a day, 2-3 days a week. In order to cope with the unreliable and inadequate water supply system, households have adopted a wide range of strategies, ranging from installing hand-pumps in their front yards to participating in community actions to share electric groundwater pumps with neighbors.

In the latter situation, on average 6-8 households share one electric pump. According to the interviewed households, although the water table is relatively shallow, they need to go to depths of 30 - 35 meters to get water of good quality. Pump sizes range between 1/2 and 1 1/2 HP and are operated between 1.0 -1.5 hours per day every other day of the week. Discharge rates vary between 4.2 - 4.8 cubic meters per hour.

Poor households pay a relatively high toll to compensate for the inadequacy of piped water supply services. On average, a 5-member household would pay LE 6.7 per month for 23 cubic meters of water. Thus, on average they pay about LE 0.31 per cubic meter of water compared to the LE 0.10 per cubic meter paid for a household connection. The above figure is estimated on the following basis:

- For the intermittent piped water supply service, the household has to pay a flat fee of LE 2 per month whether or not they get water. On average, a household receives 8 cubic meters per month from this source. (Unit cost of piped water supply is LE 0.25)
- The cost of pumping water is about LE 4.7 per month for a total consumption of 15 cubic meters per month. (Unit cost of groundwater supply is LE 0.31[12]).

Those households who live in apartment building share the water bill among all units. The typical water bill is about LE 5-7 per month. Thus, for a typical consumption of 30 cubic meters per month, these households are paying LE 0.2 per cubic meter.

Those who have access to an irrigation canal use this source for washing utensils, bathing, clothing washing, etc.

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12 This figure includes: (i) the cost of the motorized pump estimated at about LE. 0.17 per hour or LE. 0.04 per cubic meter; (ii) the cost of electricity estimated at LE. 0.03 per hour or LE. 0.01 per cubic meter ; (iii) the opportunity cost of pumping water is about LE. 0.5 per hour or LE. 0.10 per cubic meter; (iv) the cost of the water filter estimated at LE. 0.27 per hour or LE. 0.06 per cubic meter; and (v) the cost of well drilling estimated at LE. 0.45 per hour or LE. 0.10 per cubic meter.

Some households have access to piped water, they share their connection with those who are less fortunate. Water is provided free of charge.

2. *Westerver and Munire in Imbaba*

Some households in this community rely on two water sources: groundwater and street vendors. Water from street vendors is reserved for drinking and cooking purposes. In general, a household of about 5 members uses about one cubic meter of water per week. The associated water cost is about LE 4 per cubic meter. Those who live above the first floor have to bear an additional cost for pumping the water to their flats--the water vendor provides the pump service, but the household has to provide the electricity.

According to a water vendor, he gets the water free of charge from a public standpoint. Thus the price he charges for water is basically the cost of delivering the water to remote neighborhoods. Household income information was hard to get, but one can use as an indicator the income reported by the water vendor. He claims that he only makes 2 trips per day, and 12 trips per week. So, his weekly income is LE 48.

There are some households that pay LE 4 per cubic meters for a daily per capita consumption of about 30 liters. These households spend about around 1/12th or 8.5 percent of their income on water. (This figure does not include the associated electricity cost.)

Annex IV
Industrial Water Use Survey

In order to get an estimates of industrial water costs, water use per unit of output coefficients, pollution abatement costs, water use, and effluent discharge, managers of three industrial firms were interviewed. Two firms belong to the metal sub-sector and one belongs to the textile sector. This Annex presents the main findings of the field surveys.

1. Unit Name: Misr Helwen Spinning and Weaving Co.

Industrial Sub-sector: Textile
Unit Name: Misr Helwen Spinning and Weaving Co.
Type of industry: Government
Age: 45 years
Interviewed persons: Eng. Wagi and Eng. Merphat, Engineering Department

Production
- Products: Manufactured fabrics, cotton, threading
- Volume of production: About 8,000 ton/year (weaving)
- Total output: About US$ 5.6 million or LE 19 million per year
- Employment: (skilled and non-skilled): 12,000-13,000/year
- Total production cost: Not given
- Plans for expansion: Output by year 2000/2010 (No future plans)

Water Use and Associated Cost
- Total water use: 3 water pumps (only one is currently used, the other 2 are stand-by) each of 500-750 cubic meter per hour (24 hours per day) ==> 4.38 MCM per year (max 6.57 MCM).
- Potable water production is about 100 cubic meters per hour or 0.88 MCM per year.
- Direct intake: 4,380,000 m3/year @ LE 0.52 per cubic meter average cost (including chemical, labor, and energy costs).
- Groundwater: Not used.
- How much more water is required to cope with future expansion plans? Not applicable
- Will production expansion be constrained by water availability? Water availability is not a constraint. The constraint is the maximum capacity of the water plant.

Discharge and Associated Pollution Abatement Cost
- Total effluent:
  Industrial effluent = 300 cubic meters per hour or 2.63 MCM per year.
  Sanitary effluent = 100 cubic meters per hour or 0.88 MCM per year.
  Cooling = 50 cubic meters per hour (recycling) or 0.44 MCM per year
  Boiler = 50 cubic meters per hour (evaporation) or 0.44 MCM per year
- Effluent quality: (Taken from EEAA database as of December 1994)
  COD = 360 mg/l or 950 tons per year.
  BOD = 158 mg/l or 415 tons per year.
  TDS = 1145 mg/l or 3,000 tons per year.

SS = 741 mg/l or 1,950 tons per year.
Oil = 5 mg/l
HM = 0.58 mg/l
PH = 7.2
The is no problem with the quality of the industrial effluent. Concentration of pollutants is within the effluent standards even the pH (about 8) and color. From time to time, the color of the effluent seems to receive the attention of the regulator.

- Cost of wastewater treatment: Annual, capital and O&M treatment plant. (Not given)
- Quality of inflow: Almost the same quality for the past 10 years.
- Point of discharge: Industrial effluent is discharged to a private drainage canal while the sanitary effluent without any treatment is discharged to the sewerage pipeline. Since the industrial effluent meets all effluent standards, the industrial unit can now use a drainage canal that runs close by for discharge this effluent.
- Is there any sewerage fee paid to the water utility?
  No.

Water Conservation and Pollution Abatement Plans

- Is the firm complying with current effluent standards?
  Yes.
- What will the management of the firm do in case that regulations become more stringent?
  Not applicable.
- What will be the cost involved in order to cope with regulations?
  Not applicable
- Is the industrial unit making plans for conserving water intake and reducing pollution loads? (e.g., better housekeeping, increasing recycling and reusing treated effluent)
  In 1988-89, the management of the firm commissioned a study for reusing treated effluent for industrial purposes. The cost of the reuse scheme was so high (compared to the current cost of water) that the management decided to put the study on the shelves.

Indicators:

Industrial water use: About 550 cubic meters per ton.
(In 1978 the coefficient was 400 - 500 cubic meters per ton).
About 350 cubic meters per employee.
About 230 cubic meters per thousand LE of output.

Potable water use: About 70 cubic meter per person per year, or 192 lcd.

Consumptive use: 10 percent of intake, or 55 cubic meters per ton.

2. *Unit Name: National Metal Industries, Co. in Abu Zaabal*

Industrial Sub-sector: Metal
Type of industry: Public
Age: 48 years

Production

- Products: Mainly steel reinforcement bars (hot rolled steel bars), plain and ribbed rounds.
- Volume of production: 200,000 ton/year of pre-finished reinforcement bars and 170,000 ton/year of finished reinforcement bars.
- Total output: LE170 million per year
- Employment: (skilled and non-skilled): 3,200 per year (3 shifts per day or 24 hours).
- Total production cost: Not given
- Plans for expansion: No expansion, but modernization is being planned.

Water Use and Associated Cost

- <u>Water use and associated cost</u>

  The company uses 25.2 MCM per year of water from the Ismalaya canal mainly for cooling purposes. Most of the intake water is used just once and then discharged back to an agricultural drain, the Kashmir canal. The company uses a closed system for the cooling of rolled steel bars. Total withdrawal for this purpose is only 1.2 MCM per year. Consumptive use in this firm is almost negligible, only 2 percent. Associated water costs are mainly electricity and added chemical for the water used in the closed-cooling system. Total cost of cooling water is on the range of LE 50,000 to LE 70,000 per year. Thus, the unit cost of water lies something in between LE 0.002 and LE 0.003 per cubic meter. These figures do not include capital cost.

  For the production of drinking water, the company annually withdraws about 0.3 MCM from groundwater sources. It seems that the quality of water from the Ismalaya canal is too polluted to be used for drinking purpose. The management of the company did not provide information on the cost of groundwater.

- <u>Effluent Discharges and Pollution Abatement Cost</u>

  Total cooling discharge is about 25.9 MCM per year. The management claims that the only transformation suffered by the intake water before it is discharged back to the system is reheating, i.e., temperature of the water increases by 10° C. Thus, water does not suffer chemical transformation. However, the results of chemical tests of water at the intake point and at the discharge point show that several parameters actually increase in concentration. For example, the TSS concentration goes from 2 mg/l to 40 mg/l. Similarly, the TDS concentration goes up from 102 mg/l to 165 mg/l. Additional pollution loads are as follows: 1000 ton of TSS, 1,600 tons of TDS, 100 tons of sulfates, and 130 tons of phosphates per year.

  The company does not bear any pollution abatement cost, except the cost associated with the closed-system, which amounts about LE 47,000 per year. For estimating the

cost of water per unit of reduction in water use, one can assume that because of the closed-system the firm has been able to reduce intake water from 10 MCM to 1.2 MCM (a 88 percent reduction) at a cost of LE 47,000 per year. Thus, the O&M cost of saved water is about LE 0.005 per cubic meter.

Water Conservation and Pollution Abatement Plans

- According to the management, the firm is complying with all effluent standards. In terms of pollution concentration things are satisfactory, but in terms of pollution loads, levels are huge.
- The management is planning for shifting from a once through cooling system to a closed-system. Feasibility studies for this shift are already available, but at present the company can not bear 100% of the total capital cost. Financial incentives in the sort of grants or soft-loans could be appropriate.

Indicators

Cooling water use:	155 cubic meters per ton of finished product (In 1978 the coefficient was 122 cubic meters per ton). 8,250 cubic meters per employee 155 cubic meters per thousand LE of output
Drinking water use:	About 88 cubic meters per employee per year or 240 lcd
Consumptive use:	About 2 percent of intake water or 3 cubic meters per ton.

3. Unit Name: Egyptian Iron and Steel Co. in Helwan

Industrial Sub-sector: Metal
Type of industry: Public
Age: 38 years (Originally under German management, between 1964-1971 under Russian management)

Production

- Products: Heavy parts and sheets (steel plates and sections).
- Volume of production: 1,000,000 ton per year
- Total output: LE1.0 billion per year
- Employment: (skilled and non-skilled): 25,000
- Total production cost: No given
- Plans for expansion: About 2 million tons by year 2000.

Water Use and Associated Cost

- Total water use:
  5,000 m3/h (make-up water) 43.8 MCM per year
  28,000 m3/h (recycling) 244 MCM per year
  1,500 m3/h (drinking water) 13.1 MCM per year
  (to satisfy the needs of about 10,000 people in the surrounding communities).
- Water for both purposes is taken directly from a pumping house under the management of the Cairo Water Utility, Helwan branch. When the company was small in size, it used to manage the pumping house directly. Now the company has increased in size and it is cheaper relying on outsider for the provision of water service (large economies of scale).

- Associated water cost:
  The industrial unit was paying on average LE 0.11 per cubic meter. It stopped water payment after the Cairo Water Authority increased water price to LE 0.20 per cubic meter. (This rate is supposed to cover capital and O&M costs, e.g., treatment and pumping cost.) The management claims that the cost for this industrial firm should be much lower since they had contributed with 100% of the financing for building the pumping house.) No agreement with water rate has been achieved yet. Actual water and sewerage rates are as follows: industrial LE 0.09 per cubic meter and domestic LE 0.15 per cubic meter.
- How much more water is required to cope with future expansion plans?
  Since there are not plans for water conservation, probably the industrial unit will require double volume of water by year 2000.
- Will production expansion be constrained by water availability?
  The management of the company claims that there is enough water available in the Nile to satisfy the plant's future water needs. Moreover, when one mentions the possibility of water constraint in the future, the management immediately indicates that there is enough capacity at the pumping house even to triple current water requirements. (This pumping house was built to satisfy both this industrial unit's water requirements and the requirements of the communities surrounding it -- 10,000 people at present). Total

capacity of the pumping house is about 33,600 cubic meter per hour or 242 MCM per year.

Discharge and Associated Pollution Abatement Cost

- Total effluent: 2,500 m3 per hour or 21.9 MCM per year (industrial effluent)
  1,350 m3 per hour or 11.8 MCM per year (sanitary effluent)
- Effluent quality: (Taken from the EEAA database as of December 1994)
  COD = 256 mg/l or 5,600 tons per year
  BOD = 280 mg/l or 6,130 tons per year
  TSS = 648 mg/l or 14,200 tons per year
  SS = 10 mg/l or 220 tons per year
- Cost of wastewater treatment: About 2,500 m3 per hour or 26.3 MCM per year are being treated within the industry. The management claims that the associated O&M cost is about LE 63,000 per year or LE 0.003 per cubic meter.
- Cost of recycling water is: About 244 MCM are being recycled at a total cost of LE 14 million. Unitary recycling cost is LE 0.06 per cubic meter (it includes treatment and recycling).
- Point of discharge: Industrial effluent is discharged into a drainage canal that then goes to the desert, while the sanitary effluent is discharged into the sewerage system.
- Is there any sewerage fee paid to the water utility?
  This fee is included into the water bill.

Water Conservation and Pollution Abatement Plans

- Is the firm complaining with current effluent standards?
  The management claims that the unit meets all effluent standards. There are plans for shifting from an open system to a close system with a much higher rate of reuse and recycling.
- What will the management of the firm do in case that regulations become more stringent? No applicable.
- What will be the cost involved in order to cope with regulations? No applicable.
- Is the industrial unit making plans for conserving water intake and reducing pollution loads? (e.g., better housekeeping, increasing recycling and reusing treated effluent)
  Yes. Moving to a closed system.
- What do you think about current local expertise? Are there enough local consulting firms? Would you like to get technical assistance from the government? Is there any other request?
  Limited local expertise. The management feels the need for having a comprehensive study of water use and wastewater, since at present the problem is being handled in a sub-sectoral manner.

Indicators

Intake water use: 44 cubic meters per ton
(In 1978 the coefficient was 62 cubic meters per ton).
1750 cubic meter per employee per year
44 cubic meters per thousand LE of output

Recycling water use:	244 cubic meters per ton per year 9,760 cubic meters per employee per year 244 cubic meters per thousand LE of output.
Consumptive use:	50 percent of intake water
Drinking water use:	375 cubic meters per person or 1000 lcd.

Annex III
Water Pollution Cost: Helwan Water Treatment Cost

At present, very little empirical work has been done to evaluate the cost imposed to the economy by water pollution in the Nile System, let alone to estimate the environmental damage. In order to throw some light into this subject, the author has investigated the major impact on the cost of water supply of the Helwan water treatment plant after the quality of the intake water deteriorates mainly because industrial units located upstream of the plant drain their recirculation water. This event occurs during one month of the year.

In order to improve the intake water quality, the management of the plant has to increase the dosage of chemicals in the treatment process, which in turn increases the treatment cost of water supply. According to the chemical engineer responsible for the water laboratory, the treatment of the increasingly polluted raw water demands an increase in the dosage of alum powder from 30 g. per cubic meter to about 70 g. per cubic meter. Since cost of alum is about LE 1 per kg., the incremental treatment cost is LE 0.04 per cubic meter of water.

Experiences in other countries show that dosage rates for other chemicals such as lime, chlorine, and polymer would have to be increased as well. However, they were not reported during the field visit. Roughly, one can say that lime dosage will need to go up by 5 g. per cubic meter, chlorine by 10 g. per cubic meter, and polymer by 0.02 g. per cubic meter. The costs per kilogram of these chemicals can be assumed as LE 0.5 for lime, LE 5 for chlorine, and LE 80 for polymer. Thus, the associated cost of increasing these latter dosage rates is about LE 0.05 per cubic meter.

Upgrading raw water quality has a total cost of LE 0.09 per cubic meter. This represents about 16 percent increase in the production cost[13]. (The reported cost of water in Cairo is about LE 0.55 per cubic meter.) Since the total capacity of the plant is 6,000 cubic meter per hour, then during the month when industrial discharges take place, the cost to the economy is about LE 400,000.

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13 It is well known that poor raw water quality inhibits the productivity of water treatment plants. Unfortunately, in this particular case, data do not exist to evaluate this loss in productivity.

Annex IV
Cost of Water Treatment
(In LE. per cubic meter)

Cost	**Intake Water Quality**				**Unit Cost**
	Very goo	**Good**	**Fair**	**Bad**	(in LE. per Kg
Chemical dose (g/m^3)					
- Alum	0.00	20.00	30.00	50.00	1.00
- Lime	0.00	20.00	15.00	20.00	0.50
- Cl2	8.00	8.00	8.00	18.00	5.00
- Polymer	0.00	0.02	0.03	0.05	80.00
- Active coal	0.00	0.00	3.00	3.00	8.00
Other costs ($LE./m^3$)					
- Energy	0.0005	0.0012	0.0017	0.0027	0.1 LE/KWh
- Labor	0.0010	0.0015	0.0015	0.0015	
Total Cost ($LE./m^3$)	0.04	0.07	0.11	0.18	

Source: Government of Indonesia, "Jabotabek Water Resources Management Study," January 1994.

Annex V
Cost of Saved Water in the Industrial and Agricultural Sectors

Industrial Sector

A recent study on the Pulp and Paper industrial sub-sector in Egypt [UNDP (1994)] provides a future outlook of the sector and identifies potential means to reduce water and energy pollution loads. This annex briefly summaries the main findings of the study, focusing on options for improving water use efficiency and reducing pollution loads. The study concludes that within the Pulp and Paper sub-sector, there are "win-win" solutions worth exploring. From the point of view of the company, investments in pollution control projects mean reduction of production cost (only reduction of chemical -- recovery projects); from the point of view of the society, these projects mean enormous savings in water that could be available for other beneficial uses and less pollution loads into the environment.

The study looks at the Rakta company, a government-owned enterprise, with a total capacity of 89,000 tons per year (67,000 of paper and 22,0000 tons of board) and a 1990/91 production level of 74,000 tons (54,000 of paper and 20,000 of board). At present, the firm employees some 2,400 people. Enforcement of Law 48/1984 calls for a reduction of water pollution. If pollution cannot be reduced, the result would be closing it down and laying off all workers.

Water pollution is the most serious environmental problem caused by the pulp and paper sub-sector. In Rakta, total pollution load has been assessed at 80,000 kg of BOD per day. About 90 percent of the pollution is coming from Filter No 1 after cooking and washing in the digester section takes place. The effluent, commonly called black liquor, is equivalent to the pollution caused by a city of about 1.6 million people.

Although Rakta has in place a rotary vacuum filter system for washing the effluent coming from the digester, counter-current washing is not practiced because the large deposition of silica on the filters and blocking of filter pores. Rakta is not interested in practicing recovery of pulping chemicals. The current mode of operation consists on an open system of discharge from the seal tanks and use of fresh water for washing and wire cleaning. Thus, dilution is being practiced to reduce the concentration load of solid to about 2%, while about 150 cubic meter of wastewater is generated per ton of pulp produced in the pulping section. If counter current washing were practiced, volume of wastewater could be reduced to 15 cubic meters per ton with a concentration of solids of 8 percent. Massive dilution is being practiced at present.

At present Rakta uses about 360 cubic meters of water per each ton of paper. In 1978, the water use coefficient was assessed at only 194 cubic meter per ton. One reason could be that the industry is using much more water than technically needed in order to comply with water quality standards.

The average concentration of the effluent is about 1,000 mg/l while the maximum allowable limit according to the Law 48 of 1984 is only 60 mg/l. Enforcement of the Law

requires a solution to the effluent released from the filter plant. Options open to the management of the firm are: end-of pipeline treatment system, and cleaner production process. The former option, which consists on introduction of waste water treatment measures to meet water quality standards, has a cost ranging between $430 - $500 per ton of paper, whether process improvements take place. The latter option consists on the introduction of cleaner production methods in all sections of the pulp a paper mill solving the chemical recovery problem of the black liquor, has a cost of about $50 - $80 per ton of paper.

Cleaner production process seems to be the only solution to the management of the company. Present production process results in large water use, a high energy consumption, and huge losses of chemicals and other inputs. A solution needs to be found for treating all black liquor from the actual production process. Introduction of cleaner technology is financially attractive to the firm because it allows large savings in water (85%), fibers (10%), energy (25%), and chemicals (85%). In addition the quality of paper can be improved, the production cost can be lowered, and the pollution load can be reduced from an equivalence of a city of 1.6 million people to an equivalent of a city of 30 thousand people.

Total investment for introducing cleaner technology has been assessed at $20 million. Assuming a discounted rate of 12 percent and a life-horizon of 25 years, the discounted cost per cubic meter of saved water is about $0.16 or LE 0.54. Other benefits are reduction of production cost from $660 to $630 (at a cost of $0.03--LE 0.10-- per cubic meter of water), reduction of pollution loads of BOD from 80,000 tons per year to only 550 tons per year, and reduction of water use from 360 cubic meters per ton to only 100 cubic meters per ton. If water prices were to increase by five times, cost savings would double.

Agricultural Sector

A recent irrigation project financed by the World Bank [The World Bank (1994)] aims to increase agriculture production by means of improvement of main and secondary canal delivery system, and tertiary systems. The project claims to reduce water use by 11 percent, from 2,025 MCM per year to 1,805 MCM over an area of 248,000 feddans. The total cost of the project is $182 million (in 1994 prices). Assuming a discounted rate of 12% and a life-horizon of 20 years, the discounted cost of saved water is about $0.10 per cubic meter or LE 0.34.