المركز المصرى للدراسات الإقتصادية

ECES

The Egyptian Center for Economic Studies

Economic Incentives to Promote the Abatement of Nile Pollution

Raouf F. Khouzam

Working Paper No. 4

This paper was written for the Egyptian Center for Economic Studies (ECES). An earlier version was presented by the author at The Sixth Annual Meeting of the International Association for the Study of Common Property, held June 5–8, 1996, at the University of California Berkeley, and also at the "International Water Policy Conference" held Sept. 23-24, 1996, at Carnfield University, Bedford, England. A summary will be published in *Water Policy: Allocation and Management in Practice*, P. Howsam and R.C. Carter, eds. E&FN Spon, London, 1996, under the title "A Water Quality Management Strategy; Case Study: The Nile River."

Abstract

Reusing returning water provides Egypt with a solution to the detrimental effect of water shortage on its economic development. However, the degraded quality of returning water creates a serious environmental hazard which subsequently limits its reuse. Several legislative and institutional measures have been taken to enhance the quality of returning water and conserve the environment. These measures have not resulted in a clean Nile, because they focused on technical requirements and imposing sanctions on offenders, with little or no regard for firms' need to be competitive in local and international markets, nor to the distribution of the cost burden. This brought a negative attitude from firms towards the adoption of the environmental measures.

This research introduces positive economic incentives to deal with the shortfalls of the current policy to reduce pollution caused by municipal, agricultural and industrial activities. The recommendations rely on motivating firms to voluntarily adopt the proposed modifications, while leaving the responsibility of policy execution and information dissemination to the government. Water quality would be improved by eliminating or reducing polluting inputs and processes in agricultural and industrial production techniques, and by finding economic uses for emitted pollutants.

ملخـــــص

يعتبر إستخدام مياه الصرف المعالجة حلا لمشكلة ندر المياه وأثرها البالغ الخطورة على التنمية الإقتصادية فى مصر. ولكن من ناحية أخرى فإن تدهور خصائص ونوعية مياه الصرف تضع حداً لجدوى إستخدامها. وقد تم إتخاذ عدة إجراءات تنظيمية وقانونية بشأن تحسين نوعية هذه المياه وجعلها صالحة ؟لإعادة الإستخدام والحفاظ على البيئة.

ولأن طبيعة هذه الإجراءات فنية ومعنية أكثر بفرض العقوبات، فقد فشلت فى تحقيق النتائج المرجوة منها فى شأن الحفاظ على نظافة مياة النيل، خاصة إنها لم تضع فى فى اعتبارها إحتياجات المنشآت الإنتاجية ثمتطلباتهالتحقيق وضع تنافسى سواء محلياً أو دولياً. وكذلك عدم مراعاة توزيع عبء التكلفة.

كل هذه العوامل دفعت بالمنتج لأن يأخذ موقفاً سلبياً تجاه إتباع إجراءات الحفاظ على البيئة. ويناقش هذا البحث قصور السياسة الحالية ويقترح حوافز اقتصادية إيجابية للأنشطة الثلاث الأكثر تلويثاً للمياه وهى المتعلقة بالزراعة والصناعة والصرف الصحى. وتشرح هذه الدراسة دور الحوافز الاقتصادية فى الحد من تلوث المياه ومقترح كيفية إدماج هذه الأدوات فى السباسات الحالية للبيئة.

وتتناول التوصيات تشجيع المنشآت على اتباع التعديلات المقترحة. بينما يقع على عاتق الحكومة تنفيذ هذه السياسات ونشر المعلومات فى هذا المجال. نوعية المياه بالتأكيد سوف تتحسن مع القضاء أو تقليل من مدخلات الإنتاج وإيجاد استخدامات اقتصادية لمسببات التلوث.

Abbreviations

bcm	Billion cubic meters
CAPMAS	Central Agency for Public Mobilization and Statistics
CIDA	Canadian International Development Agency
DRI	Drainage Research Institute
DRTPC	Development Research and Technological Planning Center
ECEP	Energy Conservation and Environment Protection Project
EEAA	Egyptian Environmental Affairs Agency
EP3	Environment Pollution Prevention Project
IFPRI	International Food Policy Research Institute
GAMS	General algebraic modeling system
GOSD	General Organization for Sanitary Drainage
IIP	Irrigation Improvement Project
lcd	Liter per capita per day
MALR	Ministry of Agriculture and Land Reclamation
MOH	Ministry of Health
MPWWR	Ministry of Public Works and Water Resources
NGO	Nongovernmental Organization
NSC	National Specialized Councils
ppm	Particles per million
PRIDE	Project in Development and the Environment
RNPD	River Nile Protection and Development Project
TDS	Total dissolved solids
TIMS	Tabbin Institute for Metallurgical Studies
TSS	Total suspended solids
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WECD	World Commission on Environment and Development
WHO	World Health Organization
WMP	Water Master Plan

1. Introduction

The abatement of Nile pollution is of serious concern to Egypt's development.[1] Deteriorated water quality underlies many major health problems in Egypt today. With a limited water supply, Egypt has been recycling water returning to the Nile to close the growing water gap. Unless the quality of returning water is improved, the country will continue to face increasingly severe problems of rising water demand and deteriorating water quality. Demand already exceeds available fresh water; and opportunities to increase the water supply are limited. Reuse of returning water is a viable option that deserves more serious consideration.

The government has made some effort to improve water quality and to reduce environmental damage. But recent studies indicate that efforts made so far have not achieved the desired effect.[2] The hazards associated with the degraded quality of returning water necessitate the search for policy instruments to boost water quality. This paper is a contribution to that search. It attempts to demonstrate the need to improve the quality of returning water, and recommends the use of positive economic incentives in the design of water management policy. The recommendations rely on motivating firms to voluntarily adopt the proposed modifications, while leaving policy execution and information dissemination to the government. Improvement of water quality would be achieved via modifying existing production techniques to eliminate or at least reduce polluting inputs and processes, and to find economic uses for emitted pollutants.

Three sources are identified as major water polluters: municipal waste, agricultural drainage and industrial effluent. Municipal waste, which is disposed of at community expense, is recommended for the manufacture of organic fertilizers and compost. The benefits of processing municipal waste are multiplied many times when the products are used as substitutes for chemical fertilizers. In the agriculture sector, nonpoint pollution can be abated by replacing chemical fertilizers with organic and biofertilizers. In this paper, these fertilization techniques are modeled and tested using a regional linear programming model. The effect of industrial emissions can be mitigated by adopting the "pollution prevention" principle as used by the ECEP/EP3 project.

---

[1] The word "Nile" in this text denotes the Nile, all its branches, the drainage network, and terminal lakes.

[2] Actually, the pollution of one medium (water, soil or air) might lead to the pollution of another; acid rain is a good example. However, this paper is confined to direct pollution of the water medium.

This research discusses measures to increase profit while reducing pollution. These measures have several desirable policy characteristics: they are sustainable (they meet the “win-win” criteria); they do not require tedious—sometimes impossible—definition of rights and liabilities; and are immune to loopholes and lobbying.

The remainder of this paper comprises three sections. The first discusses water pollution as a public health hazard that aggravates the water shortage. The role played by returning water is explored, as well as its damaging effects. The relative importance of reusing returning water and efforts to conserve its quality are discussed, and the failure of those efforts is demonstrated. The second section lays the groundwork for a new policy by exploring the factors undermining the existing policy. The application of a new approach to emissions from municipal, agricultural and industrial activities is then discussed. In the final section, summary and recommendations are presented.

2. Water Shortage and Pollution

Egypt is almost totally dependent on Nile water, which varies in quantity according to weather conditions in the Nile basin.[٣] Normally, Egypt’s annual share is 55.5 bcm, according to the 1959 agreement with the Sudan. This is barely enough to meet the existing need. In 1990 the quantity used exceeded the available fresh water by about 6 bcm (Table 1). This deficit was met by reusing drainage water, pumping out seepage from the irrigation–drainage network (groundwater), and recycling sewage water.

The water gap is growing as a result of rising demand and limited opportunities to increase the fresh water supply. Egypt's water needs are growing because of an ambitious land reclamation program, increasing population, an expanding industrial sector, rural development, and urbanization. In land reclamation, 3.4 million feddans were identified as reclaimable (Land Master Plan 1986). About 1 million feddans had

[٣] Left aside is a gloomy hypothesis that a climatological change is shifting rainfall in the upper Nile region further to the south (Hulme 1990:59). This proposition is supported by a number of observations: (a) data of the annual river yield over 116 years suggests a generally decreasing trend over time (Khouzam 1994), (b) another study using the same time series took the percentage of long-term mean as a reference point; it shows that the river flow was high during the period 1871-1905, less than the long-term mean during 1905-1965, and significantly lower during the post 1970 period (Abu-Zeid and Rady 1991). An alternative proposition suggests that river flows during the post 1970 period is just a reoccurrence of dry conditions which prevailed in the 19th century (Biswas 1991:70,72). In any case, refuting or confirming such hypothesis requires applying more sophisticated techniques to longer time series data.

been reclaimed by 1992 (MALR 1993); the remainder (about 2.5 million feddans) needs 13 bcm of water for irrigation to be successfully reclaimed.[٤]

Municipal water use, a major component of increasing water demand, rises as a result of population growth, greater national income (which enables government to provide unserved areas with treated water), and increased hygienic awareness. Municipal supply in 1990 (3.1 bcm) represented only about 77 percent of the national target of 206 lcd. The current government plan is to raise per capita municipal water use to 269 lcd, while extending treated water to 85 percent of the population by 1996/97 (Ministry Of Planning 1992). If by the year 2001 the population receives 269 lcd, annual municipal water use will reach 6.7 bcm.[٥] This implies that 3.6 bcm, over and above the amount supplied in 1990, must be allocated to meet yearly municipal demand in the next century.

The volume of water required for industry depends on the rate of growth of the sector, the change in composition of the industrial base, the prevailing technology, and the price of water. Industrial water use is expected to reach 9.7 bcm by the year 2000 (WMP 1981-b); thus an additional 5 bcm will be needed to cover the expected increase.

In sum, about 22 bcm must be made available by the beginning of the next century to satisfy the projected increase in water demand (Table 2). Hence, demand for returning water is expected to rise. Unfortunately—as the next section will show—its poor quality forms a major obstacle to sustainable use.

Dealing with Water Shortage

Egypt has only three options to increase its water supply: upper Nile projects, water conservation and water reuse.

Upper Nile projects. Such projects can provide Egypt with up to 9 bcm annually.[٦] However, these projects are subject to political and environmental constraints, and their costs are high relative to the two other options (estimated at LE 300–350 million/bcm; Abu Zeid 1992). Their completion depends on regional political stability; for example,

---

[٤] The estimation of per-feddan water requirement is a complex issue because it depends on a myriad of factors. Estimates range from as low as 5000 to as high as 11200 m3/feddan of new land (WMP 1980:8 and LMP 1986:26; respectively). Provided that only modern methods of irrigation are allowed in the new lands, a conservative requirement of 5000 m3/feddan is adopted.

[٥] The population forecasts for 1996 and 2001 are 60.6 million and 67.9 million (CAPMAS 1994:32).

[٦] Water increments generated by upper Nile projects consist of 4 bcm from Jonglei Canal I, 3 from Jonglei II, 4 from Mashar Marches, 7 from Bahr El-Ghazal; that adds up to 18 bcm at Aswan to be shared equally with the Sudan (Abu Zeid 1992-b:4).

the first phase of the Jonglei project was never completed. The prudent planner will choose the more reliable alternatives of conservation and reuse.

Table 1: 1990 Water Budget

Item	Quantity (bcm)
Available: Fresh	
Nile	55.5
Aquifer	0.5
Subtotal	56.0
Available: Recycled	
Groundwater	2.6
Drainage	4.7
Sewage	0.2
Subtotal	7.5
Total	63.5
Uses	
Irrigation	49.7
Municipal	3.1
Industrial	4.6
Navigation	1.8
Hydropower	1
Evaporation	2
Total	62.2
Surplus	1.3

Source: Abu Zeid and Rady 1991:50-52 (Tables 9, 10, Figure 10), 62 (Table 12). Hydropower is added from Abu Zeid 1 990.

Table 2: Egypt's Water Needs by the Year 2000

Item	Quantity (bcm)
New Lands	13
Municipal use	4
Industry	5
Total	22

Source: summarized from the text

Water conservation. The Ministry of Public Works and Water Resources (MPWWR) emphasizes conservation at all levels of the irrigation hierarchy. At the national level, it has adopted a tight water policy that comprises: (i) the elimination of special water releases for generating hydroelectric power; (ii) construction of the Isna Barrage to prevent water releases used to reduce the head increase resulting from riverbed erosion; (iii) prolongation of the winter closure period, (iv) minimizing water releases through the Rosetta Branch; (v) modification of cropping patterns to reduce irrigation requirements (Abu Zeid and Rady 1991 and Abu Zeid 1990); and (vi) construction of civil works to reduce rainwater losses in the Sinai and the northwestern coast (EEAA). At the farm level, efforts are being made to improve overall irrigation efficiency, which is currently in the vicinity of 50-55 percent. MPWWR has implemented a large USAID-funded scheme, known as the Irrigation Management Systems Project., to rehabilitate the irrigation–drainage system and enhance management practices. Improvement in irrigation efficiency by 10 percent is expected to reduce the Old Lands irrigation requirement by about 3 bcm annually.[v] Another area of conservation is reducing the amount of water wasted in the municipal network, estimated at a staggering 50 percent (Chemonics 1992-c).

Water reuse. There are three sources of water for reuse: sewage discharge, seepage from the irrigation–drainage network (groundwater), and drainage water.

An estimated 18 bcm of Nile water is returned annually. In 1990, 4.7 bcm was recycled, with the remaining 13.3 bcm discharged into the sea (Abu Zeid 1992). An additional 2.3 bcm could be recycled, raising reuse of drainage water to approximately 7 bcm and reducing the release to the sea to about 11 bcm in order to: (i) get rid of water with salinity greater than 2000 ppm; (ii) sustain the Delta salt balance; and (iii) prevent sea water intrusion beneath the North Delta soil (Amer 1992).

In 1990, the amount of extracted groundwater was estimated at 2.6 bcm. This could be increased to 4.9 bcm, which is believed to be the rate of recharge (Biswas 1991). One interesting feature of groundwater extraction is its positive impact on agriculture as a result of a lowered water table (MPWWR/Ford Foundation 1988 and Biswas 1991).

The reuse of treated sewage water for agriculture has been practiced in Egypt since 1915 in Al-Gabal Al-Assfar. Pending completion of sewage plants nationwide, about 64 percent of the water withdrawn for municipal use can be recovered.[^] Treated sewage water is nutritionally richer for irrigation than fresh water. Moreover, dried sludge can be sold as organic fertilizer. Plans exist to use 5 bcm of treated wastewater annually for agriculture and forestation (EEAA).

---

[v] It is worth mentioning that the saved amount is one third the total water increment to be obtained from all upper Nile projects. Keeping in mind the high cost of upper Nile projects, conservation seems financially more attractive.

[^] The efficiency of the municipal network is targeted to reach 80 percent. Assuming an equal efficiency rate for the sewage network, then recovery of the water allocated for municipal use will be 80%*80%*6.7 bcm = 4.3 bcm.

As mentioned above, by the year 2000 industrial water demand is expected to reach 9.7 bcm (WMP 1981-b), with 5 percent consumptive use (calculated from WMP 1980). From the rest (9.2 bcm), which will be returned to the Nile system, approximately 7.4 bcm can be collected for reuse (allowing for 20 percent waste in the network).

To sum up, the supply of fresh water in Egypt is fixed. The options available to increase it at low cost and with a reasonable degree of certainty are conservation and reuse. The first is beyond the purview of this paper, which focuses on the significant role water reuse can play in closing the water gap (Table 3).

Table 3: Summary of Potential Water Available for Reuse

Item	Quantity (bcm)
Drainage water	7.0
Groundwater	4.9
Sewage discharge	5.0
Industrial effluent	7.4

Source: text summary

Current Environmental Policy

The Egyptian government has followed a number of paths to address the critical situation of the environment: enacting laws, establishing specialized institutes, implementing technical projects with foreign partners, and encouraging the public sector to participate through NGOs. Over the past four decades the government has enacted a set of laws that addresses environmental issues including: Law 93/1962 to regulate the discharge of effluents and the sewer system; Law 57/1978 to regulate swamps and concomitant pollution issues; Law 48/1982 concerning water surfaces; and Law 4/1994 and its executive regulations.

The government has established two specialized institutes to safeguard the environment: the EEAA, and the Environment Protection Fund, both of which were established by Law 4/1994. The EEAA prepared an environment protection plan for the period 1994–2008, with a budget of LE 5.8 billion (estimated in 1992 LE). The plan aims to protect Egypt's water, air, and soil environment against further degradation, as well as improving the present situation, and is to be carried out in two phases (1994–98 and 1999–2008). Of interest to this paper are measures stipulated to protect water:

- Industrial wastewater treatment projects for approximately 100 factories will be implemented at company expense.
- River cruise ship waste will be treated before discharge.
- Pilot and trial projects to create and test inexpensive techniques for wastewater treatment will be developed.
- Administrative and technical staff will be trained to run and maintain wastewater treatment systems.
- Whenever possible, chemical fertilizers will be replaced with organic waste.

Another EEAA activity is the ongoing preparation of "An Industrial Pollution Abatement Project," with World Bank assistance.[9] The project, which will last three years (the grace period provided by Law 4/1994), is designed to help the EEAA build an effective institutional capacity to monitor pollution and enforce environmental laws. The project should also help firms adjust their processes to comply with Law 4/1994.

An additional joint project, titled "River Nile Protection and Development Project," is being implemented by MPWWR and CIDA. The second phase of the project was initiated in 1993, and will end in 1997. Its purpose is to "protect and develop the River Nile system and to consolidate efforts towards strengthening issues related to strategic research and planning, soil and water quality monitoring, barrage safety and monitoring, and hydrographic survey, data management and mapping" (RNPD).

In spite of the above legislation and projects, recent reports indicate that the objectives have not been achieved, as illustrated below.

Water Pollution

The government recognizes that water pollution has a severe impact upon economic development because it affects people’s health, life expectancy, and productivity, as well as agricultural and industrial output and competitiveness in international markets. WHO estimates that 60,000 Egyptians die every year from waterborne diseases. Residents near Lake Manzalla have a life expectancy of 40 years, compared to 60 in the rest of the country; in addition, the standard of living for fishermen has dropped due to a 90 percent decline in the fish take over the past 10 years. In Lake Maryut, mercury levels

[9] Extracted from a hand-out titled "An Invitation to Industrial Enterprises and Interested Banks" which was distributed at the conference on "The Role of Cleaner Production in Meeting the Challenges of a Changing World Economy," Taba, Egypt, July, 24-27, 1995.

in some fish exceed 1,000 ppm, compared to the WHO standard of 1 ppm. In Cairo, microbiological diseases such as diarrhea, infectious hepatitis, typhoid fever and schistosomiasis are common. These diseases cause up to 10 percent of deaths among the general population and 30 percent of deaths among children (PRIDE 1994).

Irrigation with degraded water undermines agriculture production for the following reasons: (i) it has a direct adverse effect on crop yield; (ii) it lowers product quality, thus dampening its price; and (iii) if repeatedly applied, polluted water will destroy soil fertility through salt buildup and/or conglomeration of soil particles due to oil constituents. In industry, the use of degraded water raises maintenance costs because of increased equipment corrosion.

Egypt's competitiveness in international commodity and tourism markets may be damaged by a poor reputation on environmental issues. Consumer rejection of adulterated products is surging, and tourists fear waterborne disease. Unless good water quality is preserved, Egypt's exports and tourism will suffer.

Despite recognition of their adverse effects, it is now a decade since the issuing of Law 48/1982, yet industrial effluent, sewage, and agricultural drainage are still dumped into the Nile. Several studies have shed light on the critical situation of water quality. One comparatively optimistic report asserts that the river's assimilative capacity exceeds the present discharge of organic nutrients and biodegradable matter. However, inorganic salts, nutrients, pesticide residues, and oils have been steadily increasing in the Nile water—and its fish—since the construction of the Aswan High Dam (El Gohary 1993).

The National Specialized Council estimates industrial pollutants dumped into the Nile as 1151 ton/day (t/d) of dissolved solids, 296 t/d of suspended solids, 168 t/d of oils, and 1.65 t/d of heavy metals. The following is a survey of industrial pollutants (NSC 1992):

- The first Nile reach (from Aswan to Isna) receives effluent from Kima fertilizer factory, Kom Ombo sugar factory, a paper factory, and Sebaiaa Phosphate Port.
- The second reach (Isna to Nag Hammadi) receives discharges from sugar factories in Armant, Quos, Deshna, and Nag Hamadi, and from an aluminum factory.
- The third reach (Nag Hamadi to Assiut) receives the effluent of Sohag factories: onion dehydration, Coca Cola, oil, and soap.

- The fourth reach (Assiut to Kourimat) receives chemical waste of highly concentrated soluble material from fertilizer and phosphate factories, and the Minya oil and soup factories.
- The fifth reach (Kourimat to the Delta) receives the most hazardous pollutants, from factories in Hawamdia, Tebeen, Helwan, Torah, and Shoubra El Khima. This reach, which is the source for Cairo's municipal water, is also polluted by Nile cruise ships.
- The sixth reach (Rashid Branch) has two main sources of pollution: Rahawy sewage and drainage discharge, and effluent from Kafr El Zayat industrial region.
- The seventh reach (Damietta Branch) is polluted mainly by Talkha Fertilizer Factory; though a unit to purify discharge was installed at the factory at a cost of LE5 million.

Out of 20 cities and towns equipped with water treatment plants, only nine have reliable sewage treatment systems. Rural villages have no sewage systems. Sewage services cover 80 percent of the population in urban areas and only 5 percent in rural areas (PRIDE 1994). Sewage of the major areas in Egypt exceeds current treatment capacity. The 173 Nile cruise ships discharge their untreated waste directly into the river. Sewage from these ships is loaded with nitrogen, as well as microbial and viral infections.

Agricultural drainage is comprised of residue of toxic chemicals used to fight insects and plant disease, chemical nutrients added to enhance plant growth, and soil particles. The negative impact on public health of contamination with toxic chemicals requires no elaboration. Eutrophication caused by nitrogen, potassium, and phosphate stimulates rapid growth of aquatic micro- and macrophytes and encourages algal bloom. Sedimentation causes clogging of water conveyance facilities. Together they raise turbidity, boost maintenance costs of waterways and establishments, and alter the water habitat. Residues reach the Nile itself via 72 drains between Aswan and the Delta Barrage (NSC 1992). This does not include drainage north of the Delta Barrage.[١٠]

The above review poses important questions: Why have results been so limited? What can be done to reverse this trend?

---

[١٠] In addition to pollution from economic sectors at large, the individual man abuses water courses in her/his day-to-day practices: villagers use canals passing throughout or close to their villages for a variety of household and other uses such as drinking, cooking, washing dishes, clothes, animals, and equipment, and disposal of garbage and dead animals (DRI 1989:17,30-33).

Why the Current Policy Has Not Succeeded

The failure to improve water quality can be attributed to a number of factors:

- Laws 4/1994 and 48/1982 assume that polluting firms possess identical marginal abatement costs, and will respond similarly to a policy tool—which is not necessarily true. Reaction of firms varies widely depending on production technique, scale, etc.
- The procedures necessary to legally formalize a policy are lengthy and complex; this makes the policy rather rigid when adjustment is necessary in response to economic variables. What may be a prohibitive penalty one day could be rendered obsolete by economic change. For example, the maximum penalty imposed by Law 48/1982 is one year imprisonment plus a fine of not less than LE 500, which the legislators considered a severe punishment at the time. However, the real prohibitive power of this penalty has diminished over time and rendered it ineffective, especially when weighed against the probability of being caught.
- In many cases, polluters are persuaded to maintain the status quo because the cost of investing in new environmentally conservative techniques or in more expensive cleaning inputs to reduce emission decreases profit substantially.
- The difficulties involved in defining rights and liabilities leave room for lobbying and exploiting loopholes, thus undermining the strict application of laws and regulations.
- Governmental budget constraints may limit the ability of environmental authorities to sustain continuous alert monitoring of the extensive Nile network, active police support, and prohibitive judicial penalties.
- Law enforcement becomes lenient if the application of a policy results in closing down a firm and leaving the workers unemployed.
- Responsibility for environmental supervision is diluted among five government organizations responsible for sampling industrial effluent: the GOSD, the Ministry of Health (MOH), the General Organization for Industrialization, the General Organization for Greater Cairo Water Supply, and the MPWWR (El Gohary 1993).

The inefficiency of government action in addressing environmental issues has been explained thus (WCED 1983):

> "The nation state is insufficient to deal with threats to shared ecosystems. Threats to environmental security can only be dealt with by joint management and multilateral procedures and mechanisms."

Thus the absence of collaboration between the state and other concerned parties underlies the government's failure to enhance environmental conservation. The issue boils down to how to neutralize the factors undermining the efficacy of water management policies so as to improve the quality of returning water in a way that secures safe utilization. This mission is the subject of the following section, wherein a policy model grounded on the utilization of positive economic incentives is presented.

3. Towards a More Effective Policy

A well crafted policy, supported by government and nongovernment agencies, is one which induces polluters to minimize pollution with little or no coercion.

The conventional framework for discussing water pollution has four elements: the Nile's assimilative capacity, existing pollution levels beyond assimilative capacity, associated marginal social damage, and marginal social net benefit from pollution abatement. The intersection between marginal social damage and net benefit determines tolerable pollution. Accordingly, permits (tradable or not), taxes, and other prohibitive tools can be designed (see Pearce and Turner 1990, Baumol and Oates 1988, and Just et al. 1982). International experience with some of these tools is reviewed in Box 1.

In practice, unavailability of information is a major obstacle to enlightened application of these tools. If one of the four essential pieces of information is not available, then economic tools cannot be properly designed. Quantification of assimilative capacity and estimation of functions require considerable investment in data collection, processing, modeling, and specialized manpower, which are not generally available in developing countries. In fact, this information is not available for the Nile. These difficulties explain why economic tools have been neglected in forming management policy. However, the availability of an array of techniques to provide substitutes for polluting inputs makes it possible to circumvent this obstacle, and induce polluters to reduce emissions voluntarily.

Box 1: Some International Cases of Pollution Abatement

River/State	Measures
Colorado River, USA	Pollution control is directly related to water rights via tradable water rights and discharge permits. The latter takes into account the effect of returning effluent on water quality (Teerink and Nakashima 1993).
The Andean Basin, Peru	A new law proposes that existing users be granted tradable free water rights, to be recorded in a public water rights registry that indicates the quality and point of returning flow. Non-allocated or additional water is distributed by public auction. Water trade is subject to a minimum ecological water requirement (Thobani 1994).
Malaysia	Firms are required to treat their waste through a consortium or a private contractor; tax relief and industrial zoning are also provided.
Japan	Financial support and tax exemptions are provided for environment-related investment. Firms are expected to pay for the treatment of their waste by private contractors. Water use permits are issued after proving that the use will not have adverse effects on water quality; firms must advertise their intentions to allow parties that might be hurt to complain (Teerink and Nakashima 1993).
Yellow River, China	Financially autonomous water institutions have been established to collect water fees (Gunaratnam et al. 1992). Land use and industrial zoning are employed. Financial incentives are used to support investment in collective treatment plants (Brandon and Ramankutty 1993).

Source: Tohamy 1995.

The three most notorious water-polluting wastes—municipal waste, agricultural drainage, and industrial effluent—are considered below. Due to innate differences, each source is studied using a different framework. The municipal waste sector is funded mainly by the government, and largely comprises similar firms with identical wastes.

The agricultural sector consists of hundreds of thousands of farms producing scores of agricultural commodities, using, to a large extent, similar technologies. Hence, the sector bears considerable homogeneity that allows farms to be grouped for modeling. Farms contribute to the nonpoint pollution of the Nile with chemical fertilizers and pesticides. Alleviating the pollution requires modifying related techniques. The financial attractiveness of the proposed adjustments is assessed using a linear programming model (see Appendix).

Unlike the first two, the third sector, industry, is characterized by a high degree of heterogeneity, even when broken down into sub-industries. As heterogeneity does not allow proper aggregation, case studies from the ECEP/EP3 project are used.

Municipal Waste

Municipal waste in this context includes sewage, town and rural garbage, and farm waste. The total quantity is estimated at 50 million tons/year (Awadallah 1995). This represents a financial burden and an environmental hazard. The financial burden is created by the cost of collecting, transporting, and treating this huge amount of solid and liquid waste. Environmental problems are associated with the different phases of handling waste. Time lags in the process of garbage collection and disposal provide insects, microbes, etc. with an environment in which to multiply and spread. Some garbage components are recycled, and much of the rest are burned, either deliberately or by self-ignition, in either case resulting in the emission of harmful gases. Sewage may not be fully treated—or not treated at all—before being dumped into the Nile.

A very simple yet effective approach is needed to reduce the cost of waste disposal while protecting the environment. Various types of waste (excluding glass and metals, which are already recycled) can be processed into inexpensive organic fertilizers and compost that are rich in nutrients, as demonstrated by the analysis of the products of El Moqattum Waste Station (Awadallah 1995).

Revenues to be generated from selling wastes are expected to be the prime motive for firms to adopt this approach, which offers several benefits. First, creating a demand for waste transforms it from a "bad" that one must get rid of, to a “good” that can be sold. Hence, there would be agents interested in collecting and selling waste.[11] Investment and employment opportunities would be created. Environmental hazards from burning and dumping waste would be alleviated, and environmentally-clean inputs would be available as substitutes for chemical fertilizers whose residues are carried with drainage water into the Nile. The demand for this product will be in the agriculture sector.

Agricultural Pollution

The positive contribution of the agriculture sector is accompanied by negative external diseconomies in the form of toxic chemical residues entering the human food chain. The harmful impact of toxic chemicals on public health requires no elaboration. The two sources of chemical residue in drainage water are pesticides and chemical fertilizers. The second source is discussed here.

[11] This kind of business is already practiced in Egypt for the purpose of recycling certain garbage elements. Similarly, in the sewage sector some firms sell the sludge to farmers.

Egyptian farmers will be more willing to adopt new production techniques if those techniques have been tested in Egypt by specialized research institutes, and have proven suitable for Egyptian conditions; this is a key component to success. These techniques will lead to reduced use of chemical fertilizers and replacing them with biofertilizers or organic substitutes. Thirty techniques are recommended by Awadallah (1995) and Siam (1995). Awadalla focuses on testing the technical viability of recycling municipal waste to produce organic fertilizers and compost, and the impact of such techniques on farm income.

Demand for chemical fertilizer tends to be inelastic. This position is supported by two studies carried out in the Eighties, and was also observed after the recent lifting of fertilizer subsidies. Although fertilizer prices rose by 300 percent between 1989–92, use dropped by only 16 percent (Siam 1995). The weak responsiveness of demand to price increase is attributed to farmers' ignorance of available substitutes. Lack of information and artificially low prices of chemical fertilizers due to subsidization combine to eliminate incentives for farmers to look for alternatives.

Biofertilization is another topic covered by Siam. Significant savings in cost and application rate for chemical fertilizers can be obtained by inoculation with nitrogen fixing bacteria or the introduction of microorganisms to modify soil pH, thus transforming phosphorous in the root zone to a form that can be taken up by the plant.

Both studies covered seven crops: wheat, broad beans, maize, barley, berseem, rice and sugar cane. The conventional fertilization technique (derived from the MALR Economic Bulletin), plus the 30 nonconventional techniques recommended by Awadallah and Siam, make up the 31 techniques used in the model. Willingness to adopt these techniques was assessed using a GAMS linear programming model. The model simulated four scenarios, of which one pair represented the conventional fertilization technique (which relies heavily on chemical fertilizers) and the other introduced the thirty nonconventional techniques. For each pair, one scenario allocated land without restriction on any of the crops, while the other restricted crop area to 133 percent of its regional area in 1993. Four indicators were adopted to assess the viability of the proposed techniques: net revenue, value added, shadow land price, and change in cropping pattern. Table 4 summarizes the first three indicators, showing that clean agriculture scenarios are superior to conventional methods, and achieve greater values.

As for the cropping pattern, the area cultivated using new techniques exceeded 6 million feddans with area restriction and 1.2 million feddans without.

Table 4: Summary of the Results of the Four Scenarios

Crop Area	Free		Restricted	
Technique	Conventional	Clean	Conventional	Clean
Net revenue (billion LE)	30	32	8	13
Value added (billion LE)	39	41	15	20
Shadow Land Price				
Upper Egypt (LE)	3,512	4,718	1,000	1,151
Middle Egypt (LE)	6,165	6,165	634	652
Lower Egypt (LE)	4,492	4,477	1,039	1,311

Source: Summarized from the output of the linear programming model.

Industrial Effluent

The industrial sector is a point-source polluter, thus it is easy to identify and measure emission per unit of time. One strategy to abate industrial pollution that is gaining worldwide acceptance is pollution prevention. This strategy can be thought of as a pyramid of actions arranged in descending order, with the most environmentally preferable at the top, and the least preferable at the bottom. An action is selected only when those above it are not viable. The pyramid is summarized from the top down as: (i) full prevention of pollution by changing a process or an input; (ii) reduction of polluting source; (iii) internal recycling of waste either as a product or a material; (iv) external recycling of waste, either as a product or a material; (v) waste treatment by pyrolysis; (vi) incinerating waste with energy recovery; (vii) incinerating waste without energy recovery; and, if the above fail (viii) land fill disposal; (ix) air emission; and (x) discharge into water (adopted from Bush 1995 and De Neve 1995).

Many factories around the world have experience with pollution prevention. The Smith & Wesson company (USA) documents a number of examples. One problem involved aging equipment, an inefficient cooling system with regard to heat treatment, and the utilization of high volumes of water. A solution was found that used closed loop cooling: a cooling tower to continually recycle the water was installed at a cost of $79,887, which was recovered within 18 months. This achieved savings in water usage of 95 percent (Autorino 1995). Another dramatic example is given by 3M, where over a period of 14 years of pollution prevention (1975–89), the company achieved savings of $500 million worldwide (De Neve 1995).

In Egypt, pollution prevention began recently with a project funded by USAID/Cairo and implemented—in cooperation with a number of factories—by four institutes: the Environment Pollution Prevention Project based in Washington DC, the Development Research and Technology Planning Center/Cairo University, which is working with a number of private sector factories, the Tibbin Institute for Metallurgical Studies, which is helping some public sector factories, and the Federation of Egyptian Industries, which is in charge of information dissemination and training. Apart from its favorable environmental impact, this project is distinguished by a number of interesting characteristics: it operates within the low-cost/no-cost range, it implements pollution prevention schemes at the factory level in full cooperation with factory staff, it is process-specific, and serious attention is paid to information dissemination.

Tentative results from the short-lived project are promising and in agreement with international experience; water savings of 220 thousand cubic meters were made in five of the factories participating in the project. The cost of one cubic meter ranged from LE 0.75 to LE 1.65 per cubic meter for treated water. Water savings were associated with effluent reduction and material conservation of about LE 1.5 million. Pollution prevention in four factories reduced VOC emissions and achieved savings of LE 1.3 million, as well as improving product quality. Similarly, the burning of *mazout* in three factories has been reduced by 2,000 tons annually. There has also been a positive impact on health and fire hazards.

The techniques used with the factories under study were prevention, source reduction, internal recycling, and external recycling, bringing about cost savings that translated into greater profit and value added. These techniques were employment-neutral except in two cases: directing waste to external recycling, and replacing external recycling with internal recycling. Directing waste to external recycling creates job opportunities. However, replacing existing external recycling with internal recycling results in unemployment. The latter case was observed in one factory, where hard zinc, zinc ash and dust were previously bought by an external contractor for remanufacture. Pollution prevention recommended internal recycling. As a result, some jobs concerned with the remanufacture of zinc were lost. The only advantage was that the remanufacturing subcontractor was operating in a heavily populated area in the slums of

Cairo, so the action was environmentally favorable. But the negative social impact must be dealt with by arranging alternative training and employment opportunities.

Summary and Recommendations

Egypt relies on reusing returning water to alleviate its water shortage. The viability of this option is undermined by the degraded quality of returning water. The government has attempted to enhance water quality by legislating environmental laws, establishing specialized agencies, designing environmental plans, and launching media campaigns. Evidently, those efforts have not been successful in achieving their goals.

The deficiency in the current environmental policy lies in its concentrating on imposing constraints and penalties on pollution emission with little or no regard for the negative impact this will have on polluting firms. Consequently, a wedge has been placed between the objective of sustaining clean environment and the polluters' interest in keeping the cost of production low so as to compete in local and international markets—an interest which is socially favorable. In other words, the dysfunction of the current environmental policy is due to forcing established polluting firms to incur the cost of cleaning the environment while the government pays the cost of enforcement.

This paper deals with the deficiency of the current environmental policy by demonstrating advantages society can gain if positive economic incentives are exploited in order to: (1) curb pollution and, meanwhile, (2) supply a built-in force that generates the momentum necessary to assure continuity of the conservation of the environment and, ultimately, secure safe reuse of returning water. This force takes the form of increment in returns associated with the adaptation of environmentally conservative adjustments in the polluting production processes. This policy has been considered for the three most notorious water-polluting sources; namely; municipal, agricultural and industrial activities. The following sections summarize the appropriate policy tools.

Municipal wastes are not thoroughly collected nor properly disposed of, and thus present serious environmental hazards. Public firms engaged in waste handling suffer the lack of funds from an already-burdened government budget. As for private firms, the low returns, limited information and social attitude towards that type of business have confined its entrepreneurs and workforce to unskilled workers operating with meager investments and; subsequently, primitive technology.

Since this type of business activity is not well known to entrepreneurs in Egypt, an action plan is needed to encourage the private sector to get involved, by:

a) initiating a promotion campaign to boost business' awareness of potential gains associated with treating and recycling wastes. This can be achieved by compiling information about relevant local and foreign experiences. Several countries have successful projects in that area. For example, Japanese firms contract specialized private plants to handle and dispose of their wastes (Teerink and Nakashima 1993).

b) providing soft loans and tax relief to help reduce the risk and uncertainty factors associated with this type of new project. Some countries continue to support such projects beyond the initial phase as a contribution from the society to environment conservation. Support is justified on the ground that a cleaner environment benefits the whole society and that an economic contraction associated with strict enforcement of environmental regulation will hurt the whole society; therefore, society should help established firms to cope with the cost of keeping the environment clean; this is being done in Malaysia and China (Tohamy 1995 and Ramankutty 1993).

Beneficial utilization of municipal wastes will make them a source of revenue for firms. A major use of municipal wastes is in manufacturing organic fertilizers and compost. Manufacturing wastes into organic fertilizers and compost is beneficial at both the social and private levels: The pollution associated with waste gathering, handling and disposal will be eliminated, since slack collection and neglectful processing will cost the firms revenues from selling waste. As such, a firm is motivated to do a better job in collecting and handling wastes which will, in addition, lead to a cleaner environment.

Municipal firms will, as in any other industry, have access to the financial markets to secure funds to modernize their technology and expand their capacities to treat wastes. The creation of a new industry specialized in manufacturing organic fertilizers and compost opens investment opportunities and creates jobs, with positive bearings on economic growth.

The agriculture sector produces nonpoint pollution as a result of heavy use of chemical fertilizers. The reduction in the use of chemical fertilizers would eventually reduce farm yield and revenues. Naturally, farmers will take a negative attitude towards using less chemical fertilizers. Nevertheless, this stance can be reversed if a more profitable substitute is introduced. Field experiments performed by specialized Egyptian institutions indicate that organic fertilizers manufactured from municipal wastes are cheaper *and* nutritionally richer than chemical fertilizers. (Further research is needed to support that this finding holds under varying circumstances.) Another option is the use of biofertilization, which can substitute for some conventionally applied chemical fertilizers. Hence, farmers who replace chemical fertilizers get greater net income because of: (i) the lower cost of organic fertilizers, and (ii) the greater revenues generated by higher yield. In order to disseminate this environmentally conservative technique, a nationwide on-farm demonstration program can be established to provide firsthand experience to farmers, showing the appropriate ways and schedules of applying organic fertilizers and demonstrating gains.

The significance of the economic complementarity (or vertical integration) between the scheme designed for the municipal waste sector and that recommended for the agriculture sector must be highlighted. The proposed plan comprises three sectors: the municipal waste sector, the organic fertilizer and compost industry, and the agriculture sector. The municipal waste sector, which is a service sector, would be transformed into a real sector producing an essential input (wastes) for the organic fertilizer and compost industry. The latter industry would add to Egypt's industrial base, and would be the demander of wastes and, meanwhile, the producer of organic fertilizers and compost. These products are demanded by the agriculture sector as a substitute for chemical fertilizers. Clearly, with the favorable environmental impact of this policy, a sizable increment in value added is expected.

Unlike the municipal waste and the agriculture sectors, industry is highly heterogeneous. This characteristic does not allow dealing with the whole sector as one unit for pollutants vary from an industry to another and even from a process to another within the same industry. A way around this complexity is to focus on processes which are similar across different industries (e.g. metal finishing process). Actually, this is exactly the approach being followed by the "Environmental Pollution Prevention Project (EP3)". The EP3 project is being applied in Egypt and is providing valuable case studies which support the positive incentives thesis advocated in this research. A distinctive feature of this approach is that it utilizes the low-cost-no-cost methods to treat several types of pollutants which harm more than one environmental media. Moreover, it introduces resource conservation; all in one package.

Being in an early phase of implementation in Egypt, only a few cases are available for this study with limited economic data. Drawing upon those studies, it is recommended that low-cost-no-cost pollution prevention approaches be exhausted before resorting to other more expensive methods; this way the private as well as the social costs of cleaning the environment can be minimized. The Federation of Egyptian Industries is already involved in disseminating pertinent information, and the industrial sector is relatively ahead of the other two sectors in terms of pollution mitigation.

The findings of this paper demonstrate the effectiveness of positive economic incentives in achieving Egypt's aspiration for a clean Nile. The power of these tools lies in alleviating the financial burden of cleaning the environment; under the current policy this burden is the responsibility of the polluting firms. Furthermore, it reduces the costs of law enforcement along with concomitant tension.

Other tools can also be integrated to mitigate water pollution. One is to rationalize the use of fertilizers. Evidently, there is no agreed upon rates of application. MALR provides application rates as a national average. Farmers are allowed to buy fertilizers from the cooperatives according to those rates, although they actually adopt different ones. In 1991/92 the application of phosphorus (P) was above that of MALR by up to 150, 160, and 200 percent in maize, wheat, and rice respectively; the nitrogen (N) rate was as low as 70 and 80 percent for wheat and maize respectively (calculated from Siam 1995). Another tool is raising the price of the polluting input so as to reduce its demand. This has been implemented when subsidies on chemical fertilizers were lifted as a part of the economic reform process. Initial observation indicate that this approach has a limited impact on reducing the consumption of chemical fertilizers (Shoals 1993:19-22).[12] Industrial zoning is a third tool where industries with safer pollutants are located relatively upstream and those with relatively less safe pollutants downstream. Zoning also helps in identifying industries with similar pollutants so as to facilitate construction of specialized treatment plants. Zoning schemes are effectively used in China.

[12] In 1989/90-1990/91, the overall nutrient price (N+P+K) was raised by about 23 percent; this resulted in a 16-percent decline in aggregate nutrient consumption (Shoals 1993:19-22). This suggests that demand for chemical fertilizers tends to be inelastic. Inelasticiy is attributed to: (a) lack of substitutes for chemical fertilizers (such substitute is proposed in this study), (b) the small ratio of the fertilizers cost to the value of crop yield (about 5-9% in main crops such as wheat, short berseem, long berseem, cotton, maize and rice; calculated from Siam 1995) has enabled farmers to absorb the increment in the cost of fertilizers without having to reduce consumption significantly, and (c) farmers replaced the nutrients with severe price hikes (P increased by 54 percent and K by 409 percent) by ones with limited price increases (N increased by 14 percent).

In light of the findings of this study, Egyptian institutions concerned with environment conservation in general and water planning in particular are urged to take the necessary measures to incorporate positive economic tools in the national environment policy. Adoption of these policy tools can avail Egypt of safe reuse of returning water to satisfy the growing water demand.

Appendix 1: The Agro-economic LP Model

Data Sources

At the time of research, 1993 data was the most recent set issued by the "Agricultural Economy Bulletin," published in mid-1995. The bulletin is published annually by the Central Department of Agricultural Economics, the Economic Affairs Sector of MALR. In addition to direct field surveys, this department is the formal data source for plant, animal and fish production in Egypt. Its data are used and published by other government authorities as well as international agencies. The bulletin provides demographic data, national aggregates, and governorate-level plant production data, with crops broken down into varieties. It lists areas planted under each variety, total production, yield, cost, revenue, and farm gate prices.

Data manipulation included entering data on an Excel 5 worksheet, checking and evaluating them manually. As a cross-check, the net revenues calculated by the GAMS program were compared with published figures. In addition, some field operation data such as planting dates, labor and water requirements, were obtained from a recent study prepared by the IFPRI team.

The Decision Variable

To operate his or her farm, a farmer makes many decisions every day. Broadly, these decisions can be classified as long-term, seasonal and short-term. Long-term decisions involve investment in machinery, farm buildings, orchards and the like. This type of decision is governed by the farmer's expectations about the time profile of the cost and benefit streams compared to alternative options. At the other extreme, day-to-day decisions involve the utilization of labor, water and other inputs, and are dominated by seasonal decisions.

Given the production environment and constraints, a farmer makes two seasonal decisions: crop choice and area planted. These are the two most important farm decisions. Farm income depends on how successful a farmer is in selecting the most profitable crops and in allocating his land among them. The welfare of his family during the following season depends on that farm income. Return to resources, whether land, labor or capital, is determined by the outcome of those decisions. The farmer's decisions also affect, on aggregate, the returns to two of the most important natural resources in Egypt: land and water.

Due to the importance of the farmer's decisions on the allocation of land, this parameter was adopted as the decision variable in this model. This decision is assumed to be guided by net revenue. Hence, a farmer maximizes total net revenue during the agricultural year (which begins in October).

Geographical Aggregation

Agricultural land in 1993 was estimated at 7.2 million feddans, most of which (6.1 million feddans) was in the Nile Valley and Delta (MALR 1993). As this area is spread across the 26 governorates with varying degrees of intensity, it was aggregated into regions for modeling.

One level of aggregation divides the agricultural land in Egypt into Old and New Lands. This practice is widely used in the literature on Egyptian agriculture. Its main concern is to distinguish between the land brought under production before aggressive land reclamation started in the early Sixties, and the lands reclaimed afterwards. Such aggregation is misleading. Confusion arises from the fact that some newly reclaimed land penetrates the Nile Valley and Delta governorates. The newly reclaimed land in 1993 was estimated at 647,000 feddans, of which 60 percent lies in the desert governorates.[١٣] The rest (256,000 feddans) is scattered throughout the Nile Valley and Delta.

Table 5: Old and New Lands in 1993

Location	Area (thousand fed.)
Desert governorates	390.8
New Lands in the Valley and Delta	256.1
Total New Lands	646
Old Lands in the Valley and Delta	5,884.9
Total agricultural area	6,531.8

Source: MALR 1993:66, Table 38; areas of New and Old Lands in the Valley and Delta are calculated.

Another aggregation was recently adopted in a study prepared by the IFPRI team (Hazell et al. 1994). The team divided the country into eight regions, five Old Lands regions and three New Lands regions. The Old Lands regions were divided, according to

[١٣] Desert governorates are the New Valley, Mattroh, North Sinai, South Sinai, and the Red Sea.

geographical considerations, into Upper Egypt, Middle Egypt, East Delta, Middle Delta, and West Delta. The division of the New Lands contains a geographical dimension only in the sense that it is mostly located outside the Nile Valley and Delta. Other than that, two main criteria were used in the classification: soil type and source of irrigation (Old Lands depend mainly on surface irrigation). Accordingly, the New Lands were divided into sandy soil with canal irrigation, clay calcareous soil with canal irrigation, sandy soil with groundwater irrigation, and a generic region that encompasses other soil types. Obviously, the IFPRI team focused on soil homogeneity and water source in order to reduce discrepancies in the New Lands sub-model.

Many of the studies on Nile pollution divide the river into seven reaches, as mentioned above (NSC 1992). The main advantage of this division is that it allows environmental monitoring of water quality and assimilation capacity in each of the Nile reaches.

Regardless of the division, there are problems associated with water-related studies. These problems are caused by inconsistencies among the three sorts of official divisions prevailing in the Egyptian agriculture system: the administrative unit, the irrigation command, and the drainage command. The WMP team wrote a computer program that switches from one division to another. However, special agricultural data have to be collected at the village level in order to use the program effectively.

Given the above, the scheme most suitable for this study was to divide Egypt into three regions: Upper Egypt, Middle Egypt, and Lower Egypt (Delta) This leaves out desert regions). The Upper and Middle Egypt governorates do not have extensive drainage systems (except for Fayoum Governorate). Thus, drainage water is discharged into the Nile network and used in Lower Egypt. In Lower Egypt, nonpoint source pollution leads to pollution of the northern lakes and the Mediterranean. Furthermore, this is consistent with the agricultural data set-up. The distinction between the newly reclaimed land in the Nile Valley and Delta and the Old Lands is overlooked. This simplification is not expected to impair the analysis for several reasons:

- New Lands in the desert governorates are mainly irrigated from sources other than Nile water (MALR 1993).[١٤]

[١٤] A reservation on this statement may rise in the future with respect to El-Salam Canal which water will be used to irrigate about 400 thousand feddans in Sinai. Water of this canal is a mix of the Nile and drainage water.

- Except for the New Valley (which represents 0.7 percent of the agricultural area of Egypt), desert governorates do not have a drainage network (MALR 1993), hence they do not contribute to Nile water pollution.
- The total area of desert New Lands is relatively small (about 9 percent).

Regional distribution of agricultural land is summarized in Table 6. Upper Egypt consists of four governorates: Aswan, Qena, Sohag, and Assiut. There are approximately 1.1 million feddans of agriculture land in Upper Egypt, approximately 18 percent of the agriculture area of the Nile Valley and Delta. Of these governorates, Aswan has the smallest share of agricultural land (2 percent). Middle Egypt comprises four governorates, Minya, Fayoum, Beni Sueif, and Giza, with a total agricultural area of 1.2 million feddans.

Table 6: Regional Land Distribution in 1993 (thousand feddans)

Region	Area	Percentage
Upper Egypt	1,090.7	18%
Middle Egypt	1,237.1	20%
Lower Egypt	3,823.2	62%
Total	6,141.0	100%

Source: MALR 1993:66; Table 38.
Percentages are calculated.

The agriculture area of the Delta represents 62 percent of the Nile Valley and Delta (about 3.8 million feddans). It is divided into 13 governorates, of which seven are basically urban or industrial centers (9 percent).[15] Agricultural land is concentrated in the other six governorates (52 percent): Menoufia (5 percent), Sharkia (11 percent), Dakahlia (10 percent), Kafr El Sheikh (8 percent), Gharbia (6 percent), and Beheira (12 percent).

Cropping Pattern

Four categories of crops are cultivated in Egypt: winter, summer, nili, and perennial. As shown in Table 6, about 88 percent of the cropped area is under winter and summer crops.

[15] Urban centers are Cairo (includes 0.08 percent of the valley and Delta agriculture area), Suez (0.17 percent), Port Said (0.09 percent), and Alexandria (1.8 percent). Minor agriculture governorates are: Qaliobia (industrial and urban center 3 percent), Ismailia (2 percent), and Damietta (1.8 percent).

Table 7: Land Allocation by Season (1993)

Season	Area (thousand fed)	Percentage
Winter	5,157	45
Summer	4,869	43
Nili	558	5
Perennial	835	7
Cropped area	11,419	100

Source: Calculated from MALR 1993:66, Table 38.

In order to keep the model manageable, and at the same time observe regional specialization, only key crops were included. The relative importance of crops in each season was evaluated according to percentage of total area allocated to each crop.

Moreover, crops that occupy no less than 10 percent of the regional agricultural area are not included. Twenty two crops met these criteria : Ten winter crops, occupying 93 percent of the national area under winter crops in 1992/1993, 11 summer crops, cultivated on 86 percent of summer land, and one perennial crop (sugar cane) were selected for study.[16] All together, the area of these crops represents 75 percent of the cropped area in Egypt.

Flexible Farming Options[17]

To approximate reality as much as possible, farmers were given six options: three planting dates and three irrigation levels. They could cultivate one crop at a time, one month early or one month late. Delaying some summer crops one month was the same as cultivating them as nili crops. However, they were treated as summer crops in terms of input-output coefficients. Early cultivation was assumed to reduce yield by 5 percent, and a one month delay decreased it by 10 percent. This assumes that the most suitable weather is always found around the normal planting date. In reality, erratic weather changes may increase the yield of late cultivation. However, as this is a deterministic model, such stochastic behavior is beyond its scope.

Table 8: Yield Response to Farming Options

Planting Date	High Irrigation	Medium Irrigation	Low Irrigation
Early	5%	11%	23%
Normal	0%	6%	18%
Late	10%	16%	28%

[16] That leaves less than 0.6 million feddans under orchids and palm trees.
[17] These options are adopted from Hazell et al. 1994.

Irrigation options were to apply 100 percent, 85 percent or 70 percent of a crop's seasonal consumptive use. The impact of the variation in irrigation level was estimated using an FAO model (CROPWAT). Yield response to the level of water application was expected to be 0, -6 and -18 percent, respectively (Hazell et al. 1994). The combined effect of the two sets of options was assumed to be additive (Table 8).

Revenue

Published per feddan yield for each region was assumed to be the benchmark under prevailing conditions in 1993. When a regional average was not available, an area-weighted average was calculated. For each yield, eight additional values were calculated to adjust for planting dates and irrigation options using the variation shown in Table 7. The same procedure was applied to by-product yield. Yields of the nine alternatives were multiplied by corresponding average seasonal prices. Thus, price advantage of early harvest was not accommodated; Yield-related cost items were subsequently adjusted.

Input Cost

Cost of production was divided into eleven items: land preparation, seed and cultivation, irrigation, manure, chemical fertilizers, agricultural operations, pesticides and the like, harvest, on-farm product transportation, miscellaneous, and rent.

Rent is a problematic issue. On the one hand, it is a fixed cost item since it has to be paid whether the land is cultivated or not. On the other hand, it is crop-specific. Its value is mainly determined by the crop that will be cultivated, suitability of land to that crop, crop duration, and other factors such as proximity to market, irrigation source, etc. Thus, rent is considered a variable cost item in this model. Market rent, not the official rent, was used. The importance of the distinction between rent as a variable or fixed cost is in the distinction between "gross margin" and "profit." The first is "gross revenue" less "variable cost." The latter nets out other paid fixed cost items. Irrigation has been adjusted according to the irrigation options. Other inputs adjusted to yield changes are harvest and transportation costs.

Resource Constraints

Monthly constraints at the regional level were imposed on the area under selected crops and on the labor requirement. A single constraint was imposed on the national irrigation requirement.

Appendix 2: Mathematical Presentation of the Agro-economic LP Model[18]

Figure 1. The "Free" Conventional Agriculture Model (CONVAG)

$$\max_{AREA} \sum_{C}\sum_{D}\sum_{G}\sum_{R} NREVENU_{CDGR} * AREA_{CDGR}$$

S.T.

$$\sum_{C}\sum_{D}\sum_{G} LABOR_{MCDGR} * AREA_{CDGR} \leq TLABOR \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G} LANDM_{MCDGR} * AREA_{CDGR} \leq TAREA \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{R} IRIREQ_{CDGR} * AREA_{CDGR} \leq TWATER$$

$$AREA_{CDGR} \geq 0 \qquad \forall C, D, G, R$$

Figure 2. The "Restricted" Conventional Agriculture Model (CONVAGX)

$$\max_{AREAX} \sum_{C}\sum_{D}\sum_{G}\sum_{R} NREVENU_{CDGR} * AREAX_{CDGR}$$

S.T.

$$\sum_{C}\sum_{D}\sum_{G} LABOR_{MCDGR} * AREAX_{CDGR} \leq TLABOR \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G} LANDM_{MCDGR} * AREAX_{CDGR} \leq TAREAX \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{R} IRIREQ_{CDGR} * AREAX_{CDGR} \leq TWATER$$

$$\sum_{D}\sum_{G} AREAX_{CDGR} \leq \mathrm{TAREAS}_{CR} \qquad \forall C, M$$

$$AREAX_{CDGR} \geq 0 \qquad \forall C, D, G, R$$

[18] Notation follows that used in the GAMS program as closely as possible.

Figure 3. The "Free" Clean Agriculture Model (CLENAG)

$$\underset{AREA}{MAX}\sum_{C}\sum_{D}\sum_{G}\sum_{Y}\sum_{R} NREVENU_{CDGYR} * AREA_{CDGYR}$$

$$S.T.$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{Y} LABOR_{MCDGYR} * AREA_{CDGYR} \leq TLABOR \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{Y} LANDM_{MCDGYR} * AREA_{CDGYR} \leq TAREA \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{Y}\sum_{R} IRIREQ_{CDYGR} * AREA_{CDGYR} \leq TWATER$$

$$AREA_{CDGYR} \geq 0 \qquad \forall C, D, G, R$$

Figure 4. The "Restricted" Clean Agriculture Model (CLENAGX)

$$\underset{AREAX}{MAX}\sum_{C}\sum_{D}\sum_{G}\sum_{Y}\sum_{R} NREVENU_{CDGYR} * AREAX_{CDGYR}$$

$$S.T.$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{Y} LABOR_{MCDGYR} * AREAX_{CDGYR} \leq TLABOR \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{Y} LANDM_{MCDGYR} * AREAX_{CDGYR} \leq TAREAX \qquad \forall R, M$$

$$\sum_{C}\sum_{D}\sum_{G}\sum_{Y}\sum_{R} IRIREQ_{CDGYR} * AREAX_{CDGYR} \leq TWATER$$

$$\sum_{D}\sum_{G}\sum_{Y} AREAX_{CDGYR} \leq \mathrm{TAREAX}_{CR} \qquad \forall C, R$$

$$AREAX_{CDGYR} \geq 0 \qquad \forall C, D, G, Y, R$$

Notes: C= crop, D= planting date, G= irrigation level, R= region, M= month, NREVENU= per feddan net revenue of crop C, AREA= area under crop C, LABOR= per feddan labor requirement of crop C in month M, TLABOR= total labor in month M in region R, LandM= land requirement of crop C in month M, TAREA= total agriculture area in region R in month M, IRIREQ = per feddan requirement of crop C in region R, TWATER= total national water. AREAX= regional area under crop C, TAREAS=1992 regional area under crop C multiplied by 133%.
Y= fertilization technique.

References

Abu-Zeid, M. A., 1992, "Major Issues in Egypt's Water Resources and Irrigation Policy: To the Next Century," Key Note, Roundtable on Egyptian Water Policy, Proceedings of a Seminar on Egyptian Water Policy, sponsored by the Water Research Center, the Ford Foundation, and Winrock International, Alexandria, Egypt, April 11-13, pp. 2-10.

Abu-Zeid, M. A. and M. A. Rady, 1991, "Egypt's Water Resources Management and Policies." Comprehensive Water Management: Policy Workshop, the World Bank, Washington D. C., June 24-28.

Abu-Zeid, M. A., 1990, "Conservation & Management of Water Resources for Sustainable Development," Desert Development Digest, Vol. 3, 1(winter):1 -3.

Amer, Hassan Mohamed, 1992, "Reuse of Drainage Water Project for Irrigation Purposes: The Current Situation, and Future Use Strategy", presented to the Conference on Agricultural Strategies for the 1990s, Feb. 16-18, Cairo, MALR. (in Arabic).

A.R.E., 1995, "Law Number 4 for the Year 1994 to Issue a Law Concerning the Environment," 2nd print, the General Authority for Official Printshop Affairs, Cairo. (in Arabic).

A.R.E., 1994, "Legislation Collection: Protecting the Environment from Pollution," 2nd print, Part 1, the General Authority for Official Printshop Affairs, Cairo. (in Arabic).

Awadallah. S., 1995, "Recycling Municipal and Farm Wastes for Bioagriculture in Egypt" (mimeograph).

Auld, B.A., K.M. Menz, C.A. Tisdell, 1987, Weed Control Economics. London: Academic Press.

Autorino, A.A., 1995, "Smith & Wesson: Environmentally Safe Production," A presentation and a handout distributed at a conference on "The Role of Cleaner Production in Meeting the Challenges of a Changing World Economy," Taba, Egypt, July, 24 -27.

Baumol, William J., 1977. Economic Theory and Operations Analysis, 4th ed. London: Prentice Hall International.

Biswas, Asit K., 1991, "Land and Water Management for Sustainable Agricultural Development in Egypt: Opportunities and Constraints," Report Submitted to the Food and Agricultural Organization, Project TCP/EGY/0052, Rome, Italy.

Brandon, Carter and Ramesh Ramenkutty, 1993. "Toward an Environmental Strategy for Asia." The World Bank, Washington D.C.

Bush, Barbara, 1995, "How Cleaner Production Can Help Industries: Lessons Learned from US Environmental Policy." A presentation made and a handout distributed at the confer ence on "The Role of Cleaner Production in Meeting the Challenges of a Changing World Economy," Taba, Egypt, July, 24-27.

CAPMAS, 1994, Statistical Year Book 1952-1993, Cairo, Egypt.

Chemonics, 1992-c, Unaccounted-for Water in Rural Water Systems: A Case Study, USAID Contract No. 263-0182-C-00-8041-00, Project No. 263-0182, PWS 4-02(E).

DRI l989, Environmental and Health Impact of Irrigation and Drainage System in Egypt: Advisory Panel for Land Drainage in Egypt, ESG.

EEAA, "The Fifteen-Year Plan for Environmental Protection: 1994-2008".

ECEP/DRTPC/TIMS/EP3, 1995, "Pollution Prevention Assessment," various issues.

El Gohary, Fatma, 1993, "Comparative Environmental Risks in Cairo, Water Pollution Problem." In PRIDE (Project in Development and the Environment), 1994, "Comparing Environmental Health Risks in Cairo, Egypt", Vol. 3: Technical Annexes, Reports by Egyptian Consultants, USAID Contract Number: ANE-0178-Q-00-1047-00.

Gren, Ing-Marie, 1993, "Alternative Nitrogen Reduction Policies in the Malar Region, Sweden, Beijer Reprint Series, No. 14, Beijer International Institute of Ecological Economics, the Royal Swedish Academy of Sciences.

Gunaratnam, Daniel J., Gary P. Kutcher, and Stephen J. McGurk, 1992, "Application of a Basin-level Model to the Yellow River. Water Policy and Water Markets. Guy Ley Moigne et al., eds. The World Bank, Washington, D.C.

Hazell, Peter, Nicostrato Perez, Gamal Siam, and Ibrahim Soliman, "Effects of Deregulation of the Agricultural Production Sector on Food Availability and Resource Use in Egypt." In MALR/IFPRI 1994, "Maintaining Food Security in Egypt during and after Agricultural and Food Policy Reform," pt. III. (manuscript).

Hulme, Michael, 1990, "Global Climate Change and the Nile Basin," in the Nile Resource Evaluation, Resource Management, Hydropolitics and Legal Issues, P.P. Howellaud and

J.A. Allan (eds), Centre of Near and Middle Eastern Studies: University of London, pp. 59 - 83.

Just, Richard E., Darrell L. Hueth, and Andrew Schmitz, 1982, Applied Welfare Econ omics and Public Policy, New Jersey, Prentice Hall.

Khouzam, Raouf F., 1995, "Collective Action in Irrigation," in Resolution of Water Quantity/Quality Conflicts, Ariel Dinar and Edna Loehman, eds., Greenwood Publishing Group.

Libby, Lawrence W. and Will iam G. Boggess, 1990, "Agriculture and Water Quality: Where Are We and Why?." in Agriculture and Water Quality: International Perspectives, Boulder, John B. Braden and Stephen B. Lovejoy, eds., Lynne Rienner Publishers, pp. 9 -38.

Land Master Plan :1986, Final Report, Main Report, prepared by Euroconsult/PACER Consultants, Code 5.09.077, Cairo, Egypt.

Lundqvist, Jan and Torkil Jonch-Clausen, eds., 1994. Putting Dublin/Agenda into Practice: Lessons and New Aproaches in Water and Land Management. Special Ses sion at the 8th IWRA World Congress, Cairo, Egypt, November 21 -25.

Meadows, Donella H. Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1973. The Limits to Growth. Universe Books, New York.

MPWWR/Ford Foundation : 1988, "Groundwater Extraction and Use in Irrigating Old Lands in the Nile Valley," Final Report, Main Report, Cairo, Egypt.

MALR, 1993, Agricultural Statistics Brief, No. 1, Cairo, Egypt (in Arabic).

Ministry Of Planning : 1992, The Third Five Year Plan for Economic and Social Devel opment (1992/93-1996/97) and its First Year 1992/93, Second Volume: The Sectoral Picture. (in Arabic).

NSC, 1992, "The Policy of Protecting the Nile River from Pollution," in Encyclopedia of the National Specialized Councils: 1974-1992. Vol. 18, pp. 229-254 (in Arabic).

De Neve, Frans (3M), 1995, a presentation made and a handout distributed at the conference on "The Role of Cleaner Production in Meeting the Challenges of a Changing World Economy," Taba, Egypt, July, 24-27.

Pearce, David W. and R. Kerry Turner, 1990. Economics of Natural Resources and the Environment. Baltimore: John Hopkins University Press.

RNPD, "River Nile Protection and Development Project—Phase II, 1993-1997" (mimeograph).

PRIDE, 1994, "Environmental Assistance to Egypt," Status Report.

Siam, G., 1995, Approaches for Environmentally-Conservative Agriculture in Egypt (mimeograph).

Shoals, Muschle,1993. "Fertilizer Policy Impact Study," Final Report, prepared for the Government of the Arab Republic of Egypt and USAID/Cairo.

Teerink, John R. and Masahiro Nakashima, 1993, "Water Allocation, Rights, and Pricing: Examples from Japan and the United States," The World Bank, Washington D.C.

Thobani, Mateen, 1994. "Peru: A User-Based Approach to Water Management and Irrigation Development," The World Bank, Washington, D.C.

Tohamy, S., 1995, International Experience in Controlling River Water Pollution and Policy Recommendations for Egypt (mimeograph).

WCED (The World Commission on Environment and Development), "Our Common Future," condensed, Yvonne Kupsch, ed.

WMP, 1980, "Draft Final Report on the First Phase of the Master Water Plan Project."

WMP, 1981-b, "Industrial Water Use and Wastewater Production," Technical Report #10, UNDP-EGY/73/024.

World Bank, 1993-a, World Development Report 1993: Investigations in Health, World Bank 1993-b, "Water Resources Management: a WB Policy Paper," Washington, D.C.