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Wastewater Operation and Maintenance in Egypt

(Specific Challenges and Current Responses)

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Abstract

Sanitation services in Egypt are less developed than water supply services. Egypt had 372 municipal wastewater treatment plants in 2012, treating an average of 10.1 million cubic meters per day. The wastewater and sanitation sector in Egypt are suffering from some problems as lack of public awareness, reliance on manual systems, lack of coordination between different water and wastewater authorities, over staffed unskilled labors, inadequate operation and maintenance plans, lack of accurate and reliable data, incomprehensive Master Plan, most of the facilities are over loaded, inefficient water & wastewater networks, small capacities of the Wastewater Treatment Plant (WWTP), lack of new technologies, financial crisis level, as well as absence of plans to preserve sector investment. However the water and sanitation services in Egypt as they have a very low price, which do not reflect the real cost. The cost recovery levels are still below international comparators and as a consequence sector debt is a contingent liability for the Egyptian Government. As introduction, this paper gives an overview on the sanitation and wastewater treatment sector in Egypt through discussing the current situation and facing problems as well as the available investments of the wastewater sector. Moreover, it illustrates the current regulations, standards, and laws as well as the organizational and institutional framework deals with the wastewater sector and its operation and maintenance services. More studies and research conducted in this paper discuss and evaluate the operation and maintenance procedure of WWTPs in Egypt, cost, and its facing problems.

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As conclusion, the paper set the remediation and the recommendations required to develop and enhance the operation and maintenance service including the operation and maintenance process, cost recovery, management system, regulation, guidelines, and standards, organizational and institutional framework setup, private sector and stakeholders' participation, the institutional and staff capacity building, as well as popular awareness and understanding. The study concluded, Strategic Agenda and Action Plan should be established to develop, enhance, and regulate the operation and maintenance sector in Egypt.

Keywords: Water Policy and Challenges; Wastewater Treatment; Operation and Maintenance; Economic Evaluation; Private Sector Participation

1. Introduction and Background

Sanitation services have, understandably, been given less priority than water supply since people tend to grant more urgency to the provision of water. Access to improved sanitation can have different interpretations from one country to another. The extent of coverage of sanitation services in the developing countries region is shown in Figure-1.

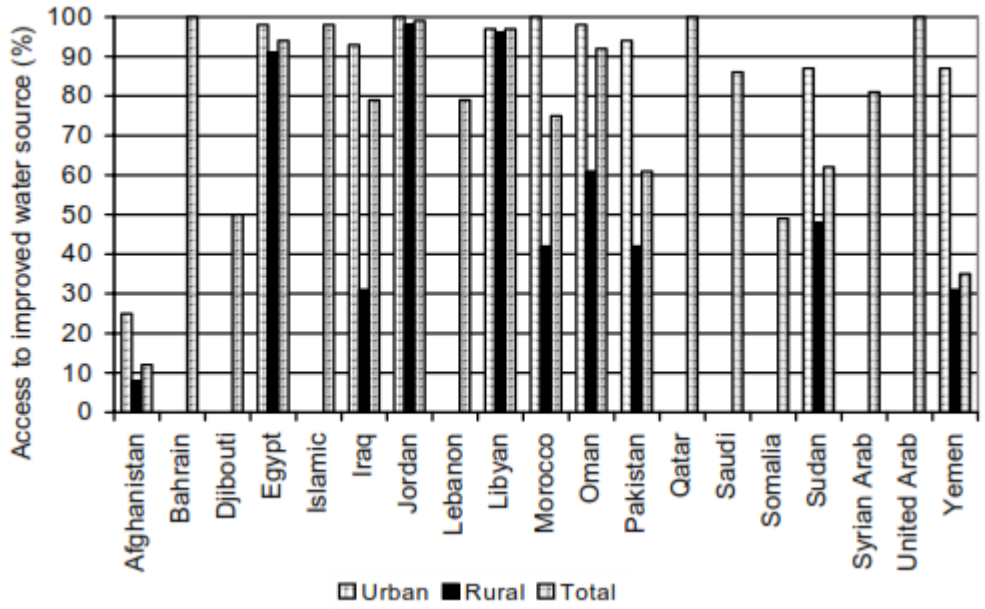

Fig.1: The extent of coverage of sanitation services in the developing countries region

Wastewater treatment is becoming ever more critical due to diminishing water resources, increasing waste-water disposal costs, and stricter discharge regulations that have lowered permissible contaminant levels in waste streams.

Within the Arab world Tunisia, Jordan, and the GCC counties are the leaders in the area of wastewater reclamation and reuse. ***Tunisia***, in 2008, the number of wastewater treatment plants operating in Tunisia were 61, collecting 0.24 billion km of wastewater. ***Jordan***, There were nineteen wastewater treatment plants in full

operation in 2001. The total wastewater flowing into these plants was estimated at 88.637 million cubic meters during 2001, 85% of which were treated in seven wastewater stabilization pond plants. At present, activated sludge and trickling filter plants are employed for the treatment of 15% of the total wastewater collected in the country. Jordan has adopted a policy of including maturation (polishing) ponds as a final treatment stage in most of the mechanical wastewater treatment plants. ***Lebanon***, in 2001, 310 million m³ of wastewater was produced in Lebanon by the domestic and industrial sectors. In 2006, 4 million m³ of wastewater were treated and 2 millions m³ were used for informal irrigation. ***Syria***, According to [1], the Damascus and the Homs wastewater treatment plants in Syria account for more than 98% of all treated wastewater with capacities of 177 million m³/year and 49 million m³/year, respectively [2]. ***Kuwait***, the Sulaibiya Wastewater Treatment and Reclamation Plant is considered by far the largest facility of its kind in the world to use reverse osmosis (RO) and ultra filtration (UF) membrane-based water purification systems. The plant's initial daily capacity is 375,000 m³, which could be expanded to 600,000m³/day in the future. It is believed that treated wastewater will contribute to 26% of Kuwait's overall water demand, reducing the annual demand from non-potable sources from 142 million m³ to 26 million m³. ***Bahrain***, Bahrain has a 70% sewerage connection in the major cities. The daily wastewater quantity collected and treated in the Tubli Water Pollution Control Centre is estimated at 150 000 cubic meters. Only municipal wastewater is allowed into the network; industrial wastewater is treated in separate utilities. There are eight other wastewater treatment plants and number of small wastewater treatment plants of varying sizes serving from 100 to 800 people. The majority of these wastewater treatment plants are based on the activated sludge extended aeration system. There is only 1 aerated lagoon plant and another biological rotating contactor. ***Iraq***, The quantities of sewage generated within the urban areas of the mayoralty of Baghdad are estimated at 1 426 013 cubic meters per day and in its rural areas at 2354 cubic meters per day. Recent reports by the United Nations Development Program (UNDP) showed that each day 500 000 cubic meters of raw sewage are discharged into Iraqi waterways. The capacity of all wastewater treatment plants in the mayoralty of Baghdad is estimated at 789 200 cubic meters per day, representing 55% of the sewage generated in the mayoralty.

Egypt, Egypt produces about 3.5 billion m/year of municipal wastewater, while current treatment capacity is about 1.6 billion m3/year. An additional treatment capacity of 1.7 billion m3 is targeted by 2017 [3]. Although the capacity increase is significant, it will not be sufficient to cope with the future increase in wastewater production from municipal sources and therefore, the untreated loads that will reach water bodies are not expected to decline in the coming years. The Delta Region alone generates more than 2 million m3/year, mostly originating from Egypt's two greatest urban centers, Cairo and Alexandria. Treatment plants serve 55% of the population in towns and cities [3].

The selection and design of waste-water treatment facilities is greatly dependent on the costs associated with treatment processes, including capital investment, operation and maintenance (O&M), land requirements, sludge handling and disposal, and monitoring costs [4]. Major cost elements of the O&M budget are briefly outlined in the following table.

Table-1: Major cost elements of the O&M budget

Factor	O&M 1998 USD/year
Maintenance	4 per cent of total capital cost
Taxes and insurance	2 per cent of total capital cost
Labour	$30,300 to $31,200 per man-year
Electricity	$0.08 per kilowatt-hour
Chemicals:	
Lime (calcium hydroxide)	$57 per ton
Polymer	$3.38 per pound
Sodium hydroxide (100% solution)	$0.28 per pound
Sodium hydroxide (50% solution)	$0.14 per pound
Sodium hypochlorite	$0.64 per pound
Sulfuric acid	$1.34 per pound
Ferrous sulfate	$0.09 per pound
Hydrated lime	$0.04 per pound
Sodium sulfide	$0.30 per pound
Residuals management	Technology-specific cost

2. Water Resources In Egypt:

Renewable water resources available to Egypt total approximately 57 billion cubic meters (BCM)/year. Approximately 97 percent comes from the Nile, with the remainder from precipitation, which is mainly confined to the north coast. The quantity of supply is essentially fixed. Water demand, on the other hand, is increasing. Currently, it is estimated at 72 BCM per year, over 80 percent of which is used for agriculture [5].

Egypt is an arid country facing challenges due to its limited water resources. The present per capita water share is below 1,000 m3/year (Figure-2) and it might reach 600 m3/year in the year 2025, which would indicate water scarcity (water scarcity level starts at 1,000 m3/year).

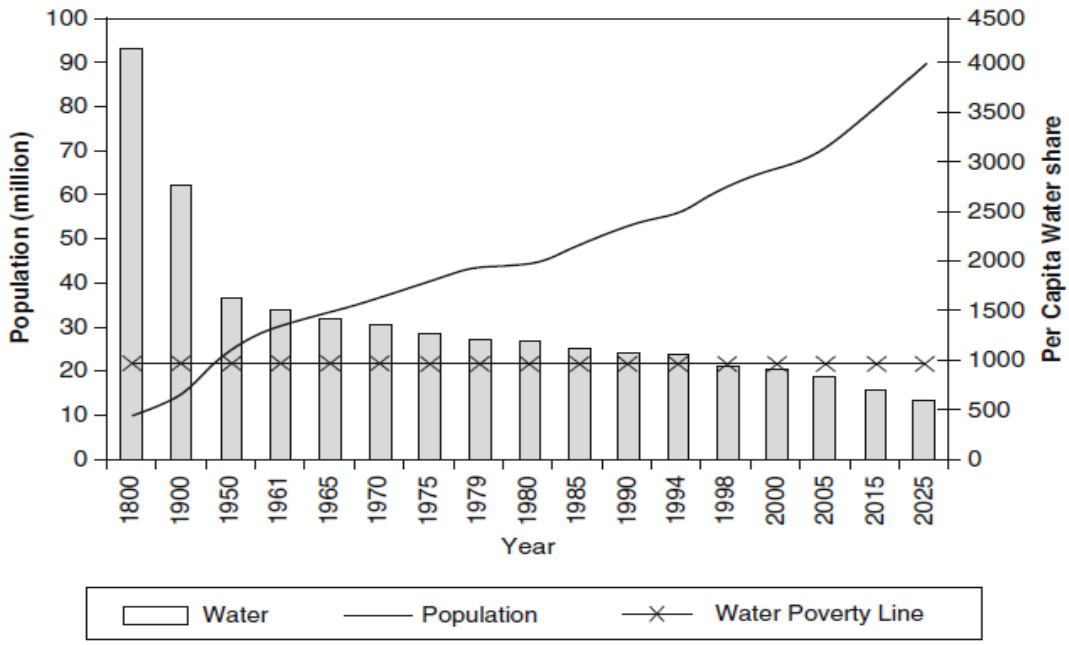

Fig.2: Population Growth and Per Capita Water Share in Egypt (m3/year)

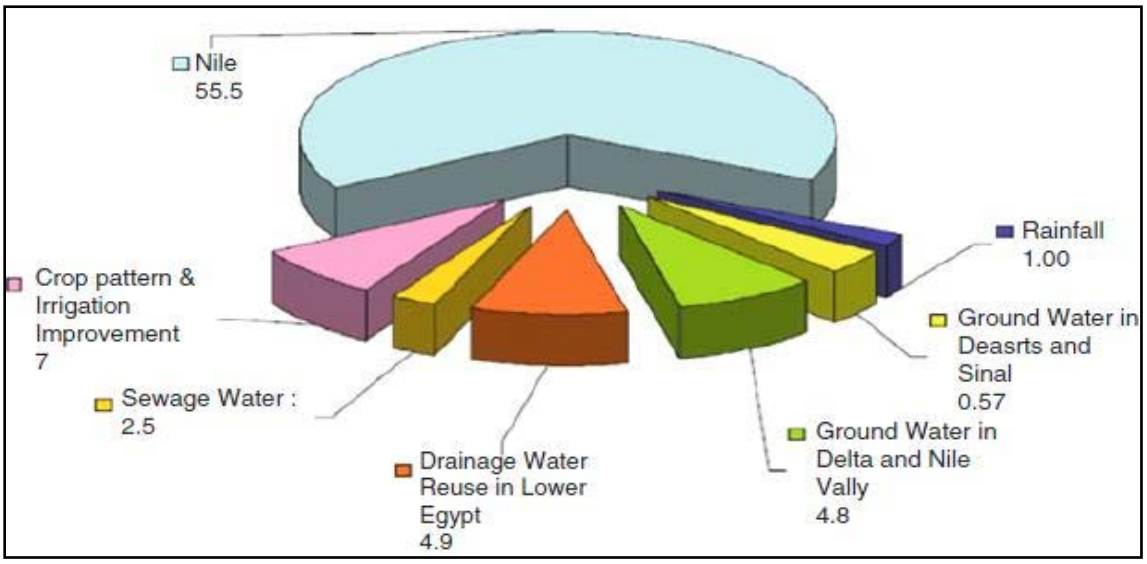

Fig.3: Water Resources in Egypt

It has been estimated that about 3.5 BCM/year of municipal waste water was being discharged into the Nile and the sea in 2002, out of which only 1.6 BCM/year (about 45%) were treated. Industrial effluents contribute to about 1.3 BCM/year of waste water being discharged to surface waters, only some of which is being treated. Agriculture is the largest water consumer in Egypt with its share exceeding 80–85% of the total demand for water. Sustainable agriculture strongly depends on the country‘s ability to conserve and manage its water resources [6].

3. National Water Planning

The concept of a formal long-term national water resources planning was introduced in Egypt through foreign technical assistance during the 1970s. In 1981 a Master Plan for Water Resources Development and Use was finalized with the support of UNDP and the World Bank. Rather than being an actual plan, the document aimed at introducing planning tools such as data bases and flow models that would allow better planning. In subsequent years a number of events increased water scarcity. These include a drought in 1979-88; cessation in 1983 of construction works on the Jonglei Canal in Sudan; and a revitalization of a land reclamation program, requiring one billion m3 of additional water each year. These events helped trigger a greater emphasis on integrated long-term water planning. In 1990 the government adopted its first national water plan covering the period until 2000.

Beginning in 1998 the Dutch government provided technical assistance to prepare a second national water plan. The [7] was completed in 2003 with a time horizon until 2017. The plan, which is not publicly available, is based on four principles: to develop additional resources, make better use of existing resources, protect public health and the environment, and improve institutional arrangements. In June 2005 the Ministry presented an Integrated Water Resources Management Plan, which was prepared with technical assistance from the World Bank, as a "transitional strategy including further reform interventions" building on the NWRP. The Plan

includes irrigation improvement and rural sanitation without mentioning the government's mega-projects that are at the heart of Egypt's actual water policy.

4. Wastewater Services Provision, Organizational and Institutional Framework:

- Wastewater Services Before Privatization

In before, construction, treatment, and rehabilitation of water and sanitation services was controlled and managed by the government through the National Organization for Potable Water and Sanitary Drainage (NOPWASD). Falling under the Ministry of Housing and Urban Utilities Development (MHUUD), NOPWASD also was, and continues to be, responsible for construction and rehabilitation of large water and wastewater services in all governorates except Greater Cairo and Alexandria. These operations are financed by the government, which channels the funds through the Ministry of Finance. The broader environmental health factors associated with the impact of water and sanitation programs are the responsibility of the Ministry of Health and Population.

Until recently, the Operation and Maintenance (O&M) of drinking water and sanitation services was the mandate of MHUUD branches at the local government level financed by the central investment budget, channeled through the Ministry of Finance.

- Wastewater Services After Privatization

In the 1990s, in line with the Egyptian government’s privatization program, utilities were established in all governorates for the O&M of water and sanitation services. Although subsidized by government funds, these utilities were allowed to retain fees obtained from meter connections and monthly bills, and to develop their own O&M plans. The Ministry of Water Resources and Irrigation is in charge of water resources management and irrigation [8].

The Ministry of Health and Population is responsible for monitoring drinking water quality. The Egyptian Environmental Affairs Agency is responsible for environmental affairs and the assessment and monitoring of water use. The Holding Company for Water and Wastewater, founded by decree in 2004, is responsible for the

financial and technical sustainability to the Governorate-based utilities. The Egyptian Water Regulatory Agency (EWRA), established in 2006, is in charge of the economic and technical regulation of utilities [9]. Figure-4 shows the water and wastewater services stakeholder after reforming.

Creation of the Holding Company for water and wastewater (HCWW), Presidential Decree No. 135 of the Year 2004 established a national Holding Company for Water and Wastewater (HCWW). Gradually, all water and wastewater utilities in the governorates were converted to subsidiaries of the HCWW. Through its branches in the governorates, the Holding Company for Water and Wastewater "HCWW" is the primary entity officially responsible for installation of house connections and O&M of all water supply and sanitation facilities in Egypt. The HCWW and its 26 affiliated companies are in charge of operation and maintenance of water and sanitation

infrastructure. The Holding Company owns all water and sanitation infrastructure in Egypt. In some governorates water and sewer services are still provided directly by the Holding Company. It is envisaged to establish affiliated companies in all governorates, bringing the total number of affiliated companies to 28.

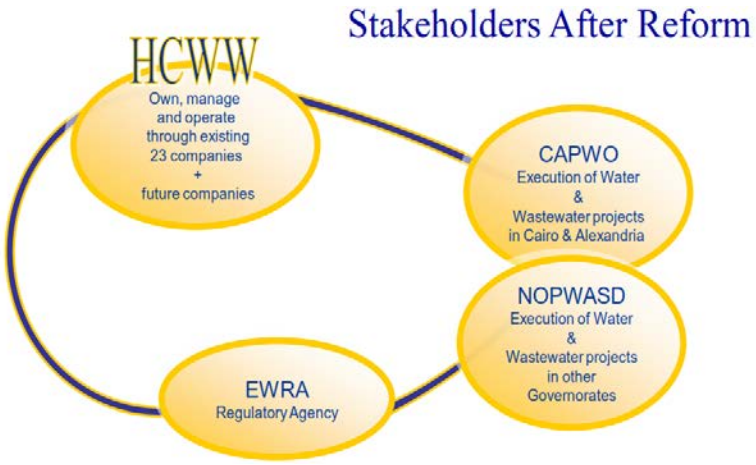

Fig.4: Water And Wastewater Services Stakeholder After Reforming.

Creation of the Egyptian Water Regulatory Agency (EWRA), in 2006 the sector reforms were complemented by the creation of a regulatory agency, the Egyptian Water Regulatory Agency. The creation of an "autonomous" regulatory agency for utilities was a standard recommendation made by donors for infrastructure sector reforms in developing countries at that time. The agency's tasks include reviewing proposals for tariff adjustments, monitoring the application of technical standards and reviewing customer complaints. The agency also has a mandate to both promote and regulate private sector participation.

- Public Private Sector Participation,

PPP is short for Public-Private-Partnership and involves a contract between a public-sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical and operational risk based upon the type of PPP. The PPP projects in the Egypt wastewater sector have involved design, finance, construction, operation and transfer back to Government [10].

In 2006 the government created a Public-Private Partnerships (PPP) Central Unit in the Ministry of Finance to promote private green field investments in infrastructure across various sectors. The government's support for private sector participation in water supply and sanitation is focused on build-operate-transfer (BOT) for wastewater treatment plants, through which private finance is mobilized. This approach is limited to Cairo and Alexandria where external donors had become less keen to provide assistance [11].

The Government of Egypt (GoE) contracts with private sector companies to finance, design, build, and operate public infrastructure. At the end of the contract term, the infrastructure is to be transferred to GoE, in original condition. The contracts are long-term – generally 20 years. Under the PPP mechanism, the investor/developer

will receive periodic payments once the plant begins to operate. During construction no payments will be made by Government. The Ministry of Housing, Utilities, and Urban Development (MHUUD), in coordination with the PPP Central Unit is taking the lead on wastewater PPP projects.

5. Regulations, Standards, and Laws:

There is no single overarching water resources law in Egypt. The main laws of relevance for water resources management include laws about irrigation and drainage on the one hand, and laws to protect the environment on the other hand. Among the irrigation and drainage laws are: Law 12 for the year 1984 for the Irrigation and drainage, Law 213 for the year 1994 for farmer participation and cost sharing, Law 93 for the year 1962 for the discharge to open streams and its modifications for the years 1962, 1982, and 1989, Law 27 for the year 1978 for the regulation of water resources and treatment of wastewater, Law 48 for the year 1982 Regarding the protection of the River Nile and waterways from pollution, Law 4 for the year 1994 for Environment Protection.

Recently, Egypt published its own *Operation and Maintenance Code* of Practice which regulates the operation and maintenance procedures for the wastewater treatment facilities. This code is consisted of nine chapters. Chapter-1 is introduction to treatment processes, chapter-2 discusses the treatment processes and their control method, chapter-3 illustrates the tests for analysis and measurements of properties of the wastewater treatment process, chapters 4&5 sets the mechanical and electrical operation and maintenance procedure of treatment equipments while chapter-6 deals with the civil maintenance procedure of treatment units, chapter-8 organizing the required management system, chapter-8 puts the strategy of the recording, reporting, and information systems. Finally, chapter-9 establishes the safety and health instructions for workers and labors while handling the treatment process.

6. Sanitation and Wastewater Treatment Sector in Egypt: *A General Review*

Sanitation services in Egypt are less developed than water supply services. Egypt had 372 municipal wastewater treatment plants in 2012, treating an average of 10.1 million cubic meters per day. The capacity of Egypt's wastewater treatment plants was more than 11 million cubic meters per day, serving more than 18 million people.

Egypt had 372 municipal wastewater treatment plants in 2012, treating an average of 10.1 million cubic meters per day [7]. The amount of water which is released into the Nile is 3.8 billion m^3 per year, out of which only 35% was treated properly as of 2004 [12]. The main criteria affecting selection of the wastewater treatment technologies are availability of land, skilled labor, cost for operation and maintenance, power supply, performance efficiency, implementing costs. The main wastewater treatment technologies used in Egypt are Trickling Filter, Conventional Activated Sludge, Oxidation Ditches, Stabilization Ponds, Constructed Wetlands, Rotating Biological Contactor (RBC), Sequencing Batch Reactors (SBR), Up-Flow Anaerobic Sludge Blanket, and Modified Septic Tank.

The wastewater treatment systems in Egypt are suffering from some problems as lack of public awareness, reliance on manual systems, lack of coordination between different water and wastewater authorities, over

staffed unskilled labors, inadequate operation and maintenance plans, lack of accurate and reliable data, incomprehensive Master Plan, most of the facilities are over loaded, inefficient water & wastewater networks, small capacities of the WWTP, lack of new technologies, financial crisis level, as well as absence of plans to preserve sector investment.

Due to insufficient funds for operation and maintenance and technical know-how, many of the treatment plants are not able to meet these standards. Some data on the present production of wastewater has been obtained from two sources: the Egyptian Public Authority for Drainage Projects-EPADP and the Holding Company for Water and Wastewater-HCWW [13]. Tables 2&3 show the data collected.

Table -2: Actual and Design Capacity of WWTP belonging to HCWW

Governorate	Actual Capacity (m3/day)	Design Capacity (m3/day)	Type of Treatment	Drain
Alexandria	1,128,800	1,231,600	Different types	Different drains and
Assiut	70,000	177,500	Oxidation Ponds	Not available
Aswan	109,330	141,350	Oxidation Ponds	
Bani Suef	94,195	165,550	Biological treatment and others	Different drains and forests
Behira	82,000	272,000	Different types	Different drains
Cairo	3,330,000	3,250,000	Activated sludge	Bilbes and Shbeen Alkanater Drains and the Alsuff Canal
Dakahlia	218,547	360,500	Oxidation ditches with activated sludge and others	Different drains
Domiat	169,650	259,300	Activated sludge, oxidation ditches and other	Different Drains
El-Fayoum	148,428	226,879	Oxidation bonds, activated sludge, and others	Al Battes, Alwadi, and other drains
El-Menia	65,955	131,600	Oxidation ponds, secondary biological, and others	Al Mohit, Al Dayer Al Bahary, and KobKob Drains
Gharbia	268,619	431,940	Activated sludge and others	Different drains
Giza	1,420,000	870,000	Activated sludge and primary treatment	Niha, Alremal, and Al Rahaye Drains, and Green Belt of 6thOctober
Kafr El-Sheikh	29,211	140,000	Activated sludge	Drain No.4,7 and
Marsa Matrouh	22,000	25,000	Oxidation ponds	Forests
Monofia	176,650	376,000	Different types	Different drains and one forest

Governorate	Actual Capacity (m3/day)	Design Capacity (m3/day)	Type of Treatment	Drain
Qena	40,000	67,000	Trickling filters and	Forests
Red Sea	10,000	18,000	Oxidation ponds	Forest
Sharkia	153,548	318,200	Trickling filters, extended oxidation, activated sludge	Different drains
Sohag	83,000	232,500	Biological and Oxidation ponds	Forests
Sinai	53,600	133,000	Mechanical and oxidation ponds	Forests
Luxor	48,000	52,000	Biological, and oxidation ponds	Forests
Al Baher Al	10,000	18,000	Oxidation ponds	Forest
Total	**7,731,533**	**8,897,919**		

* source: [14]

Table-3: Actual and Designed Capacities of WWTP in the Regions of Egypt

Region	Actual Capacity 3	Designed Capacity 3
Upper Egypt	134,500	168,550
Middle Egypt	288,181	501,391
East Delta	581,930	965,300
Middle Delta	430,150	711,240
West Delta	654,700	890,000
Total	**2,089,461**	**3,236,481**

* source: [13]

7. The Egyptian Investments In The Water And Wastewater Sector:

Over the last 25 years, the Egyptian Government has invested heavily in the water and wastewater sector. The Government reports spending over $11 billion on water and wastewater plant construction over this period. International donors, mainly USAID, have contributed an additional $ 4.5 billion in infrastructure development (David, 2010). The following chart illustrates this investment as well as the following table indicates the required investments in the sector.

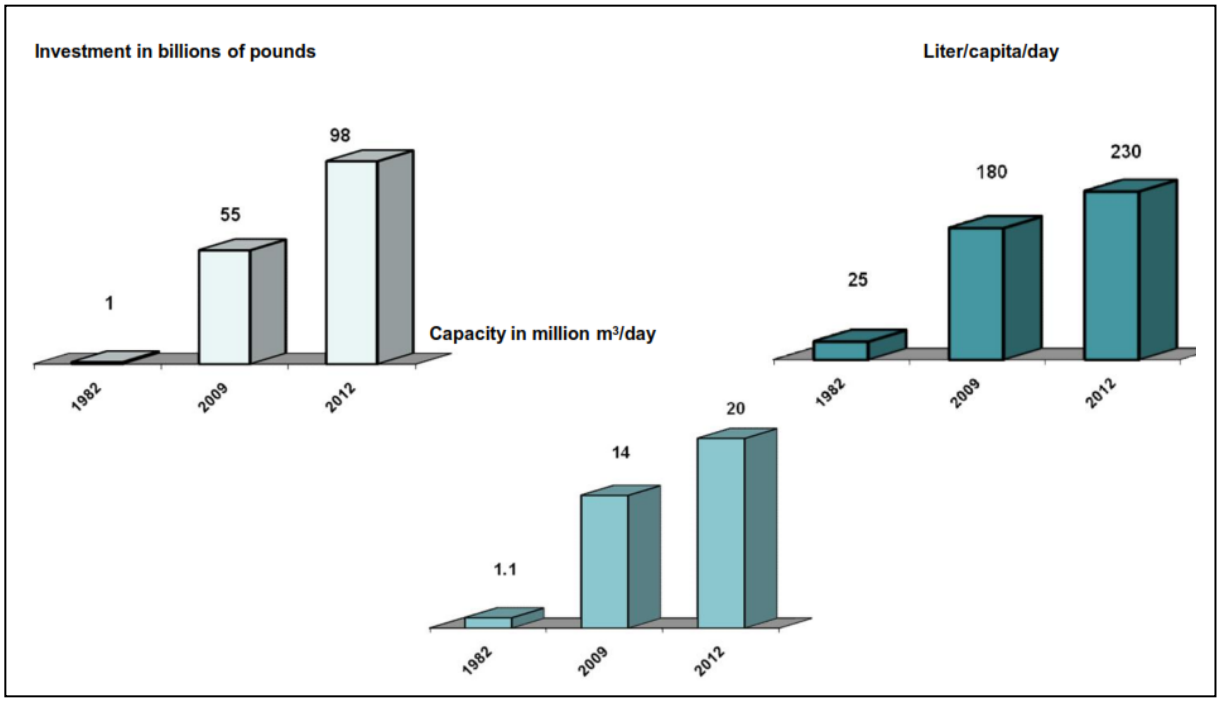

Fig.5: The Wastewater Services Status

Table-4: the required investments in the water and wastewater sector

Implementation Phase	(Million LE)		
	Water	Sanitation	Total
2007-2012 Five Year National Plan	11,009.05	15,045.91	26,054.96
2007-2012 High Priority Projects	13,121.86	32,813.58	45,935.44
Total High Priority Projects	26,592.10	48,071.49	72,202.4
2012-2017 Planned projects	12,697.59	20,011.31	32,708.90
2017-2022 Planned projects	7,338.69	14,849.25	22,187.93
2022-2027 Planned projects	8,759.68	11,482.74	20,242.41
2027-2032 Planned projects	4,975.57	7,184.25	12,159.82
2032-2037 Planned projects	2,266.55	8,487.56	10,754.11
Total Planned Projects	36,038.08	62,015.11	98,053.17
GRAND TOTAL	**60,168.98**	**110,086.60**	**170,255.58**

8. Operation and Maintenance of WWTPs in Egypt:

Operational and maintenance responsibilities are delegated to local agencies, public/private companies, or utilities in 27 governorates (Water and Wastewater affiliated Companies) and supervised by a central organization (Water and Wastewater Holding Company, HCWW).

8.1 Monitoring Parameters:

Most of wastewater treatment facilities are generally in poor to very poor conditions due to poor design, process, construction failure, poor O&M, and lack of well trained staff. So, some monitoring parameters should assess during the operation and maintenance procedure [15]. The following table is summarizing some of these parameters.

Table-5: The Operation and Maintenance Assessment Parameters

Items	Parameters
General	Assessment of the treatment efiiciency and estimating the energy consumption, determination of actual flow and design flow.
Treatment Units	Design parameters, Hydraulic Loading Rate, Organic Loading Rate, Hydraulic Losses, Control of Inlet Flow,
Chlorination and Dosing Unit	Breakpoint chlorination ata labortory, Determination of contact time, montly consumption, control of dosing, free clorination quantity, Control of dosing pump.
Discharging Pumps	Follow up the treated wastewater feeding pumps (flow, head, power, operating time, efficiency…..etc).
Documentation	All WWTP documents should be available (Drawings, Technical specifications, Equipments manuals and catalogs, O&M manuals as well as list of spare parts).
Personnel Level	Assement of the personnel and staff levels and skils (Required and adequate numbers and skills, Well understanding of the treatment systems and perfomance and O&M manuals)
Registration System	All maintenance recording tables and lists should be registered periodically

8.2 Overview on the Technical Sustainable Management (TSM in Egypt):

Plants managers have the overall responsibility for all processes in their water or wastewater treatment plants. Their duties and activities must be performed in accordance with local legal provisions, official requirements and safety regulations, as well as the generally recognized technical rules. For that reason HCWW and affiliated companies must have at their disposal the proper personnel and organizational procedures in addition to the correct equipment to guarantee a supply of drinking water that is reliable, sustainable and of impeccable

quality, and furthermore the safe collection, treatment and disposal of wastewater.

In the context of the Egyptian-German Water Supply and Wastewater Management Program (WWMP), financed by the German Federal Ministry for Economic Cooperation and Development (BMZ), GIZ cooperates with HCWW in the developing the TSM (Technical Sustainable Management) certification process. The objective of TSM program is to improving the Operation and Maintenance of water and wastewater facilities through the implementation of a plant certification system to enable the utilities to comply with national or international standards in Operation and Maintenance (O&M). This way the companies will learn how to systematically identify deficits in their organization, technical performance and management. They will also be able to eliminate weak points and operate the plants following the Egyptian legal provisions and technical standards. Impacts, The TSM process improves all process of O&M in the plants, the quality of drinking water and wastewater effluent, the safety of the work conditions for all plant staff, the economic position, as a result of efficient management, knowledge transfer between all plant managers, the understanding of relevant standards and processes, and will ultimately encourage the deep discussions on the regulations and best practices.

9. The Wastewater Operation And Maintenance Cost:

Most investment and operation and maintenance (O&M) costs of water services in Egypt are funded from the national budget. However, cost recovery levels are still below international comparators. The domestic per capita water (and wastewater) consumption in Egypt is around 237 l/c/d a very high figure compared to the international figures, which needs to be reduced drastically. The current legal framework, which makes tariff adjustment very complicated and the overall economical and political situation are major reasons for low tariffs. Another problem is the fact that sanitation is counted to public goods, where no one can be excluded from using them. In this case people start to be wasteful because finally this “good” do not belong to anyone. However the same is with water and sanitation services in Egypt as they have a very low price, which do not reflect the real cost. For this reason people do not have an incentive to consume less water and indirectly wastewater.

The total recurrent costs of the drinking water treatment plants and the waste water treatment plants in the same period 2003-2017 are estimated at LE 44 billion. These costs include the operation and maintenance costs of the system but exclude the personnel costs of the government agencies. The municipalities (Ministry of Local development) take by far the biggest share of the O&M costs (70%) for the operation and maintenance of the drinking water treatment plants and the waste water treatment plants [7]. However, according to the obtained information's, the average cost of treating one cubic meter sewage water in Egypt is almost 5000 L.E which is about $840 before final discharge. Operation and maintenance cost (O&M) is at 15% of investment cost. In Egypt, Sanitation tariffs are about 35% of the water bill regardless the actual consumption which accordingly does not reflect the real cost. So, a cost-covering sanitation tariff, which at least covers operation and management costs, is a first step for an efficiently working sanitation company, as it will reduce the high burden on national budget. Theoretically, HCWW subsidiaries are free to set their own tariffs, and they are ultimately expected to achieve complete financial self-sufficiency. They are expected to begin by covering O&M costs, then balance depreciation of their infrastructure with revenue.

However, as sewerage systems expand, many companies are becoming further in debt because of their expanded wastewater services. Rising salary, electricity, and chemical costs are also affecting companies' balance sheets. These and other obstacles continue to obstruct the performance of the HCWW and its subsidiaries and their ability to become completely privatized companies. To a large extent, government financing and subsidies continue to be a lifeline for these institutions, even while they are allowed to retain their revenues from monthly bills. In Egypt, the Egyptian Community Development Association (CDA) manages the operation of complete low-cost sewerage systems in small towns and villages, including collection of tariffs from householders; however, operation and maintenance are contracted out to a private entrepreneur. Figure-6 illustrated example of the percentage of different cost categories for wastewater service in some Egyptian governorates.

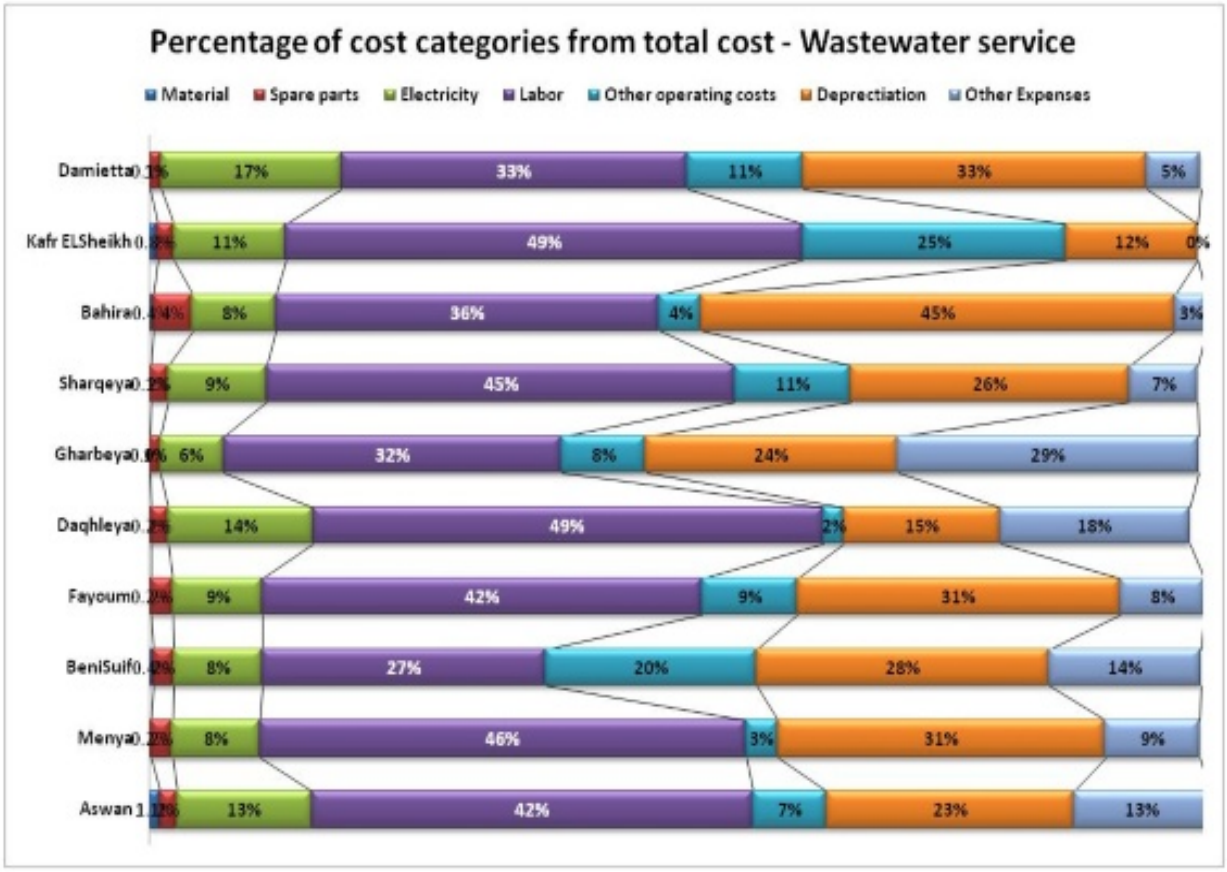

Fig.6: percentage of cost categories for wastewater service, source: [16]

10. Conclusion and Recommendations:

Sanitation services in Egypt are less developed than water supply services. Wastewater use in Egypt is an old practice. Currently, 0.7 BCM/yr of treated wastewater is being used in irrigation, of which 0.26 BCM is undergoing secondary treatment and 0.44 BCM undergoing primary treatment. In general, treated wastewater use is of tremendous potential importance for Egypt. At present, there are more than 323 wastewater treatment plants in the country.

Egypt had 372 municipal wastewater treatment plants in 2012, treating an average of 10.1 million cubic meters per day. The capacity of Egypt's wastewater treatment plants was more than 11 million cubic meters per day, serving more than 18 million people. The wastewater and sanitation sector in Egypt are suffering from some problems as lack of public awareness, reliance on manual systems, lack of coordination between different water and wastewater authorities, over staffed unskilled labors, inadequate operation and maintenance plans, lack of accurate and reliable data, incomprehensive Master Plan, most of the facilities are over loaded, inefficient water & wastewater networks, small capacities of the WWTP, lack of new technologies, financial crisis level, as well as absence of plans to preserve sector investment.

The selection and design of waste-water treatment facilities is greatly dependent on the costs associated with treatment processes, including capital investment, operation and maintenance (O&M), land requirements, sludge handling and disposal, and monitoring costs. The Operation and Maintenance (O&M) of drinking water and sanitation services was the mandate of MHUUD branches at the local government level financed by the central investment budget, channeled through the Ministry of Finance. Operational and maintenance responsibilities are delegated to local agencies, public/private companies, or utilities in 27 governorates (Water and Wastewater affiliated Companies) and supervised by a central organization (Water and Wastewater Holding Company, HCWW).

However the water and sanitation services in Egypt as they have a very low price, which do not reflect the real cost. For this reason people do not have an incentive to consume less water and indirectly wastewater. The cost recovery levels are still below international comparators and as a consequence sector debt is a contingent liability for the Egyptian Government.

To enhance the Operation and Maintenance of the WWTPs, HCWW in cooperate with GIZ is developing the TSM (Technical Sustainable Management) certification process. The objective of TSM program is to improving the Operation and Maintenance of water and wastewater facilities through the implementation of a plant certification system to enable the utilities to comply with national or international standards in Operation and Maintenance (O&M). Moreover, to regulate the Operation and Maintenance of the WWTPs, recently, Egypt published its own Operation and Maintenance Code of Practice to deal with the operation and maintenance procedures for the wastewater treatment facilities.

Therefore, Strategic Agenda and Action Plan should be established to develop, enhance, and regulate the operation and maintenance sector in Egypt which could be recommended as following:

- Efforts should be made to advance policies that advocate the allocation of funds to expand improved wastewater operation and maintenance services.
- Well-prepared design, management, operation, and maintenance manuals for planners, engineers, technicians and all stockholders should be issued. They should include prudent, economic approaches to operation and maintenance.
- Provision of design, operation and maintenance manuals for wastewater management systems should supply information on centralized and decentralized concepts, targeting planners, engineers, utility managers as well as

individual homeowners.

- All WWTP documents should be available and provided to the operation and maintenance staff (Drawings, Technical specifications, Equipments manuals and catalogs, O&M manuals as well as list of spare parts).
- All maintenance recording tables and lists should be registered and monitored periodically.
- High efficient measures and equipments should be provided in adequate numbers as well as should be calibrated periodically.
- Well-designed and properly managed databases should be created.
- Establish a high safety and health instructions for workers and labors while handling the treatment process.
- Personnel and staff levels and skills (Required and adequate numbers and skills) should be provided as well as well understanding of the treatment systems which controlled by periodical evaluation
- Develop and enhance the institutional and staff capacity building through establishing comprehensive technical training programs.
- Provide practical onsite (in-plant) training with emphasis on the operation and maintenance process.
- Professionals at all levels; decision-makers, planners, engineers, laboratory analysts, plant operators and other concerned parties should be brought together at periodic seminars and workshops.
- Strengthen the quality of regulation, guidelines, and standards that can promote the expansion of wastewater systems, control of wastewater discharges and operation and maintenance service as well as enforce all stockholders to follow and comply with Regulations, Standards, Laws, and code of practice.
- Developing and strengthen the strong Organizational and Institutional Framework setup deals with the operation and maintenance service.
- Establish a higher committee for operation and maintenance management to facilitate the coordination between the stockholders deals with the operation and maintenance service.
- The dilution of responsibility should be avoided by reducing the overlapping undertakings of many authorities and departments.
- The proper private sector involvement in wastewater management, and operation and maintenance should be carefully considered.
- Ensuring effective stakeholders participation, and ensuring financial sustainability.
- Conventional, centralized, wastewater collection and treatment systems should not constitute the only acceptable option as this has decelerated service expansion due to the high costs entailed.
- Appropriate and affordable wastewater collection and treatment systems should be applied instead of the expensive, imported technologies that have delayed the provision of services.
- Appropriate, low-cost, viable options of the wastewater treatment that suit local conditions should be considered as a first solution to reduce the operation and maintenance cost.
- Industrial wastewater should be pretreated to domestic wastewater quality levels prior to discharge into public sewers. This should help avoid high cost of the treatment process which lead to reduce the operation and maintenance cost.
- Periodic evaluations of actual impacts after completion and during operation and maintenance phase are recommended.
- Local further comprehensive studies should be conducted to develop the operation and maintenance system.
- Creating popular awareness and understanding.

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