Rapid Assessment Study Towards Integrated Planning of Irrigation and Drainage in Egypt – Natural Resources Perspective

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SUMMARY

A.1 Egypt is facing an increasing demand for water by multiple sectors whereas the supply possibilities are used almost to its full extent. Supply-side solutions are hard to find. The shortage problems are aggravated by a serious pollution and salinity problem of the water. To deal with the complex problems an integrated water management approach is now advocated for. The IIIMP project is among the first of its kind in Egypt, although it still carries 'irrigation' prominently in its name.

A.2 This study is carried out to see whether the so-called "DRAINFRAME" approach could help the IIIMP to become really integrated, both in its design as well as during its implementation. The study itself is following the DrainFrame approach in analysing the functions, values, and stakeholders of the natural resources, particular water, in the study area, Mahmoudia Command Area (MCA). As far as possible the stakeholders were involved in the analysis, and presented a number of issues related to water management.

A.3 The exercise started with the identification of 4 landscapes in the command area: the alluvial land, reclaimed lake bottom, irrigation canal system and, the drainage system. An inventory was made of the possible (water-) interactions between the upstream neighbouring land and the command area. It turned out that these interactions can be defined as boundary conditions to the MCA. The water intake from the Rosetta Branch and the drainage flows from upstream command areas are point interactions and can be quantified. Downstream, the MCA borders the coastal zone, with important fishery activities, vegetable growing, and natural lakes (Edku). Since the drainage effluent enters these landscapes, they are heavily influenced by water management practices in the command area.

A.4 Following the identification of landscapes, the most important water related functions of these landscapes have been identified and briefly described. For agriculture and fisheries, some quantitative information could be obtained. Obviously much work still needs to be done in this respect. The main functions coming out of this analysis are: *agricultural production; settlement; fish production; water distribution for irrigation and domestic use; water evacuation from agricultural land and settlements; the capacity of land to maintain a ground water and salt balance; the capacity of open water to purify and transport pollution; the capacity to prevent salt water intrusion.* The stakeholders could easily be identified. It should be noted that there are often conflicts of interest between users of different water functions, but even more so between stakeholders of the same function. Well known are the conflicting interests over water between farmers in the head reach of canals and in the tail-end.

A.5 Once the mapping of landscapes, functions and stakeholders was complete, a problem and opportunity analysis was made for the most important functions. The following results were obtained:

Agricultural productivity: Although the yields of the main crops are rather high, there is still scope for improvement. In general, agronomic impulses are considered more promising than water management improvements. More emphasis should be put on improvement of the net benefits per unit of irrigation water than on improvement of net benefits per unit land area. The costs of irrigation can be lowered. It is believed that more efficient water use at the field level does not necessarily lead to higher overall benefits of water in the entire study area, including the downstream areas. The issue deserves further investigations. More potential can be found in a more equitable water distribution between head and tailend reaches. New stakeholder institutions (WUAs and Water Boards) are required to achieve this.

Maintaining water quality: The losses from impaired water quality are considerable, mainly in terms of poor health conditions. In the study area pollution of irrigation and drainage

water comes from domestic sewerage, solid waste, and agro-chemicals. In the lower parts industrial point pollution is widespread. The irrigation and drainage systems are affected by the practices of uncontrolled waste dumping. However, the responsible sectoral organizations have no mandate to clean up the mess. There is a clear need for an integrated approach to this problem, with the involvement of important stakeholder groups.

Irrigation efficiency, water reuse and net drainage outflow: These three components of the water balance of the MCA are interconnected. Moreover water quality is also determined by these three factors. A study is needed to consolidate the present knowledge on these matters, and identify needs for further research. At the moment in irrigation circles much emphasis is put on efficiency and reuse, in order to make more Nile water available for horizontal expansion. The beneficial use that is made of drainage water in downstream landscapes (fisheries, control of salt water intrusion, vegetable growing) is often not recognized, although there is a significant potential for development.

Maintenance of ecological processes and biological diversity: this function has eroded dramatically in the lower delta and coastal zone. The function, when vivacious, contributes much to human life-support systems in general. Often they have great tourist and recreational potential.

A.6 Consequently, the critical review of the main activity components of IIIMP give rise to the following observations and recommendations:

- Integrated water management requires stakeholder involvement in the planning and decision making process. The drain framework indicates where and how stakeholders can play their role. In IIIMP a start has been made with WUAs and Water Boards. IIIMP should seek multi-stakeholder representation especially with respect to Water Boards.
- The investment components of IIIMP are not detailed in the PCD. It is recommended to fine-tune the technical solutions to the diversity of irrigation and drainage situations in the MCA. This fine-tuning should be done in participatory planning sessions with the stakeholders of water also (not only agriculture). Water related needs, other than irrigation, should be given due consideration.
- It is recommended to make the Environmental Management Plans an integrated part of the planning and design processes at Mesqa, Branch and Main Command level. The “DrainFrame” approach offers ample opportunities to realize this.
- As regards on-farm demonstration plans, it is recommended to combine them with agronomic improvements, make clear to farmers what will be done with the saved water and, make an attempt to embed on-farm demonstrations in on-mesqa-level demonstrations on improved multifunctional water use.
- The EIA study can take advantage of the “DrainFrame” approach and the results as used in this study.

A.7 The main conclusion of this working paper is that the so-called “DrainFrame” approach (possibly to be renamed as “WaterFrame approach”), provides an excellent framework, both conceptually and practically, for the development of Integrated Water Resources Management in Egypt. There is still need for further improvement of the practical tools, computational models and, methodologies to integrate institutional aspects, attached to the framework. IIIMP on the one hand can take advantage of the framework to achieve its main objectives; on the other hand IIIMP offers a unique opportunity to further operationalize the framework.

B. INTRODUCTION

B.1 Egypt's dependency on the Nile for its economic and social survival is a well known fact from historical times. However, in recent years, population growth and economic development are putting the water system under increased pressure. Egypt already consumes more water than the Nile brings into the country, indicating that water is being reused. Only 12.5 BCM of Nile water annually reaches the Mediterranean nowadays.

B.2 The known limitations of water resources combined with an increasingly complex, multi-sectoral use of water, creates problems for the sectorally organized water management institutions. Interventions carried out for the enhancement of water use in one sector will inevitably lead to impacts on other sectors. Agricultural, industrial and domestic uses of water require cautious water quantity management. Moreover, water quality management becomes an even more urgent necessity. The uncontrolled dumping of industrial and domestic sewage and solid waste in the drainage system increasingly constrains the reuse of drainage water. The salinity from leaching of agricultural lands and saline groundwater intrusion from the sea further complicates the management of water resources in the Nile delta.

B.3 The above-mentioned problems are well known and recognized among water management authorities. However, there is no mechanism in place yet for an effective integration of various uses and users of water and their responsible authorities. According to EEAA (2000) "*policy making in Egypt is largely based on a sectoral approach. This has resulted in fragmented policies with little understanding of the interrelationship between issues. With the absence of an adequate framework for coordination and prioritization, environmental decision making is, to a large extent, highly political and crisis driven.*"

B.4 However, various pilot activities are being implemented that address the described water-related issues to a larger or lesser extent. From the water end-users perspective one of the most relevant initiatives is the establishment of water boards at branch canal level, and the extension into district water boards. From governmental perspective an important opportunity for the enhancement of integrated water resources management is presented by the Integrated Irrigation Improvement and Management Project (IIIMP).

B.5 The project builds further on experiences of the Irrigation Improvement Project (IIP) and Drainage Project (EPADP), being sectorally organized projects respectively aimed at increased water efficiency and equitable sharing of water by improving irrigation water supply, and aimed at enhancing soil productivity by introduction of sub-surface drainage. It became evident that a more integrated approach is needed in order to address water resources management issues effectively. For example, irrigation improvement may not always address the most urgent water related problems such as water pollution and reallocation of water among different stakeholders. Moreover, there is a need to also look at the effects of such activities on other sectors depending on water.

B.6 A possible mechanism for the identification of water management issues and how to address these in an integrated manner is provided by the so-called *"DrainFrame" approach*. This analytical tool for participatory water resources management planning has been developed by the World Bank, based on experiences in the drainage sector of 6 countries. Although the emphasis in this study was on drainage, the approach inherently is a natural resources management tool and thus can also be applied for the entire water resources management sector.

B.7 In this report the tool is redefined in such a manner that it may be used as a practical intervention planning tool for the IIIMP project.

C. OBJECTIVE OF THE STUDY

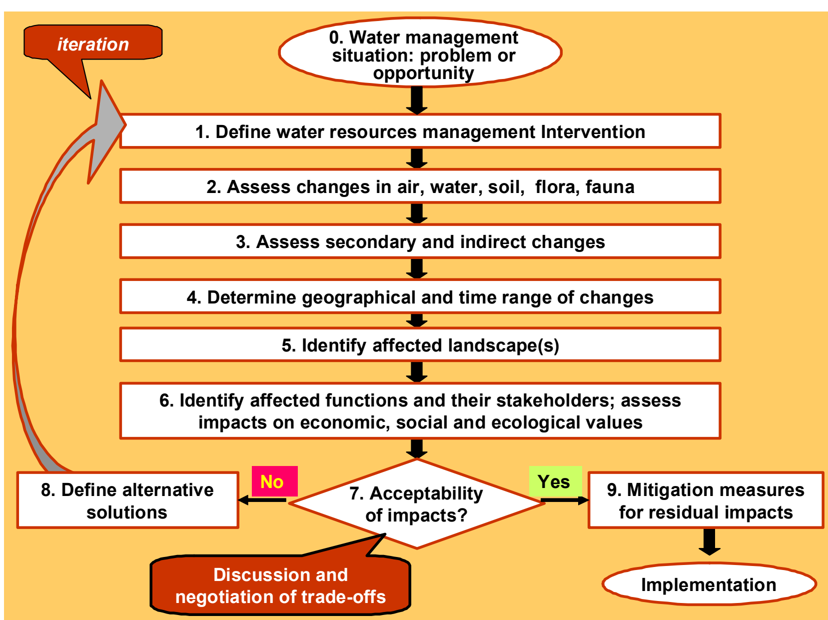
C.1 The DrainFrame methodology has been developed from a drainage perspective. However, the methodology is geared towards natural resources planning in general. It can consequently also be applied to water resources management, thus including irrigation, drainage an other water resources related activities. Therefore the word “DrainFrame” could be replaced by “WaterFrame”, as a short name for integrated analytical framework for water resources management.

C.2 DrainFrame combines:

- theory and practical experience in environmental and social impact assessment that allow systematic and comprehensive analysis of the effects and impacts of interventions in natural resources, and
- recently developed views on natural resources management planning, taking an area oriented and participatory approach.

C.3 Central to the methodology is the integrated analysis of water resources management issues, from an area perspective. This implies that interventions should be based on a sound analysis of problems and opportunities in an area, and not be based on a predefined type of intervention (for example irrigation improvement). Water resources management needs will differ between geographic areas. Water frame provides the tool to identify these needs from a stakeholder perspective. It further provides the means to identify the type of institutional arrangements necessary to address these issues and consequently identify potential institutional or organizational gaps. In Figure 1, the sequence of steps is given which have to be followed for a systematic analysis of the consequences of water management interventions.

Figure 1: Stepwise, iterative analysis of (proposed) water management interventions



(Source: Abdel-Dayem et al., 2004)

C.4 The study team decided to select one command area in the Western Nile delta as an example of how to apply the DrainFrame approach in a practical manner. The objective of the exercise was threefold:

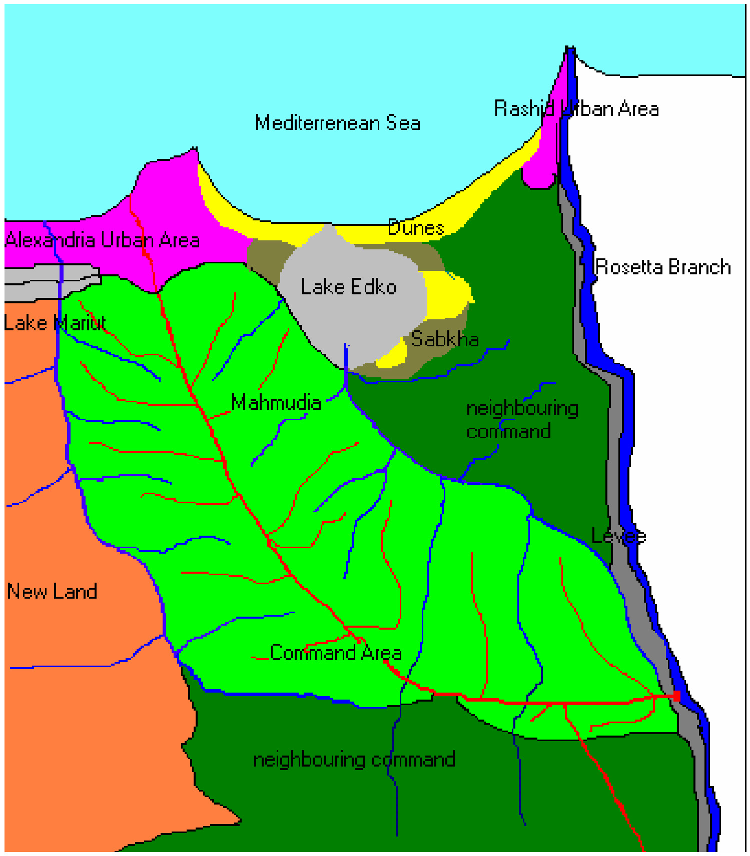
1. to analyse the functions and values of the water resources system in an integrated manner in order to come to an overview of water resources management issues that need to be addressed and for which priorities have to be defined (in this study intervention priorities have not been defined although some suggestions will be made);
2. to test the usefulness of the DrainFrame approach in a practical situation;
3. to provide recommendations on the potential use of the DrainFrame approach for the IIIMP project.

C.5 All aspects will be dealt with in this internal report. The scope will be on providing an overall picture of the situation, and providing detail on those issues that will not be covered by the other experts in the mission team.

D. THE STUDY AREA

D.1 The main focus of this study is on the command area of the Mahmoudia main canal, being one of the areas in which IIIMP interventions will take place. From an integrated perspective on natural resources management, one has to pay attention to other areas which are influenced by, or which will have influence themselves on the effects of interventions in the MCA (Mahmoudia Command Area). Ultimately the management of the entire Nile system up to the operational rules of the Aswan High Dam could be taken into account. However, since this is beyond the scope of this study, a selection was made of those areas which are directly interacting, through water flows, with the MCA. Upstream boundary conditions for the analysis are the availability of water in the Rosetta Branch, the design capacity of the Mahmoudia canal, and the quality of the irrigation water entering the system, drainage water quantity and quality that enters the MCA from upstream irrigation command areas like the Nuberia old new lands. Since drainage water flows to downstream areas beyond the boundaries of the MCA, it had to be analysed where the boundary has to be drawn of downstream effects of interventions in the Mahmoudia area. So, the first exercise of the study was to select provisionally the boundaries of the study area, based on expert judgement. It starts at the Mahmoudia intake on Rosetta branch with ATF pumping station, covering the entire area served by the canal (305,000 feddans). The intake of the water treatment plant of Alexandria is the downstream boundary for the irrigation system. Upstream areas which deliver directly their surface drainage water and/or groundwater to MCA, where included to analyse the importance of these water flows for the MCA. The downstream areas that receive the drainage water from the MCA via Abu Kbeer, Muheit Edku, Atf, Shereshra and Umum drains include the whole coastal zone: the coastal lakes Edku and Maryut, the dune strip, and finally the Mediterranean. Again the Mediterranean Sea is the source of salt water intrusion into the lowest parts of the study area. This should also be given attention in this study.

Figure 2: Sketch of the study area



Box 1: BEHEIRA socio-economic profile

- **Administrative Structure** (*Ministry of Interior's structure*)
  - *13* centers
  - *14* cities
  - *417* villages
  - *5,333* sub-villages (kafr)
- **Area**
  - governorate area *9,121 km2*
  - percentage to national *0.93percent*
- **Population density:** (Average) *697 capita/km2*
- **total population:** *3,981,209*
  - male *50.97percent* ; female *49.03percent*
- **percentage to national:** *6.72percent*
- **population rate of growth:** *2.05percent*

Industrial activities

Industrial establishments	Number	Average percent
Chemical Industry	20	5.24
construction Materials	56	14.66
Metalic Industry	0	0.00
Engineering Industry	54	14.14
Xylose products	35	9.16
Textile industry	62	16.23
Paper industry	8	2.09
Food industry	144	37.70
Others	3	0.79

Total number of industrial establishments: 382

Health care

- ***79* hospitals – *4,171* beds = *954* inhabitants/bed**
- ***2,266* physicians = *1,757* inhabitants/phycsician**

Infrastructure

- **potable water**
  - **produced potable water *513,000* m³/day**
  - **potable water per capita *128* litre/day**
- **electricity**
  - **consumed electricity *1,587,000,000* KWH**
  - **consumed electricity per capita *398* KWH yearly**
- **sewer drainage**
  - **sewer capacity *302,000* m³/day**
  - **sewer capacity per capita *76* litre/day**
- **transportation and communication**
  - **transportation**
    - ***3,359* km of paved roads**
    - ***1,185* inhabitants/km of paved roads**

EGYPT Governorates InfoHighway (data 1997): www.highway.idsc.gov.eg/govern/BEH.htm

E. LANDSCAPES

E.1 The first step in the approach to come to an integrated view on water management problems and opportunities in and around the project area is to make an inventory of relevant landscapes with their functions. The "DrainFrame" concept identifies these landscapes at three levels of aggregation (see Box 2). The same has been done here in a wider context of integrated water management.

Box 2: Levels of analysis of natural resources landscapes
From: Reclaiming Drainage: Toward an Integrated Approach (Abdel-Dayem S. et al., 2004)
As stated, drainage types and typologies can be described at several levels of aggregation, serving different purposes. Three levels of analysis can be defined.

1. The *hydro-ecological region* is a macro-scale characterization focused on the physical characteristics of a region, broadly defining the main drainage issues at hand and drainage interventions that may be appropriate. Typologies at this level serve policy development.
2. The *landscape level*. A landscape provides a coherent set of functions that deliver goods and services for society (agricultural production, water supply and sanitation, tourism, navigation, fisheries, etc). Groups in society value these goods and services and become stakeholders. Drainage interventions aim to enhance certain functions for the benefit of these stakeholders. Institutional arrangements are created to manage these interventions. Landscape level typologies serve the planning of such drainage interventions.
3. A *system-level* typology provided detailed and locally specific descriptions of drainage systems. Typologies at this level serve field-level design and implementation of drainage interventions in particular land and water resources control systems.

E.2 Table 1 presents the hydro-ecological zones, landscapes and sub-landscapes and water management systems which were identified in several rounds. The first round involved the consultation of studies, maps, informed people and own expert judgment. In the second round, some modifications and refinements have been made upon a field visit and consultation of identified stakeholders. The hydro-ecological regions are important to link-up with broader water management policies which may differ considerably. The main landscapes mentioned in Table 1 are the landscapes in terms of uniformity of resources and functions. The third level is a sub-division of the second level and takes water management systems and practices as the main characteristic.

Table 1: Overview of landscapes in the study area

Hydro-ecological Regions	Main landscapes	Sub-landscapes and water management systems
New land	New-new-land Nuberia New-old land	Nuberia command and sub-commands Masraf Umum (main drain)
Nile Delta	Low deltaic old land	Rosetta Branch and levees Alluvial higher land (with/without subsurface drains) Reclaimed lake bottom (with/without subsurface drains) Irrigation canal systems - main canal - branch canals - mesqas Drainage system - main drains - secondary drains
Coastal Zone	Lagoon area Dunes	Lake Edku Fishponds Sabkha land (abandoned) Dunes
Large Urban Areas		Water treatment intake and waste water outlets
Mediterranean	Mediterranean	Mediterranean

F. LANDSCAPE, FUNCTIONS, STAKEHOLDERS AND ISSUES

1. Overview

F.1 This chapter intends to describe in some detail the landscapes and sub-landscapes/wm-systems, the most important functions (goods and services) delivered by these landscapes, the main stakeholders of the functions, and the “values” attached to these functions by the various stakeholders or by Egyptian society as a whole. The fact that 'functions' are varied in nature (see box 3) makes this part complex. Especially when it comes to the quantification of the 'goods and services' delivered, often there is a need to select some relevant proxy parameters as a measure for the amounts delivered.

Box 3: Environmental functions - the supply of goods and services
From: Reclaiming Drainage: Toward an Integrated Approach (Abdel-Dayem et al., 2004)

Nature provides many functions, representing goods and services that humans can exploit. Four categories of environmental functions can be distinguished:

Processing and regulation functions: These functions relate to the maintenance of life support systems on Earth. These functions are often not recognized until they are disturbed. Examples linked to drainage are: buffering of flood peaks in wetland systems, recharge of groundwater reservoirs by infiltration, recycling of organic matter and pollutants as a natural water cleaning mechanism, maintenance of migration and nursery habitats for fish, maintenance of biological diversity, trapping of sediments in floodplains, regulation of fresh and saltwater balance in estuaries, river mouths, coastal aquifers, and regulation of biological control mechanisms.

Carrying functions: The availability of space together with a particular set of environmental conditions associated with that space make an area suitable for performing certain functions for nature or for humans. Examples include: suitability of an area for human habitation and settlement, waterways for navigation, sites for energy conversion (e.g. hydropower reservoirs), sites for recreational activities.

Production functions are goods that are produced by nature and for which man needs to invest time and energy to harvest them (natural production functions), or biological products (animal or plant) produced in ways that involve active management and inputs by people (nature based human production functions). Examples: soil productivity for cultivation of crops, water as harvestable resource, fisheries, animal husbandry, aquaculture, timber, firewood, etc.

Significance functions: nature provides opportunities for spiritual enrichment, cognitive development and recreation. Examples: aesthetic information (scenery, landscape), spiritual and religious information (religious sites, emotional attachment), historic information (historic and archaeological elements), cultural and artistic information (inspiration for folklore, music, dance, art), educational and scientific information (natural science classes, research, environmental indicators), etc.
Source: adapted from R.S. de Groot, (1991)

F.2 The quantification of the agricultural goods i.e. the annual yields of crops, delivered by agricultural land is relatively easy to do. The same holds for fish production, which also can be expressed in tones/feddan or so. More difficult it is to have a single expression for e.g. the processing function of water to natural purification. Depending on the case of analysis at hand, one may decide to select one or two quantifiable parameters, like the BOD and the turbidity of water bodies. For a carrying function like navigation a parameter such as depth and width of the water may be combined with the distance of the waterway without any cross obstruction; or the maximum size of ships that may use the waterway.

F.3 The value of these functions needs to be expressed in economic, social and environmental terms. For the tradable goods the economic value is simply to express in financial terms. For social and environmental values again one has to rely on few proxy parameters.

F.4 Table 2.a and 2.b give an overview of the most important landscapes, functions and stakeholders in the study area. The last columns are an expression of the shortages of supply as compared to the demand of the function. They are in fact a first indication of issues that are connected to water management in the study area. The following sections elaborate on these functions and values in a narrative way, using the sequence of Tables 2.a, and 2.b.

Landscape: New Land ***(picture J. Hoevenaars)***

Table 2.a. MCA: the relevant landscapes, their functions and stakeholders: an overview

	Landscapes	Functions	Stakeholders	Issues
	Mahmudia command			
1	Alluvial land	irrigated mixed farming	- agricultural sector	low farm income
		rice cultivation	- rice cultivators	high water consumption
		animal production		
		Settlement	- households	loss of agric. land
		maintenance of groundwater and salt balances	- farmers - housing	threat of waterlogging and salinization
2	Reclaimed lake bottom	irrigated mixed farming	- agricultural sector	low fertility; low income
		rice cultivation	- rice cultivators	high water consumption
		animal production	- farmers	
		Settlement	- households	
		maintenance of groundwater and salt balances	- farmers	threat of waterlogging and salinization;
3	Irrigation canal system	conveyance and distribution of irrigation water for command area	- agricultural sector	inequity of water supply
		mixing and diluting reuse water	- downstream agriculture - domestic and industry - municipality of Alexandria	low water quality
		domestic and industrial water supply	- households and industries	water quality; shortage
		solid waste dumping and transport	- households and industries - agriculture	pollution; flow obstruction
		sewerage transport and sedimentation	- households and industries - agricultural sector	pollution; flow obstruction
		natural purification of water	- all users	
		Navigation	- transport sector	water depth; obstructions
		delivery of water to Alexandria	- municipality of Alexandria	water quality; shortage
4	Drainage canal system	collection and transport of surplus groundwater	- agriculture - housing	maintenance of water levels in drainage canals
		collection and transport of surplus rainfall	- agriculture - housing	pumping capacity outfall drains
		collection and transport of surplus salinity	- agriculture	
		collection and transport of solid waste	- households/industries - agriculture	pollution; flow obstruction
		collection and transport of sewerage	- households/industries - agriculture	pollution; flow obstruction
		delivery of reuse water to canals	- agriculture - households/industries	water quality
		delivery of unofficial irrigation water	- agriculture	water quality; salinization
		natural purification of water	- all users	
		transmission of drainage water and salts from neighbouring commands	- command users - upstream users	water quality; system capacity
		water borne diseases	- all inhabitants	malaria; bilharzia
		fish and waterfowl	- farmers	public health
		disposal of drainage water to Lake Edku and Sea	- Mahmudia command area - fisheries lake Edku	water quality and quantity

Landscape: Old Land near Damanhur ***(picture J. Hoevenaars)***

Landscape: Irrigation Canal system ***(picture J. Hoevenaars)***

Landscape: Drainage Canal system (picture J. Hoevenaars)

Settlement (picture J. Hoevenaars)

Table 2.b: Neighbouring landscapes: relevant landscapes, their functions and stakeholders: an overview

	Landscapes		Main functions	Stakeholders	Issues
	Off-site upstream				
5	*Rosetta Branch*		delivery of Nile water delivery of water quality	- all users downstream - all users downstream	quantity of delivery
6	*Old new land*		delivery of groundwater and salts	- agriculture old new land - agriculture on-site	waterlogging and salinity through upward seepage
7	*Umum drain*		collection, conveyance and transport of drainage	- agriculture on-site - agriculture old new land	water quality reuse
8	*Upstream old land commands*		delivery of water and salts	- upstream farmers - on-site farmers	water quantity and quality
	Off-site downstream				
9	*Downstream command*		receiving drainage water	- on-site agriculture - downstream agriculture	water quantity and quality
10	*Lake Edku*		receiving drainage disposal purification sedimentation regulation of salt water intrusion	- fishermen - upstream agriculture	water quantity and quality loss of functions threat of salinisation
11	*Fish farms*		fish production	- fish farmers	water quantity and quality
12	*Sabkha land*		temp. surface water storage salt sink space for reclaimed land	- nature - vegetable growers	availability of fresh water
13	*Dunes*		vegetables and fructiculture shore protection	- vegetable/fruit growers - State of VAR of Egypt	
14	*Greater Alexandria*		water consumption	- municipality	water quantity and quality
15	*Mediterranean*		delivery of salt water intrusion coastal erosion	- farming community - fishermen - State of VAR of Egypt	

F.5 The following sections describe most landscapes with their main bio-physical features, the relevant functions from the water point of view and stakeholders, and a rough quantification of the goods and services they provide, as far as quantitative data could be obtained. The issues are discussed in Chapter 6.

2. Landscapes of the Mahmoudia Command Area

Alluvial land and reclaimed lake bottoms

Salient features

F.6 The larger part of the MCA consists of old alluvial land, with heavy montmorillonite clay soils, a very flat topography, generally sloping from 2m +m.s.l in the south to 1 to 2m -m.s.l. in the lowest north-western parts. Isolated higher spots (up to 5m+m.s.l.), most likely remnants of old river levees and dunes, may be found scattered throughout the command area (EGSA, 1996). In most cases these are used for settlements. Groundwater is found at shallow depths. Before the implementation of tile drainage systems, it was fluctuating between 0 and 1 m. below surface (RIGW, 1986). Since almost the entire area has been covered with tile drainage systems by EPADP, the groundwater table has been lowered and fluctuates between 1and 1.6 meter below surface. In most parts a freshwater layer is overlying saline water. Towards the north the fresh water lens becomes thinner and also more saline. Locally, water logging occurs, notably along continuous flowing canal sections (seepage and leackage). Rainfall is significant during the winter season, and reaches averages of 200 mm/yr. near the coast. In the south of the MCA it is only 175 mm/yr (RIGW, 1986). The total area of MCA is about 122,000 ha (305,000 fed.). Part of the area can be called the sub-landscape of reclaimed lake bottoms. These are less fertile lands, very flat, at an elevation of around sea level. They have high groundwater tables. Farmers often add soil from elsewhere on it to improve the chemical and physical properties. A larger stretch of this landscape is found north of Damanhur.

Observed functions, stakeholders and values

Irrigated mixed farming and rice cultivation

F.7 The most important function of this landscape is agricultural production. A wide variety of crops is cultivated in two main seasons, summer (May-October) and winter (November-April). All crops are irrigated, or in winter, supplementary irrigated. The plots are mainly small to very small (see report of socio-economist). The prevailing irrigation method is level furrow irrigation (broad and narrow) for row crops like cotton and maize, and basin irrigation for broadcasted crops like berseem and wheat. The main crops are often intercropped with vegetables like onions, or peppers. Land levelling and furrowing more and more is done mechanically. Both tractors and animals are used for land preparation. Rice cultivation is a special form of irrigated agriculture. The difference of this function with other forms of irrigated agriculture is that rice fields are ponded for most part of the season. Rice is a summer crop which is cultivated in rotation with the other main field crops. Rice cultivation in winter season is not possible because temperatures are too low.

F.8 The performance of the two functions from the water point of view is quite obvious. Irrigation water has to be brought in and, because of the leaching requirement of soils, over irrigation and upward seepage of groundwater, water has to be drained. Part of the rainfall also has to be drained, mainly as runoff water.

Table 3. Economic value of agricultural production function *(provisional figures)*

Total Area (MCA) 120.000 ha.

summer crops	approx. percent of total area	hectares cropped	**net revenue[1)] (LE/ha)**	net return (LE/crop)
Rice	39 percent	46841	**2,341**	109,633,870
Maize	20 percent	23465	**1,962**	46,041,178
Cotton	26 percent	31179	**2,008**	62,614,980
Winter crop				
Wheat	37 percent	44715	**2,419**	108,175,011
Fababean	9 percent	10378	**1,363**	14,144,099
Berseem short	31 percent	37623	**3,308**	124,465,118
Berseem long	16 percent	19200	**6,890**	132,288,000
Total				**597,362,255**

Summer crops	ETcrop (mm)	L. Req. + Losses (mm)	50percent re-use (mm)	net use (m3/ha)	total use (m3)	**net value of water (LE/m3)**
Rice	1,200	400	200	14,000	655,774,580	**0,17**
Maize	840	414	207	10,469	245,645,762	**0,19**
Cotton	1,065	525	262	13,273	413,831,026	**0,15**
Winter crop						
Wheat	375	185	92	4,674	208,974,885	**0,52**
Fababean	400	197	99	4,985	51,735,461	**0,27**
Berseem short	400	197	99	4,985	187,554,531	**0,66**
Berseem long	800	394	197	9,970	191,426,866	**0,69**
Total					**1,954,943,109**	**0,31**

Source: MARL, Agricultural Affairs Sector, "Agricultural Statistics", Crop Data 2003.

F.9 Table 3 is an attempt to quantify the agricultural goods and services of the command area. It is based on a standardized cropping pattern. Agricultural production figures in Egypt are monitored and aggregated by district and Governorates. It is therefore not easy to compare these figures with the production of a command area.

F.10 Apart from the economic value of the products, parameters need to be selected to express the social value, e.g. employment opportunities and food security, expressed as the ratio between total wheat production and locally consumed wheat production. However, no quantitative data could be found during the mission. Agriculture also generates an environmental burden, which represents a negative value. If agricultural practices change, e.g. introduction of more productive varieties but also more vulnerable to pests, the consumption of agrochemicals is likely to increase and more residues will end up in the drainage system. So far, representative proxy indicators for the environmental burden of agriculture have not been identified.

F.11 All farmers in the area are stakeholders.

Settlements and industries

F.12 The Nile delta is densely populated. The Beheira governorate counts 5 million inhabitants, distributed over some urbanized areas and many rural villages and hamlets. Typically the villages are compact, if possible established on an elevated piece of land or along a branch canal or mesqa. Because of the loss of agricultural land to urbanization, a recent law has stopped housing development on agricultural lands. The law is enforced, but violations still occur. The percentage of land used for settlement is not exactly known. It varies also over the MCA.

F.13 The relationships of this function with water are: settlements are the source of solid waste and sewerage which frequently enters the water bodies of the MCA. Settlements require drinking water, which is almost everywhere provided by public water supply systems. Other domestic water needs are often supplied by the irrigation canals.

F.14 No further enquiries have been made into the economic and social values of settlements.

F.15 The stakeholders are the 5 million inhabitants.

F.16 The Mahmudia main canal is a secure source of water which has attracted a large number of industries. These industries use the canal water for processing. Meanwhile they deliver polluted water untreated back into the water system.

F.17 Certainly the produced goods per square meter or per cubic meter of water, as well as the employment density, is much higher for industries as compared to agriculture. The industries offer off-farm employment to the small farmers that helps them to gain a sufficient income.

F.18 The stakeholders are the *e*nterprises, labourers/farmers and shareholders.

Maintenance of the fresh/saline groundwater balance

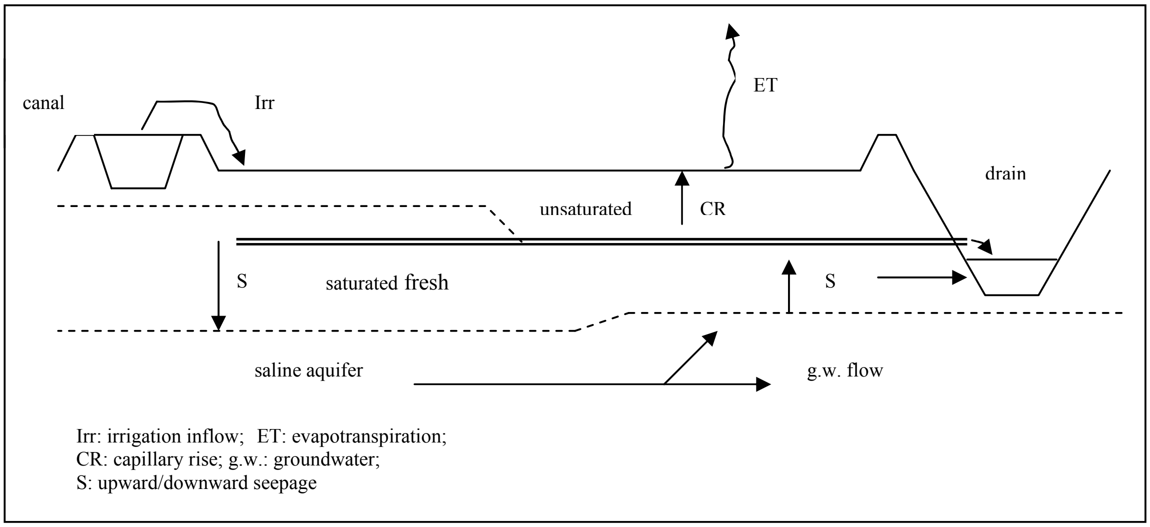
F.19 An important function of the landscape is the 'regulation' of the groundwater depth and the salinity levels of this groundwater. Since the saline groundwater/fresh water interface is at shallow depths in the MCA, this is also considered an important part of this function. A thorough knowledge of the groundwater dynamics is required to fully understand this function (see figure 3). In Egypt there is still a scientific debate on the extent of saline groundwater intrusion from the sea. The saline groundwater may be of fossil nature as well, generated during delta formation. Time didn't allow to identify studies which may have been conducted on this subject on this issue in the past. At the field level, irrigation of agricultural land in the lower delta area is required to maintain a layer of freshwater, which counteracts the influence of deeper saline groundwater. Rice plays a main role in this context and the operational policy allows increase of rice intensity towards the coastal region. Thus rice cropping has an environmental function. Once the downward flow of surface water stops, the reverse will take place and capillary rise will bring saline water to the root zone of the plants. The net downward flow from irrigation which is required to keep the effect of salinity below reasonable limits is called the 'leaching requirement'. In almost all parts of the MCA subsurface drainage has been installed, taking these requirements and the groundwater dynamics into account. This results in a net output of salts from the soils, at the cost of certain amounts of leaching water. Modifications of the general design of drainage systems to minimize leaching requirements were recently proposed by water boards that participated in the planning and design of the systems.

F.20 The increasing areas cultivated with rice in combination with subsurface drainage locally cause an extra demand for water, at the expense of downstream farmers. The economic returns per hectare of rice are high on the one hand, the salinity problems are effectively counteracted by this culture on the other hand. However, inequity of water supply is aggravated. The mixed cropping pattern makes it difficult to practice controlled drainage.

F.21 *Value*: maintenance of soil productivity for agriculture, thus maintaining income levels of farmers.

F.22 *Stakeholders*: farmers in the lower delta

Figure 3: Definition diagram of groundwater variables



The irrigation system

F.23 The Mahmoudia irrigation system is defined as a separate landscape in order to be able to attach specific functions to it, which otherwise may be overlooked. This section will not deal with most of the technical-hydraulic characteristics. The report of the Irrigation and Drainage specialist will cover these details. Here the main canal and branch system is considered as a continuous water body, flowing for most of the time throughout the command area. The mesqas in the improved and unimproved areas are taken as separate sub-landscapes. Most of the improved mesqas are centrally pumped and lined canals or underground piped distribution networks deliver water to the open field channels or marwas. In the unimproved areas, the mesqas look more like an extension of the open main and branch canal network, and are not very different in terms of functions.

F.24 The functions which do not differ for different parts of the system are discussed first. Functions which are specific for the main and branch canals or mesqas are discussed at the respective sublevels.

Observed functions, stakeholders and value

<u>Water conveyance and distribution</u>

F.25 The dedicated function of the whole canal system is to receive, convey and distribute irrigation water in an equitable way over the entire MCA. This is a regulation function which makes other functions possible, like agricultural production, drinking and domestic water availability, etc. The stakeholders of this function virtually are all inhabitants of the MCA, downstream water users such as fishermen and Alexandria municipality. The interesting features of the system are: the discharge pattern along the canals (time and quantity) and the water quality. The value of a regulating function is difficult to define. At the cost side it is clear that a substantial amount of money is needed for operation, maintenance and replacement.

<u>Weed growth and sedimentation</u>

F.26 Landscapes not only perform functions which are appreciated by men, but also functions which are disliked. In other words, functions may be valued positively and negatively. An open canal not only delivers irrigation water (positively valued), but also a certain amount of sediments. Since sedimentation of a canal diminishes it's capacity it represents a negative value. If these sediments are excavated by farmers to raise their land (as some of them in the lake bottom landscape do), or to increase the fertility of the land, then the negative value of sedimentation may be partly or fully turned into a positive value. All of the open canals are unlined or semi-lined. Weed growth is therefore abundant and sedimentation of solid particles takes place in certain stretches of the system. This leads to a decreasing conveyance capacity and a rise of water levels (heading-up). Both effects result in tail end water shortages. The tail-end users are therefore the true stakeholders of this negative function. Regular maintenance is required for a sustainable and equitable performance of the irrigation system. The costs of maintenance and the loss of agricultural production due to water shortages are expressions of the value of this function.

<u>Sewerage conveyance, solid waste disposal and washing</u>

F.27 It was assumed that use of irrigation canals for sewerage and solid waste disposal would not be serious since rural farming communities depend on this water supply. Somewhat surprisingly, branch canals running through villages are getting heavily polluted and congested with solid waste and water quality is visibly deteriorated only a few kilometers from the inlet. Washing in canals can be observed frequently. See also the description under Section 5.1.3 Drainage system. Different stakeholders have conflicting interests. Upstream and downstream conflicts, as well as between the agricultural and the housing sectors can be expected. The value of this function can be expressed in social (health) terms as well as in financial terms (cost of alternative waste and sewerage management).

<u>Domestic geese and ducks</u>

F.28 All over the entire irrigation (and drainage) system large numbers of geese and ducks can be seen, making use of the canals. These birds are appreciated for their eggs and meat.

Mahmoudia main canal

<u>Water supply to branch canals</u>

F.29 The main canal receives water from the Rosetta Nile branch through the El-Atf pumping station. The Mahmoudia canal is operated on a continuous basis. At more or less regular distances branch canals are provided with water through controlled inlets. In areas with unimproved irrigation, gates are controlled manually and receive water in a pre-established rotation (e.g. 5 days on, 5 days off). In areas under the IIP the branch headworks are (or will be) replaced by automatic downstream level controlled gates, and receive water on a continuous basis.

<u>Supply of Alexandria drinking water</u>

F.30 Alexandria depends on the Mahmoudia canal for its supply of drinking water. In periods of water shortage and high demands for irrigation water, conflicts about water have occurred. Formally, drinking water supply has top priority, but due to large demands for rice cultivation (surpassing the officially allowed proportion of rice in the area) the capacity of the canal is not enough during periods of peak demand. Ideas have been launched to construct a pipeline from the

Nile to Alexandria to overcome this problem. Inevitably, this supply oriented solution will lead to higher water consumption since the constraint on water use is lifted.

F.31 The price per m^3 paid by Alexandria is well under cost level; inherently there is little incentive for water savings. The Alexandria drinking water system allegedly works with some 70 percent unaccounted losses. A demand management solution might significantly contribute to a solution.

F.32 *Value*: quality of life and health of inhabitants in Alexandria; agricultural productivity in the Mahmoudia command area.

F.33 *Stakeholders*: 5-7 million inhabitants of greater Alexandria area. Approximately two million people depending on agriculture as their first livelihood.

Navigation

F.34 The Mahmoudia canal has ship locks and is connected to a larger system of waterways for navigation. Very little activity has been observed during the mission.

Fish (cage) culture

F.35 Egypt is at it's limit of fisheries productivity. Attempts to meet future demand in fish have to be met by fish culture. There is increased pressure on the Ministry of Water Resources and Irrigation to allow cage culture in the main irrigation canals. So far, fish culture is only allowed (by law) in drainage water. MWRI fiercely opposes the idea of cage culture in canals (it also applies to the Nile river and Lake Nasser) as it is believed to be polluting irrigation and drinking water, and interfering with the cross-sections of the canals. According to NWRP (2002) scientific evidence for this opposition is largely lacking.

F.36 *Value*: increased economic use of irrigation water. Fish culture is said to be a very profitable business. Consumer demand for fish is higher than what Egypt can provide at present.

F.37 *Stakeholders*: fish culture entrepreneurs and consumers; irrigation and drinking water authorities.

Branch canals

Water supply to mesqas

F.38 Again a distinction has to be made between unimproved and improved irrigation situations. In the unimproved situation, water flows in the branch canals on a rotational basis. Again some rotation is followed for the distribution of this water to the unimproved mesqas through manually controlled slide-gates. The operation is given to a ditch-rider of the Irrigation Department. The delivery of water to the unimproved mesqas is below field level. In the so-called improved situation, the branch canal runs continuously. Mesqas are provided with a central pumping station for the whole downstream area. The mesqa pumping station is operated by the water users association. An important change in water delivery from the unimproved to the improved situation is the change from rotational supply to continuous supply with downstream control at branch level. Only one or two automated gates are needed in the branch canal. Since the control over the tertiary intakes will be given to the WUA's, the water supply to the mesqas will become continuous as well, or at least as often as the WUA's believe is good for themselves.

Water supply to drains (overflow)

F.39 Overflowing of canals into drains is often said to be a loss of water. However, the overflowing of canals leads to a higher drainage water quality. The complete coverage of the area with a functioning drainage system, combined with reuse of drainage water, puts this perceived loss in another light. In fact, hardly any water is lost, and it performs a multitude of other functions when spilled into the drainage system.

F.40 *Value:* increased quantity and quality of drainage water to be (re)used for multiple purposes.

F.41 *Stakeholders*: multiple

Receiving water from main and secondary drains

F.42 To add water to the total available amount, Egypt has adopted a policy of reuse of drainage water for irrigation to the extent possible. Pumping stations on the main and secondary drains lift the drainage water a few meters and dispose it in the irrigation canals. Since the water quality, in terms of salinity and pollution of the drainage water is far less than that of the irrigation water, the water quality of the irrigation water downstream of the reuse pumping station deteriorates as well. In principle there are standards for water quality and the extent to which it can be mixed safely with fresh irrigation water. However, here practice seems to be less strict than theory. The value of this reuse can be expressed as an incremental agricultural production minus the cost of pumping. Socially, the effect of reuse of drainage water through mixing is that the water becomes less fit for domestic use. This has a serious impact on public health. Therefore, there is a conflict of interests between farmers and households.

Mesqas

Distribution of irrigation water

F.43 The mesqas receive water from the secondary canal and distribute it over the tertiary unit to the landholdings. In the unimproved situation water is delivered below surface through an open and unlined mesqa. Farmers themselves pump it out of the mesqa into their marwa (field canal) and from there on the field. There used to be little regulation on timesharing of the water flow. This results in over irrigation in the head reach of the mesqa, and increased rice cultivation. The lower reaches are confronted with serious water shortages and yield reduction. These tail-enders then often practice unofficial reuse of drainage water to cope with the situation. All-in-all there are many conflicts over water in the unimproved mesqas. The improved mesqas provide water, in most occasions through a piped underground system with alfalfa-valves, sometimes through a lined open mesqa with division boxes. The valves are freely accessible to farmers. In order to prevent inequity in water supply a WUA is given the responsibility to introduce timesharing and supervise it.

F.44 The advantage of the improved mesqas is also that no further pollution takes place at this level. The only function that remains is the provision of irrigation water.

The drainage system

F.45 Comparable to the irrigation system, also the drainage system is defined as a particular landscape. The status of the subsurface part of the drainage system (collector drains and laterals) is a little bit ambiguous. One the one hand, it can be considered as an attribute of the soil and landscape to which the soil belongs, as it partly determines the groundwater regulating function of the landscape. On the other hand, the subsurface drainage is managed to a certain extent by the farmers and drainage maintenance staff (flushing, blocking). In the new land upstream of MCA, controlled drainage becomes more and more popular. For this reason, in this study the subsurface drainage systems are defined as a (sub-) landscape.

F.46 Another conceptual problem is posed by the fact that the drainage basins are not coinciding with the irrigation commands and sub-commands. The Umum and Edku main drains serve the dewatering of the MCA, but also large other command areas. The secondary drains normally serve branch canal commands on both sides, and the sub-surface drainage systems are not necessarily entirely in one tertiary unit. However, since the DrainFrame approach always also considers the neighbouring landscapes for analysis to investigate the impacts of certain interventions, there is not much of a practical problem. The whole drainage system is considered one landscape, whether it is inside the MCA or partly outside. For the analysis of functions of the drainage system, a distinction is made between the open drainage system, (main, secondary and tertiary open drains), and the sub-surface drainage system. Part of the functions of the open drainage system are similar in nature for the canal system.

Subsurface systems

F.47 The technical details of subsurface systems will be dealt with in the working paper of the Irrigation and Drainage Specialist.

Maintaining a groundwater and salt balance

F.48 The dedicated function of the subsurface drainage system is to maintain a certain groundwater and salt balance in the fields where it has been installed. A network of closed collector pipes is discharging the effluent of a number of connected and perforated lateral pipes. The depth and spacing of the laterals, in combination with the properties of the soil determine the effect of subsurface drainage. Almost the entire area of MCA is now provided with subsurface drainage systems. In comparison with the earlier situation, with only scattered open drains, water logging and associated salinity has been brought under control with beneficial effects on crop production. The Egypt case study (van Achthoven et al., 2003) reports considerable increases in yield for almost all main crops, with the exception of rice. The latter is quite understandable, because rice is not much affected by water logging, and due to the practice of ponding fresh water on the field, a suitable freshwater micro-environment is created for the rice plants. Other sources show that rice yields increased in saline soil areas after subsurface drainage was provided.

Drainage construction in progress *(picture J. Hoevenaars)*

F.49 Apart from the increase in yields, the Egypt case study mentions a number of other effects (Box 4).

Box 4: Various benefits from agricultural drainage in Egypt. (Achthoven et al. 2003)

Other agricultural benefits

- Wider range of crops/improves the trafficability and workability of the top soil.
- Farmers interviewed claim less incidence of fungal diseases and better seed emergence rates after improvement of drainage conditions
- Leaching of salts even in heavy clays.
- Land prices often increase.

Other non-agricultural benefits

- Reduction in water-borne diseases, improvement in sanitation and domestic water supply, and protection of built-up areas. Apart from positive effects on human health, drainage can also improve animal health by reducing the number of water-related animal diseases.
- Drainage reduces the damage to property considerably and improves living conditions in those areas. Well-known in Egypt is the effect of high groundwater tables on archaeological monuments. Drainage of agricultural land helps to reduce this damage, especially in those situations where monuments are found surrounded by farmland.

F.50 It was reported by the Egypt case study that the average farm-income had improved by about US$ 200 per year in saline areas after the installation of subsurface drainage, and up to US$ 375 per year in other areas. The stakeholders are the farmers and the households living in the nearby settlements. A negative aspect is that salts and agrochemical residues are now traveling much faster downstream than before.

Open drains

Conveyance of subsurface drainage effluent (including salts) and rainwater

F.51 The main function of the network of drainage canals is to convey drainage water from agricultural and residential areas to receiving water bodies. The water levels in the outfall drains, such as Masraf Umum and Edku, are below sea level, so the entire discharge has to be pumped out. Drainage and pumping capacity in some areas appear to be insufficient to deal with heavy rainstorms.

F.52 *Value:* increased agricultural productivity due to improved drainage (as part of the entire drainage intervention package; see section on agricultural lands).

F.53 *Stakeholders*: farmers in the Mahmoudia command area that have improved subsurface drainage or old open field drains; inhabitants of residential areas.

Sewerage conveyance

F.54 Waste water treatment in Beheira governorate is largely confined to the urbanised areas where 8 treatment plants are operational (one of which needs rehabilitation). Priority of the governorate lies with rehabilitation or expansion of existing facilities. The sewerage of approximately 70% of urban households is treated before released into drains. In rural areas only 10% of household sewerage is treated. The majority of households possesses storage tanks that are emptied regularly by trucks. These trucks dump this liquid waste into the main drainage canals, thus contributing to the organic load in the canals. The high organic load leads to algae development and in extreme cases to anoxia, causing massive death of aquatic organism. Apart from the organic pollution, the use of canals for sewerage presents a danger to public health since diseases may be transmitted by this practise.

F.55 *Value*: The savings made on investment costs in sewerage collection and treatment facilities are high. However, environmental, social and economic costs of the present situation have been calculated to be higher (see next chapter on problems and opportunities). On a larger scale the official policy of reuse of drainage water is threatened by the decreasing water quality in the drains.

F.56 *Stakeholders*: all inhabitants of the study area; increasing impacts expected in northern direction.

Washing

F.57 Public drinking water supply covers some 95 percent of rural households. Some households still depend on groundwater wells. Nevertheless, many people still use canals and drains for washing of clothes or food such as vegetables (as observed during the field visit). Diarrhoeal diseases are among the most serious causes of child mortality. According to the National Water Research Center (NWRC, 2001) a correlation with the following factors has been scientifically established: disposal services, water supply, water quality and water collection. Open water is still often used because the storage capacity of sewerage tanks is limited. Washing of clothes contributes to the rapid filling of tanks. The washing of vegetables in canals probably is a habit which should be strongly discouraged.

F.58 Some water boards have taken the initiative to create so-called "water clubs", specially designed public areas with safe water supply for washing. The allocation of land and the investments for the construction of such areas appear to be problematic in some cases. The environmental committees of some water boards, usually consisting of women, are also involved in awareness raising activities and communal cleaning activities.

F.59 *Value*: cost of emptying of sewerage tanks makes people use open water. Public health consequences are serious.

F.60 *Stakeholders*: inhabitants of rural villages.

Solid waste disposal

F.61 In most rural as well as urban communities, solid household waste is dumped on the banks of canals and drains where it ultimately causes serious water pollution and obstruction of the water flow. Organic waste contributes to the high organic contents of water and anoxic conditions; non-degradable plastics cause drainage congestion.

F.62 *Value*: Maintenance cost of drainage canals increases because of the practice of dumping of solid waste. Downstream users of drainage water suffer from decreased flow and/or decreased water quality.

F.63 *Stakeholders*: inhabitants of the entire area who are dumping waste and at the same time are depending on the water resources of the Nile delta. Conflicting interests between upstream and downstream stakeholders.

Official reuse for irrigation

F.64 A number of mixing stations pump drainage water back into the irrigation canals. Drainage water with relatively high salinity is mixed with irrigation water of higher quality. Drainage water thus can be reused for irrigation. Six mixing stations in the entire Nile delta had to be closed (one on the Mahmoudia main canal) because of low water quality and its threat to the intake of drinking water further downstream in the irrigation canals. The government is planning to implement a policy on intermediate reuse, emphasising the recycling of water at points upstream of significant pollution discharges to reduce the problem of cross-contamination and accumulation of pollutants.

F.65 *Values:* agricultural productivity is significantly increased by the reuse of irrigation water. Water quality problems at the inlet of drinking water facilities lead to health hazards and/or increased treatment cost. Food products may become polluted.

F.66 *Stakeholders*: farmers downstream of the mixing station receiving an increased amount of irrigation water. Industrial and drinking water agencies downstream of the mixing stations, notably Alexandria municipality.

Unofficial reuse for irrigation

F.67 Because of uneven distribution of irrigation water along the branch canals and mesqas, tail-end farmers are often obliged to pump water from drains in order to irrigate their fields. It is estimated that unofficial reuse amounts to 50 percent of the total reuse of drainage water in the delta (DRI/SC-DLO, 1995). One of the main objectives of the Irrigation Improvement Project is to enhance the equitable distribution of water along mesqas in order to prevent social problems caused by unequal distribution of water. If successful, this intervention may influence the unofficial reuse considerably.

F.68 *Value*: agricultural productivity maintained in case of water shortage.

F.69 *Stakeholders*: tail-end farmers throughout the delta, increasing in a northern direction in the lower delta area.

Water provision to downstream landscape

F.70 Drainage water of Mahmoudia area is conveyed to Lakes Edku and Maryut or directly to the Mediterranean Sea. The official policy is to increase water use efficiency in the agricultural areas in the delta by introducing improved irrigation techniques, and reuse of drainage water. The consequence of this policy, if successful, is that the amount of drainage water will be reduced, and the concentration of salts and pollutants will increase, thus threatening the livelihoods of stakeholders depending on drainage water.

F.71 *Values and stakeholders:* As described under the downstream neighbouring landscapes: “coastal lakes” and “coastal ridge” the entire fisheries and fish farming community depends on drainage water; and a large proportion of farmers in the lower reaches of the delta depends on drainage water.

Breeding of bilharzias vector snail

F.72 Drains are good breeding sites for freshwater snails transmitting bilharzia (schistosomiasis), a parasitic disease which leads to serious illness at high levels of infection. During the field visits, vector snails of both vesicle (urinary) and intestinal bilharzia have been observed in large numbers. Infection risk correlates with the availability of household water supply, reducing the necessity to be in contact with open water (National Water Research Center, 2001). In the past bilharzia was an enormous public health problem in Egypt. Nowadays, an effective primary health care infrastructure and improved public water supply have contributed enormously in controlling the disease. Subsurface drainage has contributed substantially in reducing the number of suitable breeding places.

F.73 *Value*: health risk to (predominantly) rural people still present, but at a level controllable by the primary health care service. Cost of treatment and days lost in labour.

F.74 *Stakeholders:* all people in contact with water. Professionally: farmers, household work: mainly women, playing children.

Navigation

F.75 The main drains are suitable for navigation. However, the only movement of boats observed during the field visit was the ferrying of people from one side to the other side of the drain. In most cases culverts, low bridges and pipelines crossing the drains make them unfit for navigation. The economics of transportation is beyond the scope of this report, but apparently road transport is less costly (or more efficient) compared to water transport.

Self-cleaning capacity

F.76 Reportedly, natural processes in the drains itself contribute significantly to the reduction of organic pollution load.

3. Upstream neighbouring landscapes

F.77 There is no need to describe and analyze the upstream landscapes in every detail. It suits if the relations in terms of water quantity and quality exchange between these landscapes and the MCA are understood. It is not expected that interventions in the MCA have important consequences for these upstream landscapes. If one wants to evaluate water management interventions on a higher scale, obviously these landscapes have to be analyzed in more detail.

Rosetta branch and river levees

F.78 The Rosetta branch delivers water to the Mahmoudia command area through the El-Atf pumping station. The dedicated share of water for the MCA is decided upon at the national level. All downstream inhabitants are stakeholders of this function. The river levees bordering the Rosetta branch have little interaction with the MCA and are left out of this analysis. The water quality in Rosetta Branch is a factor as it has impact on the functions of the landscapes downstream. Rosetta branch receives excessive loads of municipal and industrial waste water.

Upstream old land command areas

F.79 South of the MCA, another command area is bordering the MCA. This area delivers surface drainage water, salts, and groundwater to the MCA landscapes. Especially the amount of re-usable surface drainage water is important for the agricultural production in the command area, and for more downstream landscapes.

Nuberia old new land

F.80 The south-western and western neighbouring landscape is formed by the Old New Land which comes under the Nuberia irrigation command. The divide is formed by the Umum and Shereshera drainage system. Initially the irrigation of these old-new lands created problems of upward seepage, waterlogging and salinity in the old land. These problems have been taken care of by the construction of interception drains and the installation of subsurface drainage. For the rest there is not much hydrological interaction between MCA and this landscape.

4. Downstream neighbouring landscapes

F.81 Interaction between the MCA and the downstream landscapes is much more important, since the effects of interventions in natural resources travel downstream much easier than upstream.

Coastal Lakes: Open water and reed lands

Prevention of seawater intrusion

F.82 After the coastal ridge the lakes supposedly present the second line of defense against the intrusion of underground seawater. At present there is no certainty on the mechanism by which the salinity in the Nile delta is governed. One school of thought stresses the importance of seawater intruding in the underground under a layer of freshwater maintained by the lakes and irrigated lands. Another school insists on the historical character of the soil salinity and denies a large present influence of the Mediterranean[1].

F.83 *Value:* There is, as yet, insufficient scientific evidence to support one or the other "school" so the actual value of the lakes in the prevention salinity intrusion is impossible to describe.

F.84 *Stakeholders*: farmers in the lower Nile delta.

Storage of drainage water

F.85 The seasonality of the lakes with temporary brackish and freshwater conditions has changed in a constant inflow of nutrient rich freshwater from the main drains. Although the lakes are shallow (0.5-1.5 m depth), the surface area of 27,470 feddans (11,446 ha) for Lake Edku and 16,240 feddans (6,767 ha) for Maryut represents a significant water storage facility (very roughly estimated at 114.5 + 67.7 = 182.2 million m^3). The high nutrient load of the drainage water (sewage and fertilizers) combined with the change in character from seasonal brackish and freshwater conditions to almost permanent freshwater, has resulted in the proliferation of emergent reeds, papyrus and floating aquatic weeds (water hyacinth, potamogeton), in its turn leading to increased silting up of the lakes and obstruction to navigation and fishing.

F.86 Lake Edku has an opening to the sea (boughaz) near Maadiya, maintaining a minimal part of its original ecological character. The flow through the boughaz is determined by the balance between seawater level and drainage inflow, evapotranspiration of lake and marshes, rainfall and intrusion into the underground. So seawater may flow in or lake water may flow out. Its surface area has significantly decreased by land reclamation: from 35,770 feddans in 1953 and 28,480 feddans in 1973 to 27,470 feddans in 1981. Lake Edku receives its water from the Bersik (south) and Edku drains (east). The lake is compartmentalised by chains of islands. The salinity level ranges between 1 and 5 g/l. Evaporation amounts to 1,440 mm/year (= approximately 5 m^3/sec for the entire lake).

F.87 Lake Maryut has lost 48percent of its surface to reclamation for agriculture, from 32 160 feddans in 1950 (1955: 31,370 feddans, 1973: 16,280 feddans) to 16,240 feddans in 1981. Water sources of the Lake are the Umum drain, 74 m^3/s (agriculture), and Qalaa drain (mixed wastewater 0.7 million m^3/day). The lake has no sea connection; this might be the cause of large sections of the lake having anoxic conditions, producing badly smelling hydrogen-sulphuric gases making the area unsuitable for residential settling. Because of the lack of exchange with the open sea, the lake acts as an evaporation pan where organic and chemical pollutants concentrate.

F.88 *Value*: it is difficult to establish what use is being made of the water stored in the lakes. It was observed that vegetable growing, fruit orchards and fish farming is common around the lakes.

F.89 *Stakeholders*: (fish) farmers around the lake.

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1 Detailed hydrologic studies were made by RIGW which are in favour of the first school. The other possibility is still not completely left, as became clear from discussions. The case of locked fossile salt groundwater of marine origine was demonstrated for the river Senegal delta by Audibert (1970)

Discharge of industrial and urban liquid waste

F.90 Lake Maryut is (together with Lake Manzala) defined as a black spot area in Egypt's environmental action plan. It is a most alarming example of pollution in Egypt. The Greater Alexandria area represents 35 percent of Egypt's national industry, with over 1,000 industrial units. Liquid wastes, amounting to 1 million m^3 per day, are discharged in Lake Maryut, in drains or at sea. Lake Edku does not receive similar quantities of industrial waste.

F.91 *Value:* Lake Maryut has become unsuitable for fish farming, it constitutes a potential source of health hazard (quality of consumed fish, hydrogen sulphide gases, diseases), is unsuitable for recreational activities (Alexandria), and the nuisance created by odours and mosquitoes makes surrounding land unsuitable for residential development.

F.92 *Stakeholders*: inhabitants of greater Alexandria area (7 million)

Fisheries production

F.93 National fish production in Egypt was calculated in 1998 to be 545,593 tones. Fisheries represented 406,204 tones, fish culture 139,389 tones. Northern Lakes combined represent some 30 percent of national fish production. Lakes Edku and Maryut represent respectively 1.9 percent and 0.8 percent of this total.

F.94 Mullet based brackish water fisheries has been replaced by tilapia based freshwater fisheries. In spite of dramatic changes in water quality conditions and fish species composition, the total catch in Lake Edku has between 1985 and 1998 increased from 6,600 tones to 10,280 tones. This indicates that the agricultural and residential nutrient loads carried by the drains into the lake, is effectively converted into fish mass. A yearly fisheries productivity of up to 900 kg / hectare (375 kg/feddan, see table 4) for freshwater bodies is high. Scarce available data on levels of pesticides in water and fish tissue appear to indicate that these pollutants do not pose a public health concern in lake Edku. However, NWRP (2000) states that there is considerable difference of opinion on the amounts of toxicants in water and fish. The opinions vary from heavy pollution to no pollution. Available data on laboratory fish tissue analysis point in both directions, which is enough reason of serious concern.

F.95 Reed development is a constraint to fisheries. In Lake Maryut broad sections have to be cut open reeds in order to maintain part of its fisheries potential

F.96 A peculiarity of Lake Edku is the collection of juvenile eels at the boughaz. Eels migrate from the open sea, their birthplace, to inland waters to mature. Captured juvenile eels are transferred to fish ponds for further growth. Thus far it has been impossible to reproduce eels in captivity.

F.97 In Lake Maryut total fish catch strongly fluctuates from year to year with a high at 7 700 tones in 1985 and a low of 1,900 tones in 1995. The last available data from 1998 shows that fisheries have partially been restored at 4,521 tones. The serious environmental degradation of the lake due to industrial and urban pollution and its closed nature preventing incidental flushing are causing these fluctuations.

F.98 Fish from Lake Maryut is considered to be a potential health hazard because of the accumulation of poisonous elements in fish tissue.

Table 4. Overview of fish productivity in coastal areas

Lake	Surface (feddan)	Fish production (tones/year) (1998)	Productivity (kg/feddan)	Number of boats*	catch (tones/boat/year)
Edku	27,470	10,280	375 kg	1,619	17.0
Maryut	16,240	4,521	278 kg	2,458	6.6

** A boat is operated by 3 fishermen* (National Water Research Center, Strategic Research Unit, MWRI, 2001).

F.99 *Value*: On average a fishing boat on Lake Edku catches 17 tones yearly. The freshwater tilapias are considered of lower value compared to brackish water mullets so in this respect an expansion of seawater by, for example, enlarging the outlet to sea would probably lead to increased income levels.

F.100 A boat is operated by three fishermen so in total 4,857 persons are directly employed in fisheries on Lake Edku. Figures on indirect employment in processing and marketing are not available. The situation around Lake Maryut is less favourable. Yearly catch per boat is 6.6 tones. Some 7,344 persons are directly involved in fisheries.

F.101 *Stakeholders*: directly some 12,000 fishermen; indirectly the intermediary traders and ultimately the consumers benefiting from an affordable source of protein. Consumption level of fish is estimated at 10 kg per person per year. At present Egypt is almost self sufficient in fish. Communities such as Edku, to a large extent, depend on fisheries and related activities for their economic survival.

Water purification and reed production

F.102 As stated earlier, freshwater conditions and high nutrient loads led to proliferation of emergent reeds. The reeds are being used on a small scale for the production of mats, used to protect gardens or plantations. This use is insignificant in relation to the amount of reeds produced by the lakes. Reeds are known to absorb large quantities of salts and nutrients. Regular harvesting of reeds in shifts and consequently the removal of organic matter can thus contribute both to water quality improvement and to fish productivity.

F.103 *Value*: the production potential of reeds is used in a very limited manner. Better economic use of reeds combined with its additional value for water quality improvement should receive more attention.

F.104 *Stakeholders*: fishermen benefit from removal of reeds; water quality is an issue of national concern.

Breeding of nuisance animals

F.105 The permanent freshwater character of the lakes has created good breeding conditions for bilharzias vector snails. Freshwater conditions in combination with proliferation of weeds created ideal breeding spots for mosquitoes, creating a significant nuisance for residents.

F.106 *Value*: increased health risk for those working in or with water. Nuisance of mosquitoes contributes to unfavorable conditions of the area for development of residential or recreational facilities, especially around Lake Maryut

F.107 *Stakeholders*: Alexandria with its 7 million inhabitants is in great need of possibilities for expansion of residential and recreational areas.

Maintenance of biological diversity and processes

F.108 The coastal lakes were known areas of high species diversity, aquatic species as well as birds. As described above, biological resources still represent significant values in terms of fisheries revenues and water quality improvement. However, the conservation of biological diversity has not received any attention. The area is heavily influenced by human interventions. Plant diversity has been reduced by the spread of reeds and water hyacinth. Observations in the area didn't reveal significant numbers of waterfowl. The coastal lagoons are know to be important wintering areas for waterfowl from Northern Europe, but there is no information on their present status. Available information from the Nile river suggests that fish diversity has decreased enormously. Of 47 species of commercially caught species that used to inhabit the Nile, only 17 species remain nowadays. This will almost certainly also apply to Lakes Edku and Maryut. As these lakes have no special legal status and information was not readily at hand, no further inquiries have been made on this subject.

F.109 *Value*: maintenance of biological processes.

F.110 *Stakeholders*: future generations.

Coastal Lakes: fish ponds

Fish culture

F.111 Fish culture goes back to the earliest civilization along the Nile. Present day pond culture started expanding in the 1960s and 1970s. Fish culture production has risen from 12,400 tones in 1977 to 139,300 tones in 1998, representing 25.5 percent of total national fish production. This includes fish farms, cage culture, grass carp stocking programmes, rice-fish farming. Tilapia and carp (in rice) are the most common. Only hatcheries are allowed in freshwater; fish farms are only allowed in drainage water.

F.112 A large proportion of Lake Edku has been reclaimed for agriculture. The high salinity of the soils rendered it unsuitable for sustained agricultural practice. In several areas this land has been converted into fish ponds. A 1,400 feddan fish farm (operated by Mr Sabry Belal) has been visited. The farm uses drainage water to produce tilapia, silver carp and eels. Ponds are fertilized with manure (chicken, cattle), thus creating a nutrient rich environment to develop phytoplankton and zooplankton on which fish can live. Agricultural residues such as rice and wheat bran are used as an additional source of fish food. Because of the relatively extensive way of farming, there is no need for the application of chemicals or disease controlling agents. On a yearly basis ponds are dried and residues excavated.

F.113 A typical pond measures 10 feddan. It is stocked with 6,000 fish coming from the nursery. The stocked fish grow in 1 year from 20 g to a marketable size of about 250 g. Most produce is marketed in Alexandria.

F.114 The farm started operating in 1982. In the 22 years of existence there has not been any occurrence of insufficiency of water quality or water quantity from the drainage canal. In this respect the farm is operating sustainable, completely based on the reuse of drainage water from the Mahmoudia command area.

F.115 *Values*: Beheira governorate produced 8 075 tones of cultured fish in 1995. The average production of the visited farm is 2 tones/feddan/year, mainly based on low input tilapia farming. The land is leased from government at LE 100/feddan/year; annual revenues from fish amount to

LE 6,000/feddan/year. The farm provided employments for 300 persons. From a landscape esthetical point of view, the fish farming activities are rather devastating as it creates a large-scale treeless landscape of ponds and dikes. Continuous dredging of ponds and dumping of sludge hinders vegetation to develop. Depending on the esthetical appreciation of a landscape, people will have different opinions on this.

F.116 *Stakeholders*: private enterprises in fish farming, employees and consumers (mainly in the Alexandria area). The present level of 10 kg of fish per capita cannot be maintained by fisheries; any increase in demand for fish has to come from imported fish or in increased aquaculture.

Groundwater

F.117 There are no exact data on the effects of fish farming on groundwater. It can be expected that a 1,400 feddan farm with 1.5 m of water will contribute to the maintenance of a freshwater layer on top of the saline groundwater. Even though the drainage water has a relatively high salinity, it will be far less than the underlying saline water.

Coastal Lakes: reclaimed/abandoned land

Plantation: vegetables and fruit

F.118 Efforts to reclaim the lake for agriculture have been halted because of the high salinity of soil and groundwater. Nowadays, a significant proportion of the reclaimed agricultural lands are abandoned.

F.119 However, the mission visited a site where saline land has been raised with light, sandy soil; drainage water was used to irrigate (drip irrigation) a mixed plantation of highly productive fruit trees and vegetables. Scattered over the area such landfills can be observed.

F.120 *Value:* One visited plantation (owned by Mr Belal) of 4 feddan provided employment to 10 labourers. (Figures are available with Scheumann).

F.121 *Stakeholders:* farmers, investors, employees

Coastal ridge/dunes

F.122 Along the Mediterranean coast a sandy ridge separates the sea from the inland lakes. Observed functions of these landscapes:

Coastal defence

F.123 The most seaward side of the ridge consists of low sandy dunes (up to maximally 10 m height).

F.124 *Value:* The Mediterranean coast is subject to occasional severe winter storms, so the dunes do protect the hinterland from potential flooding.

F.125 *Stakeholders*: inhabitants of the coastal zone and agricultural hinterland

Collection of rainwater

F.126 Rainfall along the Mediterranean coast amounts to approximately 200 mm per year.

F.127 *Value:* The coastal ridge is the first line of defence against the intrusion of seawater and provides suitable local conditions for plantation agriculture.

F.128 *Stakeholders:* lower delta farmers.

Plantations

F.129 The dunes have on a large scale been leveled and planted with date palms and guava trees mixed. For this, the top of the dunes has been deposited in lower depressions where seawater intrusion created saline conditions unsuitable for cultivation. The plantations are irrigated with drainage water from Lake Edku.

F.130 *Value:* Between the city of Edku and Alexandria some 5 million date palms are planted.

F.131 Stakeholders: large scale farmers (owned or leased).

Infrastructure

F.132 Sections of the coastal highways are built on the coastal ridge.

Mediterranean

F.133 In a complete analysis the influence of water resources management on the Mediterranean should be incorporated in the study (think of effects on coastal fisheries and pollution of beaches). Given the complexity of the issues and the limited available time this was considered beyond reach of the mission. However, data from written sources (WQMU, 2003 and a tourist guide) suggest that the coastline east of Alexandria suffers from significant pollution and has become unsuitable for recreational activities. Quality and quantity of fish in coastal waters will be affected by resource management practices in the study area; consequently marine fisheries are a stakeholder in the whole picture. These issues are documented (NWRP, 2000).

G. PROBLEMS, PRACTICES AND OPPORTUNITIES

1. Concept

G.1 There may be a number of reasons why the functions of natural resources do not meet the requirements of the society. Some are found in adverse user practices (e.g. field irrigation practices), some in the limited availability of a resource (e.g. availability of agricultural land per household), most of the problems however are rooted in an imperfect institutional and management system.

G.2 Complex systems of institutions, management arrangements and hardware infrastructure should bring supply and demand of functions of the natural resources in a satisfying equilibrium. The irrigation and drainage sectors in Egypt are such complex systems which try to keep a balance between the ever growing demand for water and the almost fixed supply of water from the river Nile.

Table 5. Structuring problems, inadequate functions, and issues *(not exhaustive)*

First order problems for water users	**Inadequate water related functions**	**Adverse practices**	**Limited natural resources**	**Institutional imperfections**
low income for large groups of farmers	- agricultural productivity - maintenance of groundwater and salts	- subsistence agriculture - inefficient water use - inadequate drainage	- small landholdings - irrigation water	
inequity in income of farmers	- inequity in access to water	- inequitable distribution of water - rice cultivation in upper reaches		enforcement rice regulation; technical infrastructure
fisheries income	- access to water low quality of water	- over-fishing	- lake area	water rights
low status of public health	- water borne diseases	- garbage dumping - untreated sewerage	- no space for official dumping	waste management
insecure and limited local drinking water provision	- water quality problems	- sewerage and solid waste dumping - reuse of drainage water		waste management
housing problems	- ground water depth		- limited land resources	- inadequate drainage provisions - lack of rural sanitation
degradation of land and water resources	- waterlogging - salinization - pollution - sedimentation	- agricultural practices - reuse of drainage water		- lack of maintenance - waste management

2. Agricultural productivity

Problem

G.3 In the study area large numbers of small to very small farmers produce wheat, fababeans, berseem, rice, cotton and maize as the main crops, and a choice of small crops, vegetables and animal products. The yields per unit area of these crops are rather high, thanks to a favourable soil, climate, and irrigation and drainage services. Yet the income level of many of these farmers is low, and a considerable portion of the population can not subsist anymore on agricultural production. The main cause is the very small land area per household, and therefore a small per farm revenue in terms of food and cash. Many households need additional off-farm employment to provide for a minimum income. A farm with an area of 1 hectare, cultivating the average cropping pattern at average variable cost and rent would have a net revenue of about 5000 LE or 500 US$ per year (Agricultural Statistics 2003). The average land holding in Al Mahmoudia district is about 1.2 ha. (See report of Socio-economist). The agricultural revenue of irrigation water is roughly estimated at 0.36 LE/m^3 . It is higher for the winter crops berseem and wheat (0,60 LE/m^3), and lower for the summer crops rice and cotton (0,20 LE/m^3). These figures show that there may be scope (from a macro-economic point of view, to increase the productivity of Nile water by shifting part of the production to high yield-high cash crops. This is of course against the interest of the local farmers on the old land. It is also not taking into account the social value of summer cropping on the old lands.

G.4 In general there are two questions which are relevant:

1. To what extent can changed water management practices improve the agricultural productivity of the MCA under existing farming conditions?
2. To what extent can changed water management practices increase the agricultural productivity per unit of water?

G.5 As regards the first question, the potential for further increase of the productivity of the land by improved irrigation seems somehow limited, since yields are already quite high. In general the amounts of water which are applied are sufficient, drainage is controlling the groundwater and salinity levels of the soil to the satisfaction of the farmers. Unfortunately no data were found, showing the monitored effect of IIP interventions on agricultural productivity. Of course there is scope for improvement for parts of the area which are, under the present conditions, served suboptimal because of their diverse properties. (Lower land tracts, tail-ends, etc.). These suboptimal producing areas are localised and need localised adaptations of the general water management practices. The next chapter deals with this opportunity. Otherwise, improved agricultural productivity has to be driven by agronomic interventions rather than by new water management interventions (new varieties, other crops). At the cost side there is scope to increase the net revenues of agriculture. The cost per unit water delivered at the farm can be decreased. The pumping cost in improved mesqas reportedly has come down by 30% (Report Socio-economist). The cost of water conveyance and distribution at the main system level has to be critically reviewed.

G.6 The adage “more crop per drop” is easier said than done. In the first place it should be replaced by the adage “more value per drop”. To illustrate this, one may compare the net revenue per hectare of irrigated rice and maize in MCA with the net revenue per cubic meter of these summer crops.

Table 6. Revenues per hectare and revenues per unit of water

	Net revenue/ha (LE/ha)	Net revenue/m^3 (LE/ m^3)
Rice	2 341	0.23
Maize	1 962	0.36

** Provisional figures.*

G.7 Moreover, the value of a certain agricultural product is not only expressed in economic terms. Wheat production has a strong social dimension for the small farmers in Egypt's old lands. It provides them with food security. Changes in cropping pattern are therefore sometimes difficult to realize. Nevertheless there is still scope to improve the productivity of water. Crops with a high consumptive use (evapotranspiration plus leaching requirements) like rice, can be replaced by more water efficient crops. However, the function of rice cultivation in suppressing salinity levels in certain low lying areas should not be overlooked. New on-farm water application techniques can be promoted. Controlled drainage could limit the water consumption of e.g. rice. However, the mixed cropping pattern makes it difficult to apply this to rice fields only. Consequently conflicts may rise between rice growers and others. Location specific technologies are needed to solve such problems. This is now becoming possible with the participation of stakeholders, organized in Water Boards.

G.8 A critical review of the consequences of a more efficient water application should be made (not to be confused with distribution efficiency, which is discussed in section 6.3). Water that is not used in one field, and spills over to a drain, will be used in some downstream field through official or unofficial reuse practices. Also the leaching requirement which comes out of the subsurface drains, is reused. At the lower end of the MCA, the effluent is still not worthless. Fish farms, fisheries in the coastal lakes and vegetable growers use this water directly and indirectly with success. The consequences are not only quantitative in nature, they also relate to water quality, especially salinity. If there is an overall decrease of water supply from the Nile to MCA, water will be used more efficiently, and less water will leave the area. Generally speaking, the levels of salinity and pollution in the remaining effluent will increase. The SIWARE model (DRI/SC-DLO, 1995) can probably simulate this intervention, and set safe margins for the efficiency that should be strived for.

3. Inequitable access to water

G.9 One of the reasons for sub-optimal agricultural production is a sub-optimal access to irrigation water by part of the farmers; the so-called 'tail-end' problem. This is a common feature in almost all large irrigation schemes in the world. Farmers in head-reaches have earlier access to water than tail-enders. This is valid for branches as well as for mesqas. Even in situations where there is an overall water shortage, the head reaches manage to fulfil there water requirements, and most of the time more than that. There is also a general tendency that head-reach farmers shift there cropping pattern to more water consuming crops, often rice, which aggravates the situation. The tail-enders, if they are located on the right spot, can compensate their water shortage by pumping from drainage canals. This increases their pumping costs, their land remains more saline, and yield reduction due to water stress is more likely to occur. The head-reach farmers due to lack of confidence in the water supply practice over irrigation which in turn also cause of reduction in yield. Improving the situation of inequitable water supply is probably one of the most promising opportunities to increase overall productivity of water, and improve on income distribution. Experiences all over the world also indicate that there is a strong need for institutions to deal with the problem, rather than for self-regulating technical infrastructure. The IIP project intends to improve this situation with a package of improvement interventions. The change of rotational to continuous supply in the branch canals is one of the measures. How difficult it is to change the functioning of the irrigation canal system is shown by the fact that after 7 years of project activities, only one branch canal was switched to continuous supply just during the mission.

4. Water quality

Problem

G.10 WQMU (2003), partly based on World Bank (2002), provides an estimate of the economic damage from impaired water quality (see table below), based on an approach translating water resources into a multifunctional asset, somewhat similar to the approach followed in the present study.

G.11 These figures are based on national data and are difficult to translate for the study area. However, some remarks can be made. Water-based recreation refers to the immediate Cairo area, the coast near Alexandria and the Red Sea, indicating that a large proportion of the estimated damage of LE 200 million refers to the project area. Health issues relate to child morbidity and mortality (through "*disability adjusted life years"* calculation) resulting from bad water quality. This specially applies for the lower delta area. For example, the environmental assessment for the Bahr Bagar Drain noted an increase of 5-40 percent for various forms of cancer and heart disease in areas that irrigate with drainage water.

G.12 With respect to economic damage from poor water quality, the clearest conclusion was that health impacts from water pollution appear to far outweigh all other damages or costs. This suggests that the most important areas for water quality improvement lie in actions to:

- improve management of canals and drains in the Nile delta especially to reduce the introduction of municipal and industrial wastes into these waterways, and
- to mitigate against the creation of "black spots" caused by industrial or municipal waste water discharged into the Nile or canals above the delta, especially when these threaten drinking water supplies.

Table 7. Value of health problems

Category of loss	*Estimated value in year 2003 (LE million)*
Recreation	200
Non-user benefits	0 – 400
Fisheries	400
Health	5,600 – 60,000
Municipal treatment cost	0 – 400
Industrial supplies	400
Agriculture	400 – 2,000
Tourism	200 – 1,000
Total impact	**7,280 – 64,880**

G.13 Rural areas in the study area continue to be largely without effective and environmentally sound systems for the disposal of liquid waste. Improper management of and removal of sewage lowers the quality of life and leads to premature death of thousands of people every year, with high costs to society and the economy.

G.14 Industrial activities in the lower reaches of the Nile, the drains and around Lake Maryut lead to serious pollution. Existing regulations are not always enforced and industries are allowed to dump their waste into open water. The negligence by which industrial waste is dumped into the water, and the obvious lack of enforcement of regulation and licenses, gives the impression that water is not valued as a precious resource in Egypt. Since obviously everybody knows this is not the case, the actual situation becomes astonishing.

Opportunities

G.15 The WQMU (2003) report also summarizes a number of most promising water quality management instruments at national and local/regional level:

- increase municipal sewerage and wastewater treatment;
- initiate cost-recovery for urban sanitary services;
- encourage pre-treatment and treatment of industrial wastewater by industries;
- start local action plans on domestic sanitation in rural areas;
- introduce load based discharge levies;
- stimulate private sector participation in infrastructure and O&M; and
- start public environmental information disclosure.

G.16 Our own observations show that some water boards have already taken up the task to produce local action plans at branch canal level. A number of actions related to canal cleaning and creation of safe washing places have already been implemented. Constraints often lie with the limited resources of local government that in many cases need to follow up on local initiatives (for example in the case of garbage collection). Scaling-up such practices under the umbrella of IIIMP, with the involvement of water boards, is worthwhile to consider.

G.17 Other opportunities for water quality management, though somewhat remote from the original IIIMP objectives, lie in the use of natural cleansing capacities of wetlands in the coastal lakes area. Study is needed of the actual cleansing capacity of reed swamps and a possible economic use for the reeds needs to be identified in order to create a sustainable activity. Removal of reeds will lead to removal of pollutants and will have an additional positive effect on lake fisheries (as was discussed in section 5.3.1).

5. Water quantity

G.18 The FAO case study on drainage water reuse in Egypt concludes that presently the salt balance of the delta is stable and reuse does not contribute to accumulation of salts (Kielen, 2002). (The report also states that maintenance of freshwater fisheries requires additional water, but this is questionable since brackish water fisheries may economically be even more interesting - the lake has always been characterised by a fresh to saltwater gradient.). With the presence of an effective drainage system, the perceived loss of irrigation water due to spills at tail ends of canals or due to over irrigation, in reality is not a loss. Through the mechanism of drainage water reuse, this water is returned back into the irrigation system. Moreover, a spill of water may enhance the quality of drainage water, simply by dilution of pollutants, but also by better preventing intrusion of saline groundwater.

G.19 Moreover, our study has shown that in the lower reaches of the delta effective use is made of drainage water by applying well adapted soil management and irrigation techniques, by fish culture and a highly productive fisheries sector. All of these benefits are obtained by making use of water that is considered wasted in the official irrigation language. A better economic, social and environmental appreciation of these mechanisms would probably provide a somewhat different picture on the so-called waste of irrigation water.

G.20 Any activity aimed at a reduction of water use in the delta has to take into consideration that a reduction in drainage flow may lead to increased water quality problems in the lower delta, unless effective pollution control is in effect, while the needs of established economic activities are accounted for. A careful balancing act is needed to make full use of all functions provided by the water resources system in the Nile delta. In this respect one should not focus on the maximisation of one function (for example irrigation), but on the optimisation of all functions on order to maximise the combined value of all functions, in a way that can be maintained in the future (sustainability).

6. Solid waste

Problem

G.21 Solid waste disposal is a widespread problem hindering the performance of the irrigation and drainage infrastructure. The problem is caused by a combination of:

- increased economic development leading to higher consumption levels;
- the widespread use of non-degradable materials (plastics);
- the lack of a solid waste collection system in most rural areas; and
- a careless attitude at the part of the population.

Opportunities

G.22 A solution has to be found for combined action at local community and regional units levels. Water boards can, in their action programmes, address environmental issues and try to organize the local community in cleaning up their direct environment; the municipality (unit) has to further organize the collection and safe processing or disposal of solid waste. Awareness campaigns are badly needed.

7. Maintenance of ecological processes and biological diversity

Problem

G.23 The present status of biological diversity in the delta is alarming. The two Ramsar wetland sites in Egypt have for a long time been listed as problematic; it is very difficult to maintain the ecological character of these wetlands under the enormous pressure exerted by the water quality and quantity problems listed above. Land reclamation has reduced the size of the lakes significantly.

Opportunities

G.24 Wetlands have a great restoration potential. Around the world restoration projects are being launched to restore natural processes for the maintenance of coastal wetland systems. This because these systems appear be the most productive; human interventions in these complex and dynamic systems are usually unsustainable and require continuous adaptation and investment.

G.25 In Egypt, reclamation activities of the coastal lakes have been downscaled because of salinity problems. In order to at least maintain the restoration potential of the coastal wetland system, further large scale interventions should be avoided. There probably will come a day that also Egypt will appreciate the value of maintaining some of the processes that keep a delta alive, maintaining an active interaction between the delta, the open sea and other areas in the world (for example by migration of fish and waterfowl).

G.26 Further economic development of the urbanized area around Alexandria is expected. On a national scale the importance of economic activities in the urban areas will become of more importance and the economic value of agriculture will reduce. As seen in other areas of the world this will create an increasing demand for better quality of life, including healthy recreational and residential areas around cities. The coastal lakes provide an enormous potential in this respect.

G.27 The present quality of the lakes depends on the quality and quantity of drainage water flowing into the lakes. Any activity in the upstream irrigated area which changes water quality and quantity parameters at the downstream side of the drainage system will influence the lakes. Water saving through improved irrigation, for example, will result in reduced water flow into the lake. Without water quality measures the pollutants will thus concentrate in less water, thus reducing its quality.

G.28 The important message here is that measures taken by IIIMP in the upstream irrigation area inevitably have consequences for the coastal lakes. Given their present, but also their potential future values as indicated above, impacts on the lakes should be taken into account when assessing economic, social and ecological costs and benefits of IIIMP interventions.

H. DISCUSSION OF PROPOSED IIIMP INTERVENTIONS

1. Concept

H.1 The IIIMP project envisages undertaking 5 main activities in order to achieve its broad objectives:

- *develop a framework for integrated water management plan and programme in selected command areas, combining water quantity and quality management through inter-agency and stakeholder consensus;*
- *improve institutional, financial, and environmental sustainability of water services through intensive user and private sector participation in the investment, and operation and maintenance at the district/branch canal levels and below and improved water quality management practices; and*
- *increase farm incomes through improved agricultural production based on efficient, more equitable and sustainable use and management of water and land resources.*

H.2 The intended activities of IIIMP are discussed in the following five sections. However, it should be kept in mind in the other working papers some of the components may be discussed in greater detail. This chapter will briefly discuss the different components from the point of view of the “DRAINFRAME” approach. In this regard, the following questions are relevant:

- Does the IIIMP recognize the diversity of the water management situations and fine-tune its measures to the different situations?
- Does IIIMP take into account the different functions of water, inside and outside the project area, their respective stakeholders and their values?
- Are the IIIMP measures contributing to solving the basic problems of the area
- Will there be a systematic assessment of the impacts of the proposed measures on stakeholders inside and outside the project area?

- Are mitigating measures considered in case of adverse effects for stakeholders inside and outside the project area?
- Will institutions be established and function, which reflect the representation of stakeholders in planning and decision making?

2. Developing and Implementing Integrated Water Management Plans

H.3 PCD: *"This component would include support for irrigation, drainage, pumping stations and groundwater sub-sectors of the MWRI, for piloting integrated plans and coordinated implementation arrangements for the project areas including technical assistance and training and supply of equipment, materials, vehicles and office equipment."*

H.4 From the description above, it remains unclear what "integration" really would mean in IIIMP. Reference is made to the different sub-sectors of MWRI, to pilot activities, and to funding of these organizations. Much is still to be clarified during the project preparation stage. From the "DrainFrame" point of view, integration should start with a function-stakeholder-value analysis in the possibly affected landscapes by water management changes. Then the beneficiaries/stakeholders can be identified, both those who receive the positive benefits as well as those who experience negative effects. They should really be involved in the development of integrated water management plans right from the start. The "DrainFrame" approach to integrated water management planning is further explained in Section I. The command area approach which is chosen in that Chapter can be repeated in simpler forms at lower levels, e.g. branch canal level and even mesqa level.

3. WUAs and Water boards

H.5 PCD: *"Establishment and expansion of Water User Associations (WUAs) and the Water Boards in line with Government policy of integrated irrigation and drainage water management. This would include support for WUAs at the tertiary level and up scaling them to branch canal level and their incorporation in the Water Boards at the district level."*

H.6 In view of what has been said in previous section on representation of stakeholders in planning and decision making, the establishment of WUA's and Water boards is imperative for integrated water resources management. They should be active not only in the operation of irrigation and/or drainage systems, but also they should be involved in the planning and design of the mesqas. The same holds for water boards which function at branch canal level. As a result of this stakeholder involvement, the planning processes becomes much more problem oriented, instead of technology driven. This may end in considerable deviations of standard solutions. The package of interventions at both levels may become broader than irrigation improvement only. For example, at mesqa level a need for drainage of settlement areas may exist; sewerage management may become part of the water management package; rehabilitation of subsurface drainage systems may be coordinated with irrigation improvement. At the moment WUA's are only involved in irrigation matters, and they are not (yet) equipped to deal with other water management issues which may arise in their area of action. Water Boards are more geared to integrated water management, but the disadvantage may be that a Water Board is active at a higher level. Under IIIMP, if the option is present, the division of roles and responsibilities among WUA's and Water Boards should be given due attention.

4. Improvement and Modernization of Irrigation and Drainage Infrastructure

H.7 PCD: "*This component would include the implementation of improvements, modernization of main, branch canals, tertiary systems, drains, irrigation and drainage pumping stations, implementation of new, and rehabilitation of existing sub-surface field drainage systems, their subsurface collectors and open drains, covering a total area of about 50, 000 feddans*".

H.8 Since the description of the various components in the Project Concept Document is not detailed, for some of the technical measures this report refers to the interventions as already implemented by EPADP and IIP projects. The working paper of the Irrigation and Drainage Specialist will discuss in detail what can be expected from these improvements and what can not. Here the planning and design process will be discussed.

H.9 The EPADP and IIP projects both have a very limited choice of technical solutions which can be provided. Due to the variability of water management situations, this narrow choice is likely to offer sub-optimal solutions in most situations (see Box 5).

Box 5: On diversity and multi-functionality of water management situations
From: Reclaiming Drainage: Toward an Integrated Approach (Abdel-Dayem, et al. 2004)

Integration will mean different things in different contexts, but in every context drainage would benefit from being looked at from an integrated perspective. Integrated management of drainage would mean:

- Acknowledgement of the multiple objectives served by the management of shallow water tables and the disposal of excess surface water, and need to maintain the resource system over time (resource sustainability).
- Adapting drainage interventions to the natural resources system, taking into account the diversity of drainage situations and trying to optimize the goods and services produced by the natural resources system (planning and managing diversity and multi-functionality).
- Instituting inclusive forms of (drainage) governance and decision-making with representation of the different stakeholders (democratization).
- Improving the scientific knowledge base through a major shift in the focus of the scientific community towards the fields of sustainability, multi-functionality, and stakeholder representation in governance and decision-making.

A basic implication of such an integrated rather than a sector perspective is that drainage is also seen as part of the entire natural resources management system.

H.10 If the design of these interventions is done together with the stakeholders in place, fine-tuning of the interventions can result in more effective and probably also more cost-efficient solutions. A second improvement could be obtained if a systematic impact assessment is made for each intervention. The steps as described in Section I can be followed.

5. Environmental Management Plans

H.11 PCD: "*GEF support would be sought to address environmental assessment and mitigation measures focusing on water quality for integrated irrigation and drainage in the three regional project areas which have distinctive ecological systems, and would build on site-specific pilots under the ongoing IIP, NDPII, and Pump III projects. The GEF component would be fully developed during project preparation*".

H.12 If the PCD phrase is well understood, during the project preparation phase environmental plans will be developed for each of the three project areas. These plans will consider water quality problems, and indicate measures to mitigate the adverse effects of low quality water in the areas.

H.13 This study has revealed that low water quality is one of the overarching problems in the water system of the study area. The effects are sensible not only in the project area itself, but propagate downstream into the coastal zone. In terms of environmental management, also the pollution by solid waste is an important problem that waits for a definite solution. Thirdly, the lurking threat of salinization is always there and precise water management remains a pre-requisite to keep this potential environmental hazard under control. Environmental problems are caused locally and therefore need local attention in the first place. Bad practices affect a number of functions on-site as well as of-site. New interventions may provoke new environmental problems. It is therefore recommended to make environmental assessment an integral part of the plan preparation at command area level, at branch canal level, and even at mesqa level. The DrainFrame approach offers a perfect framework, as shown in this study, to identify existing environmental problems (but also social and institutional), inside and outside the project area, and to evaluate proposed mitigating measures on their impacts. During the IIIMP preparation phase the approach can be elaborated. Solutions, in terms of measures, are location- specific and can only be developed together with stakeholder groups. Therefore, the practical environmental management planning and implementation should become part of the project implementation phase.

6. On-farm Demonstration Plan

H.14 PCD: "*The project would support the establishment of about 50 on-farm demonstrations spread over the five project areas during the five years of project implementation to demonstrate proven technologies for improved water use*".

H.15 Some remarks need to be made on this item:

1. Farmers are not interested in improved water use as long as that does not bring them higher revenues from their fields.
2. It was stated before that the potential of agronomic interventions (such as new varieties, better agro-chemicals, etc.) to increase the net farm revenues is higher than improved water use. . On-farm demonstration should be implemented at water management level 'mesqa' to combine integrated water, soil and agronomic good practices to maximize benefits.
3. Supposedly the on-farm demonstrations should lead to a more efficient use of irrigation water, and hence an alternative use of the saved water elsewhere. Will it improve overall water sufficiency in the mesqa? Or in the branch canal? Will it allow for a third crop for the same farmer? Or will savings be used to serve better the more downstream farmers?
4. Water is a precious resource in Egypt. It comes to the mesqas as a common source through the single pumping station. The management of that common source is rather new for the members of the mesqa. It can be used for irrigation, and most of it will be used to that end. But there may be other uses at that level, which serve different purposes (e.g. communal washing places, cattle drinking, small fish ponds, etc.). Such multiple use requires improved management skills and institutions at the mesqa level. Wouldn't it be useful to embed the on-farm water use demonstrations in a somewhat broader context of on-mesqa water use demonstrations? The need for it can be a result of integrated WM planning at mesqa level, eventually combined with a local environmental management plan. A kind of repetition can be made at branch canal level.

I. APPLICATIONS OF "DRAINFRAME" IN IIIMP

1. Applying the DrainFrame methodology during project preparation

I.1 In Section C, the steps of DrainFrame are indicated in Figure 1, starting from an understanding of the various water management issues, on which well defined interventions in the system are based. The situation in which the mission found itself was different. IIIMP, at the time of the study, was formulated only in broad terms in the Project Concept Document (Arab Republic of Egypt, 2003). An integrated analytical approach like DrainFrame had not been used for this first project formulation. The first question, therefore, was to verify if the problems and opportunities (step 0 in Figure 1) related to water management system of the proposed area and of the connected upstream and downstream areas had been identified and described in an integrated manner. To do this, identification of water management issues had to be elaborated (Step 0). This step included the first round of identification of possibly water-connected landscapes (broad definition of boundaries of study area), and an analysis of their functions, stakeholders and values. This reveals the sub-optimal functions of the water system. However, equally important is to discover the bottlenecks of the institutional and management system.

I.2 By identifying the problems related to water resources management in this way, an overview of the potential need for interventions is provided, and the relevance of already proposed interventions (physically and institutionally) can be evaluated.

I.3 The mission team has decided to take one command area as the point for departure. From a hydrological perspective this is a logical unit of analysis in the Nile delta, as there is one point of entry of water. The following steps were completed.

Describe affected landscapes

I.4 Describe boundary conditions for the entry point. The management of the entire Nile system up to the operational rules of the Aswan High Dam are beyond the scope of the analysis of one command area. Therefore, boundary conditions for the analysis are the (seasonal) availability of water, the design capacity of the canal, and the quality of the water entering the system.

I.5 Define the boundaries of the hydrological system (watershed). From a water resources management perspective, the boundaries of the area to be analysed may be larger than a command area, because drainage water flows to downstream landscapes beyond the boundaries of the command area. (In discussion with stakeholders boundaries may change, depending on the interactions between the hydrological system and functions of landscapes; this will be dealt with later).

I.6 Identify main landscapes within the hydrological system. A landscape is a geographically defined area with a more or less homogenous set of natural resources providing a number of functions. Based on physical characteristics of the landscapes and valuation of functions of these landscapes by groups of stakeholders, a further refinement in the description of landscapes is needed. Delta lands can, for example, be subdivided into agricultural land with high groundwater salinity, with low groundwater salinity, and residential areas.

Identify functions of the identified landscapes and their stakeholders

I.7 In consultation with experts and stakeholders, the functions of landscapes can be defined. Functions can be described as the goods and services provided by the natural resources system. Goods and services can be exploited by humans, preferably in a way which does not jeopardize the future potential of these functions (environmental sustainability).

I.8 Some basic rules apply to the identification of functions:

- Each landscape is by definition multifunctional: for example, the prime function of agricultural land is the production of crops. Yet, these lands also play an important role in groundwater recharge, soil organisms maintain decomposition processes, provide opportunities for clay mining (brick industry) and the land is also suitable for human or industrial settlement, or construction of roads.
- Each function has one or more groups of stakeholders. One of the functions of the canal system is the provision of water. Stakeholders are farmers and drinking water authorities, but also fish farmers that want to introduce cage culture in the canals; main canals may also be important as a means of navigation. Stakeholders do not have similar interests; on the contrary, often interests may be conflicting.
- Functions represent values for stakeholders. Values may come in financial terms, such as the earnings made from agricultural or fisheries production. However, values can also be expressed in social terms, such as the number of cases of water-related diseases, or the number of jobs provided by certain function. Functions can also be valued in ecological terms, for example when an area performs an important function for the maintenance of other landscapes, or for the maintenance of important biological diversity. For example, the coastal lakes play an important role in preventing seawater from intruding in the delta lands; similarly they are a breeding ground for some marine fish.
- Functions can be influenced by external factors, beyond the boundaries of the study area. For example, seepage water from the higher new lands west of the delta influences drainage conditions in the delta lands. In some cases, the boundaries of the study need to be expanded in order to obtain a good understanding of the situation.

Describe existing institutional arrangements

I.9 Functions of the water resources system are managed by humans by either informal or formalized institutions. Usually, these institutional arrangements are characterised by a number of layers. In the delta agricultural lands, the following levels can be distinguished, with examples of formal or non-formal types of institutional arrangement: field (individual farmers), mesqa (water users association), branch (water board), and command level (district water board). The concepts of Institutions encompasses a wide variety of aspects, such as actors, organizations and their interactions, property rights, governance mechanisms, regulation, control, monitoring and enforcement.

Identification of problems and opportunities

I.10 Instead of straight away assessing impacts of proposed interventions, in this step an analysis of problems and opportunities in water resources management is made.

- Problems are identified through discussion with stakeholders. As indicated before, different functions may have different stakeholders. Consequently, problems or opportunities will be perceived differently by stakeholders. For example, water shortage will be perceived differently by farmers at the head-end of a canal compared to the tail enders. Similarly, salinity is perceived differently by farmers in areas with or without subsurface drainage.

- A possible instrument to describe functions, stakeholders and problems/ opportunities is the so-called participative mapping. In group sessions different stakeholders describe their area of interest and express their views on the development of opportunities or problems encountered. Putting these issues on a map helps recognizing geographic patterns and establishing links with the water management system.
- Potential opportunities for solutions are defined.

I.11 Based on values as expressed by stakeholders, problems can be prioritized. An example of an existing mechanism for such an approach are the recently established water boards. A water board works on the basis of an inventory of water related problems and, an action plan which defines priorities for intervention.

Identify alternative interventions and define intervention levels

I.12 In order to address the issues raised by stakeholders, interventions need to be identified in response to the issues raised. Before an intervention can be identified, one needs to know at what level an issue can be better addressed. For example, a water shortage at mesqa level can usually not be solved at mesqa level, but needs to be solved at a higher level (branch, main canal or even higher).

I.13 At this stage it is important to define alternative interventions. In a later stage this will allow for comparison of expected positive and negative effects between alternatives. This provides the basis for discussion with stakeholders and decision makers on an optimal intervention design.

Describe institutional needs and gaps

I.14 Connected with the proposed technical intervention and the level at which the intervention is needed, institutional requirements for an effective implementation have to be defined.

I.15 Based on the analysis in step three, gaps in the institutional arrangements and implementation mechanism need to be defined in order to overcome this gap.

Iterative, transparent and participatory design of interventions

I.16 Moving to step one of the DrainFrame scheme and in a stepwise manner, analysis of positive and negative consequences of interventions is to be done. In consultation with direct and indirect stakeholders, determining whether the proposed interventions will result in desired impacts and whether undesired impacts can be avoided, mitigated or compensated is to be done. If necessary, interventions are to be redefined.

2. Possible use of DrainFrame during project implementation

I.17 If IIIMP is finally designed in an integrated manner, it should leave enough room for flexibility in the implementation of technical and institutional interventions. An overall study like this one is not suited for mapping the very local differences in the land and water system, its functional differentiation, an inventory of all local stakeholders, and a weighing of all values at stake. A DrainFrame approach during project implementation to sort out the details of the localized solutions is, therefore, certainly justified. The role of stakeholders in this stage will be even more important. To be able to initiate such participatory design processes, where stakeholders, engineers, agriculturalists, local governments and others have to cooperate, an independent well trained process-facilitating party seems indispensable.

3. Impact assessment: at strategic or project level?

I.18 The process as described above can be interpreted as a strategic environmental assessment (SEA) for the water resources management sector in a selected area. SEA is a rapidly developing and expanding tool to assess the social, economic and environmental consequences of policies and plans. In the European Union, as of mid-2004, it has become obligatory to assess the impacts of policies and plans using SEA. SEA has the great advantage over traditional project-level EIA (environmental impact assessment) that it can effectively deal with the cumulative impacts of different interventions and developing adequate responses on a more strategic level. So, instead of deciding where to implement irrigation improvement measures, it provides a tool to first decide what type of intervention is needed in what location. In its most ideal format, SEA should be an integrated part of national or regional planning. In countries where planning is not fully functional, SEA can be a parallel process to programme or policy development.

I.19 The IIIMP project has many characteristics of a programme that has to make strategic decisions which ultimately result in project interventions. In its present stage, only intervention areas have been identified. Actual activities have not yet been identified; only a listing of potential activities exists. So, before the project embarks on implementation of activities, first an integrated analysis of water resources management issues is needed before actual intervention can be envisaged. Furthermore, the study needs to be complemented with an analysis of existing institutional arrangements and gaps that needs to be addressed by the project. The approach following in our study could be used for this purpose.

I.20 MWRI has contracted a consultant to perform an environmental assessment following the “traditional” EIA procedure (MWRI, 2004). The main objective of the Environmental Assessment (EA) is to identify the impacts of IIIMP implementation and to prepare an Environmental Management Plan (EMP) for the direct impacts.

I.21 The approach of the environmental assessment as described in the ToR is definitely sectoral, illustrated by the following citation. “*The EA will discuss briefly broader issues, which could influence the project, especially external sources of pollution to the irrigation and drainage sector, e.g. rural waste water, industrial effluents, solid waste, and environmental-health linkages*”. Our study has shown that integration of water resources management goes beyond irrigation and drainage. Considering the importance of public health concerns related to water quality and the multifunctional nature of the irrigation and drainage system, the so-called “external sources of pollution” should be a central element in any water resources management project. Any intervention in the irrigation an drainage system has, as shown by our study, consequences on one or more of the functions performed the I&D system. Considering these functions as externalities for the I&D system is overlooking the present alarming water quality situation caused by the very existence of the I&D system.

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