Efficient Water Use for Agricultural Production (EWUAP) Project

BEST PRACTICES FOR WATER HARVESTING AND IRRIGATION

EGYPT

“Final Report”

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Glossary of Acronyms and Abbreviations

ARC	Agricultural Research Centre (MALR)
AEZ	Agro-Ecological Zones
BCM	Billion Cubic Meters
BCWUA	Branch Canal Water User Association
BP	Best Practice
CF	Continuous Flow
CMI	Community Managed irrigation
DRC	Desert Research Center
DRI	Drainage Research Institute (NWRC)
DWB	District Water Board
EEAA	Egyptian Environmental Affairs Agency
EWUAP	Efficient Water Use for Agricultural Production
GDP	Gross Domestic Production
GIS	Geographic Information system
GOE	Government of Egypt
GTZ	German Technical Cooperation
HAD	High Aswan Dam
HEZ	Hydro-Ecological Zones
IAS	Irrigation Advisory Service
IIIMP	Integrated Irrigation Improvement Management Project.
IIP	Irrigation Improvement Project
IWRM	Integrated Water Resources Management.
L.E	Egyptian Pound
MALR	Ministry of Agriculture and Land Reclamation
MCM	Million Cubic Meters (Mm^3)
M&E	Monitoring and Evaluation
MLD	Ministry of Local Development
MED	Ministry of Economic Development
Merwa	Private ditches receiving water from Meska for distribution to the fields.
Mesqa	Private Sub-branch or water courses, receiving water from branch canals
MWRI	Ministry of Water Resources and Irrigation
NBI	Nile Basin Initiative
NPC	National Project Coordinator
NWRC	National Water Research Centre (MWRI).
OFWM	On-Farm Water Management
PPMI	Public and Private managed Irrigation
SC	Steering Committee
SVP	Shared Vision Program
SWERI	Soils, Water & Environment Research Institute
TAC	Technical Advisory committee
USAID	United States Agency for International Development
WRPMP	Water Resources Planning & Management Project
WMRI	Water Management Research Institute
WH	Water Harvesting
WUA	Water Users Association
ARC	Agricultural Research Centre (MALR)
AEZ	Agro-Ecological Zones

Local Terms, Units and Rates

- US$1 equal L.E. 5.5 Egyptian Pound
- 1 Feddan is about 0.42 Hectare (i.e. 1 Hectare equal 2.38 Feddans).
- 1 Ardab of Wheat is about 150 kg.
- 1 Ardab of Maize is about 140 kg.
- 1 Ardab of Rice is about 120 kg
- 1 Ardab of Been is about 155 kg
- 1 cutl. of Barseem is about 150 kg.
- 1 Kantar of Cotton is about 157 kg

N.B

This work is done for the "Efficient Water Use for Agricultural Production" (EWUAP) Project - Shared Vision Progamme (SVP) under the Nile Basin Initiative (NBI). The TOR requires the National Consultant to identify, list, document and describe Best Practices, profile sites of best practices, prepare inventory of institutions for twinning activities, and identify gaps in any existing guidelines in the areas of water harvesting and irrigation.

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OVERVIEW OF LAND AND WATER IN EGYPT

Egypt is one of the countries facing great challenges due to its limited water resources mainly because of its fixed share of the Nile water and its aridity as a general characteristic. Egypt lies in the north-eastern corner of the African continent, with a total area of about 1 million km^2. It is bordered in the north by the Mediterranean Sea, in the east by Palestine, Israel and the Red Sea, on the south by Sudan and in the west by Libya.

The total cultivated land has been estimated to be 3.5 million ha, or about 4% of the total area. About 88 % of the total cultivated area consists of annual crops and 12% of permanent crops. Agriculture accounts for about 17% of Egypt's GDP and provides employment for 38% of the labour force.

In its 2017 agricultural strategy (MALR/FAO 2003) the government emphasizes on the need to considerably increase the water use efficiency. Agricultural needs exceed 80% of the total demand for water. In view of the expected increase in water demand from other sectors, such as municipal and industrial water supply, the development of Egypt's economy strongly depends on its ability to conserve and manage its water resources.

Egypt prepared its first water policy after the construction of the Aswan High Dam in 1975. Since then, several water policies have been formulated to accommodate the dynamics of the water resources and the changes in the objectives and priorities. The most recent policy was drafted in 1993. It included several strategies to ensure satisfying the demands of all water users and expanding the existing agricultural area of 7.8x106 feddans by an additional 1.4×10^6 feddans. As the next century approaches, new strategies have to be adopted *(Egyptian National Committee on Irrigation and Drainage).*

Climate

The mean annual rainfall is estimated at 18 mm. It ranges from 0 mm in the desert to 200 mm in the northern coastal region. In many districts rain may fall in large quantities only once in two or three **years**. During summer, temperatures are extremely high, reaching 38°C to 43°C with extremes of 49°C in the southern and western deserts. The Mediterranean coast has cooler conditions with 32°C as a maximum.

Surface water resources

The Nile River is the main source of water for Egypt. Under the 1959 Nile Waters Agreement between Egypt and Sudan, Egypt's share is 55.5 km^3/year. The 1959 Agreement was based on the average flow of the Nile during the 1900-1959 period, which was 84 km^3/year at Aswan. Average annual evaporation and other losses from the High Dam Lake were estimated to be 10 km /year, leaving a net usable annual flow of 74 km^3/year, of which 18.5 km^3/year was allocated to Sudan and 55.5 km^3/year to Egypt. (**www.fao.org**).

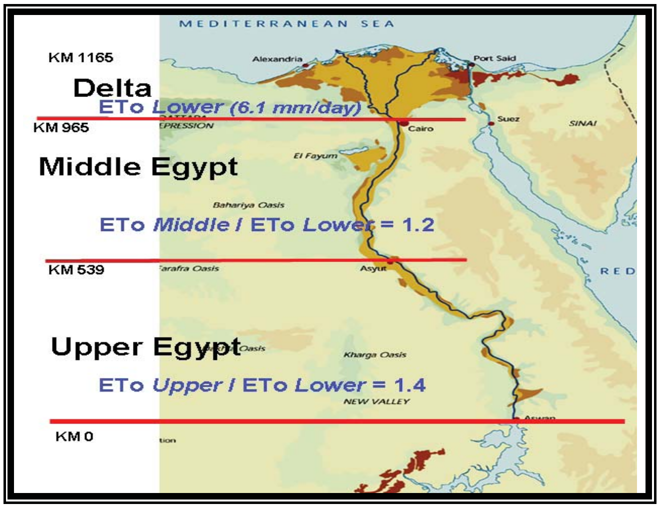


Figure 1. Climatic and Hydrologic regions

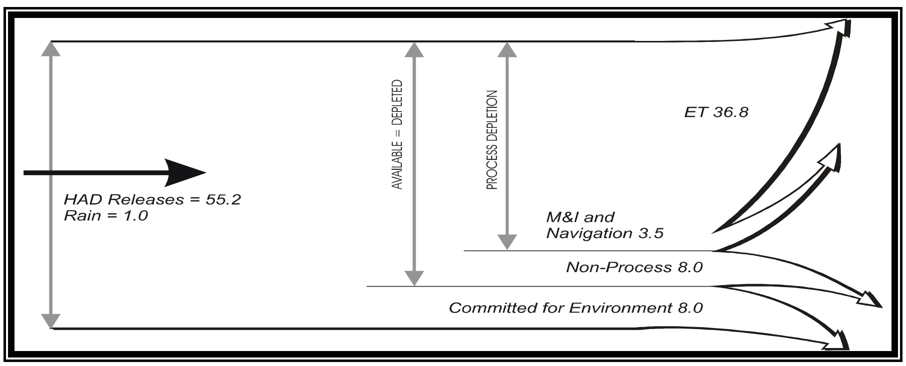


Figure 2. Water account for Egypt's Nile River based on 1993/94 water balance data.

Source: Molden et al. 1998

In a study on the use and productivity of Egypt's Nile water, Molden et al (1998) used the 1993/94 Nile water balance in order to prepare a water account, which is a methodology for revealing water use information at different levels. It was found that most of the water released from the High Aswan Dam is depleted (84%) and being put to productive use (process fraction 0.82).

In financial terms, each cubic meter of water delivered (gross) in agriculture returned US$0.16, which is classified as "quite good". The opportunities for water savings are restricted to capturing more drainage water. The potential for reuse is determined by the quantity of water (and salt) that is to be released to the Northern Lakes and the Mediterranean Sea.

The water resources include conventional and non-conventional water resources

- Conventional resources such as:
  - annual rainfall,
  - surface runoff and
  - groundwater
- Non-conventional resources such as:
  - Shallow groundwater

- Drainage reuse
- Treated Sewage
- Desalinated water

Table 1. Conventional and non-conventional water resources in Egypt.

Resources	Type of Water Source	Value
Conventional Resources	Annual Rainfall (million m^3)	18.100*
	Surface Runoff (billion m^3)	55.5
	Groundwater abstraction (billion m^3)	0.5
Non- conventional Resources	Shallow Groundwater abstraction (billion m^3)	5.0
	Drainage Reuse (billion m^3)	4.5
	Treated Sewage (million rn^3)	700.00
	Desalinated water (million m^3)	25.00*
Per capita share		926*

*Data from FAO Water Report 9, Irrigation in North East Region in Figures, 1997.

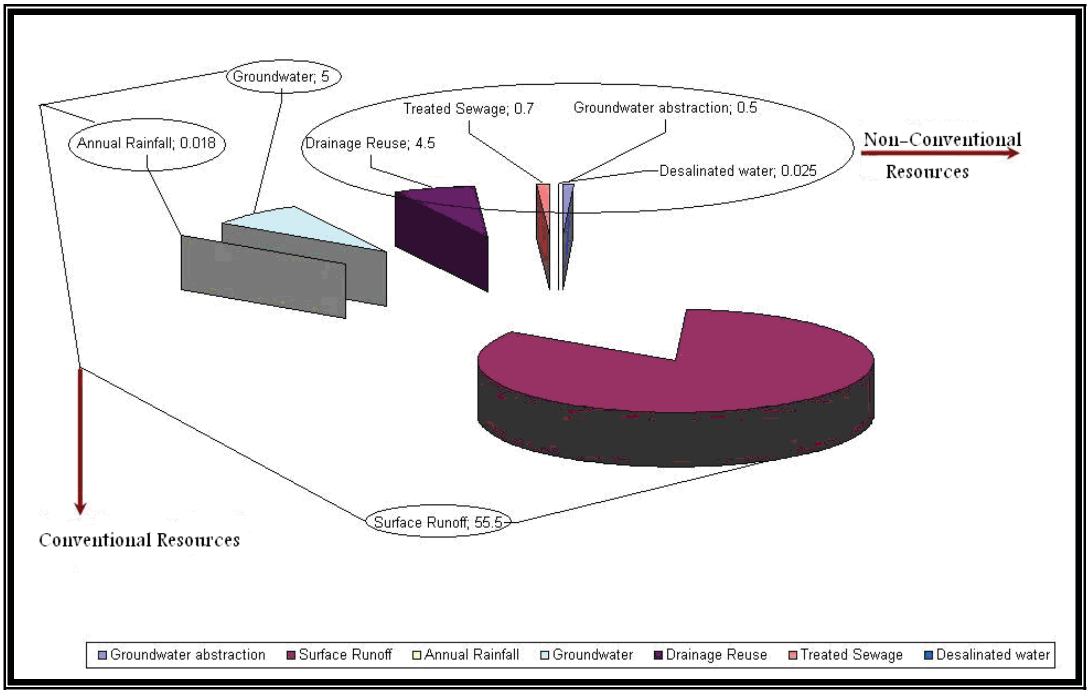


Figure 3. Conventional and non-conventional water resources in Egypt

There are a number of government institutions engaged in the development of the irrigation sector, of which the Ministry of Water Resources and Irrigation (MWRI) plays a dominant role. Other ministries include the Ministry of Agriculture and Land Reclamation (MALR) and the Ministry of Local Development (MLD).

2. INTRODUCTION

2.1. Challenges and Gaps in Water and Agriculture Sectors

The water and agricultural policies and strategies are affected by different natural conditions and human activities presenting challenges and gaps in the current operation of water and land sectors that include:

- Securing water and food supplies
- Meeting basic needs
- Valuing the water & Land
- Shared available resources
- High population growth rate
- Increased industrial and mining activities
- Lack of governmental funds to achieve proper maintenance and rehabilitation of system components
- Weakness enforcement of water related laws and regulations
- Governing resources wisely
- Protecting the ecosystems
- Managing operational risks
- Lack of users participation in system planning, designing, operation, and maintenance.

These challenges (gaps) delay the improvement of the system management and results in low water use efficiency and increasing conflicts among water users.

2.2. Irrigation system and Agricultural Practices in Egypt

The traditional irrigation system in the old lands of the Nile Valley is a combined gravity and water lifting system. The main canal system (first level) takes its water from head regulators, located upstream of the Nile's headwork. Water is distributed along branches (second level) where the flow is non-continuous. At the third level, distributaries receive water according to a rotation schedule. Water is pumped from these to irrigate the fields (about 0.5-1.5 m of lift). Under the new improved system, the level of tertiary canals (mesqa) is raised to above-ground level or set under pressure in order to allow for improved distribution along the canal. The rotational systems along branch canals are replaced by continuous flow.

A key feature of the Egyptian irrigation system is that the canals deliver water about 0.5-1.0 m below ground level, requiring farmers to lift the water onto their land. Lifting takes place at the head of the ditches (marwas), either from the sub-branches (mesqas) or, in many cases, directly from the branch canals themselves, most of which are illegal. In the past, lifting was carried out by mainly animal-driven water wheels (sakias) which were licensed by the Irrigation Districts. The sakia was a fixed installation whose sump was connected to the canal or mesqa by an intake pipe of specified diameter. The farmers' capacity to abstract water from the delivery system was thus restricted in terms of both number and location of lifting points and of discharge.

In particular, the need to share the use of the sakia with several other farmers in the same sakia "ring" and the limited discharge of the sakia, combined with the restrictions of the rotation system, meant that farmers were considerably constrained in terms of when and for how long they could irrigate.

Figure 4. Old Sakia in the Nile Delta

Figure 5. Private lifting Pump on old Meska (old practice)

Over the last 20 or 30 years, sakias have been progressively replaced by mobile diesel-driven pumps. Unlike the sakias, which were almost always collectively owned by the members of the sakia ring, most pumps are privately owned by individual farmers. However, a significant number of farmers do not own pumps, but have to rent them from others.

It is estimated that newly developed short duration rice varieties, coupled with water management changes, could reduce applied water by about 2,000 cubic meters and "save" as much as 1,000 cubic meters of consumptive use per-feddan. However, early planting of the winter crop (principally clover) would reduce these savings somewhat. Rice has become a very attractive crop to farmers, particularly with short season varieties that permit early clover establishment. The Ministry of Water Resources and Irrigation personnel unofficially estimated that rice cultivation expanded to about 2 million feddans in 1999, which would have exhausted most of the calculated water savings (MALR 2003). The above mentioned substitution possibilities for rice in the northern part of Delta are not easy to adopt. In the case of rice the environmental problems concerning the sea water intrusion should be considered carefully. In addition to these technical considerations, proper incentives should be given to farmers in order to change to proposed new activities.

In the command area, irrigation is commonly practised in basins. Although crops such as cotton, maize and beans are grown on ridges but these ridges are still within basins. The new BP activities in old land has included an on-farm irrigation management demonstration programme aimed at promoting measures to improve farmers' irrigation practices and water use efficiency, including land levelling, selective soil amendments and planting techniques.

2.3. Agricultural Production in Egypt

Crop yield and farm income are generally influenced by many factors other than one activity, e.g. water availability, water quality, on-farm management, agricultural inputs, etc. Successful evaluation of the impact of drainage on both crop yield and farm income is only achieved with site-specific and long time series of monitoring. Its results were generally positives in relation to increase in crop yields and farm income, (Monitoring and Evaluation Study of IIP in Old land-WMRI-NWRC 2005). According to the M&E study, annual farm income in the improved BP sites has increased from a level around 1400 LE to 2000 LE per feddan. Crop productivity levels in Egypt are relatively high when compared to the world standards, thanks to the highly productive soils, good climatic conditions, perennial source of irrigation water and relatively favorable irrigation and drainage services. Crop productivity of rice, corn and wheat are 9.4, 8.1 and 6.5 tones per hectare respectively (Agricultural Statistics, Crop Production, 2003). On the other hand, the productivity of water in agriculture is relatively good with a very high percentage of inflowing water being depleted and most of this depleted water being put to productive use (Molden and Sakthivadivel, 1999). However, the aggregate productivity of water can still be increased.

For cropping system intensification and/or crop development in Egypt, economic analyses show that there are differences in the total economic returns for different crops grown in Egypt. However, the value of certain agricultural products 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 a potential to improve the productivity of water.

2.4. Strategies of BP of Irrigated water

Farmers are expected to have better water delivery services so that they will receive the right amount of water at the time they need it. Consequently, crop productivity and farmers' return will improve. Although there might not be water saving through this process in some areas, stability of water allocation will provide water in the canal for farmers at the tail end who were formerly deprived of their fair share. Farmers complained of water shortages at the canal tail and relied on neighboring drains unofficially to complete their irrigation. Irrigation with deteriorated water affects crop productivity.

On the national level, an established system will be of great importance in the future, when most of the reclaimed lands are in operation. The water distribution system will be more complicated and better scheduling will be needed to prevent wasting water. Prior to the liberalization of agriculture, the MWRI has delivered water to farmers on the basis of indicative cropping patterns and calendars determined by the MALR. Water releases from the High Aswan Dam (HAD) are based on these "indicative" cropping patterns and calendars, which are often released months in advance of real planting dates.

Frequently, they are not accurate representations of the actual crops grown. Liberalization and farmer free choice have resulted in much more uncertainty about actual irrigation water demands. Cases of significant "mismatch" have occurred. In some cases, large amounts of water (sometimes millions of cubic meters) were delivered but not used, while at other times water has not been available to farmers when needed, causing a reduction in agricultural production. The MWRI has identified several specific situations that give rise to mismatching, which can be grouped into three general categories:

1. Under- or over-estimating crop water demands under free cropping choices, including cropping patterns and calendars.

2. System constraints, such as canal capacity, system storage capacity, and lag time between water releases from HAD to the farm.
3. External factors, such as climatic change and unanticipated drainage water reuse.

Water shortfalls have resulted from lack of information about cropping patterns and calendars, and from cropping patterns and calendar selections by farmers that are not consistent with the ability of the Nile system to deliver adequate supplies when needed. Information on crop selection and the dates of planting and harvesting is essential for good water management. However, there is no routine, accurate, and systematic transfer of this information from farmers or the MALR to the MWRI; nor is there an understanding of system constraints on the part of the MALR and the farmers. Both ministries are recognizing that matching real-time irrigation water demands with water deliveries is an important step toward an efficient, demand-driven irrigation system.

The specific expected impacts of current MWRI/MALR strategies are:

- Development of strategies to balance irrigation water demand with water supply.
- Establishment of better collaboration between farmers, the MWRI and the MALR for determining actual real-time irrigation demands at the directorate and district levels.
- Establishment of a national policy for managing the transfer of real-time information about water supply and demand.
- Improvement of the Nile system operations, which are critical to the Egyptian agricultural economy.
- Movement toward a real-time, demand-driven water distribution system.

Reducing the agricultural water consumption can be seen as an effective measure for increasing water productivity. The gradual replacement of sugarcane with sugar beets, the reduction of rice-cultivated areas, the replacement of currently used varieties of rice with shorter life rice varieties which have higher productivity and less water requirements due to their shorter lifetime, the development of new crop varieties using genetic engineering that have higher productivity and less water consumption, and the design of indicative cropping patterns are all effective means for increasing water productivity.

In view of the increasing water demands and the limited possibilities to develop additional resources, water resources are becoming scarcer and efforts should be made to increase the efficiency of the available resources. Measures should be identified to reduce water losses by different users (small scale projects) and sectors (large scale projects), and to augment and optimize the use of water and Land.

Water and Land management can be better performed through an integrated package of resource utilization and institutional arrangements at the local level, or at the irrigation district level in Egypt's case. However, the current Nile water allocation is decided at the ministries central departments and commanded at the lower irrigation inspectorate and district levels. Lower level offices have rare coordination or consultation. Strengthening district management capacity to utilize all available resources and decentralizing the current MWRI/MALR top down administration structure will need reforms.

The efficiency and effectiveness of the stakeholder participation process could be highly improved by identifying the different interests of the stakeholders including their abilities and also the limitation of stakeholders to contribute to the implementation of the national water policy. Thus, main performance indicators could be outlined by the MWRI/MALR to measure the degree of success of the implementation of the various measures of the strategy.

The Delta lands soil is predominantly alluvial-clayey soil, black to brown. As expected with such type of soil, the rate of soil permeability is fairly low and the hydraulic conductivity is less than 0.1 cm/hour in the soils' surface. The soil salinity generally degrades from normal to very high from upstream to downstream while groundwater table ranges from 70 to 120 cm.

The majority of the farmers in the command area cultivate five feddans or less. Farm holdings between five to ten feddans represent a small percentage while those that are larger than 10 feddans are minor. The intensity of cropping in the area is almost 200 percent which means that the whole area of land is approximately cultivated both in winter and in summer. Berseem (long clover), beseem (short clover), wheat and broad beans are the main crops cultivated in winter besides the winter vegetables and some perennial crops. Cotton, rice and maize are the main crops in the summer season besides water melon seeds, summer vegetables and some perennial crops. Crop yields in the area show generally high figures. The average cotton yield is 2.4 ton/ha, while the average rice yield is 6.5 ton/ha. The average wheat yield is 4.3 ton/ha, while the average broad beans yield is 2.4 ton/ha.

3. SCOPE OF WORK AND METHODOLOGY

3.1 General

The current study involved performing a desk review of documents, consulting experts and resource persons, and carrying out field visits to some selected sites to provide an overview and overall picture of the existing best practices activities in such sites. Institutions with capacity for partnering in future activities related to water harvesting, community managed irrigation and public private irrigation with greater emphasis on efficient water use and productivity of water were considered. Most of the information collected in terms of best practices as well as the potential institutions was reviewed after the appropriate ministries, international agencies, institutions of higher learning, national, regional and international research organizations were consulted.

The study requirements are to cover the following EWUAP project's three main components in the country:

(i) Water Harvesting (WH)
(ii) Community-Managed Irrigation (CMI)
(iii) Public/Private-Managed Irrigation (PPMI)

The report is to provide an overview of the current status in the country regarding water and land BP activities and to elaborate upon the RBA study to establish a list of sites suitable for illustrating best practices for all the three main Components. The purpose of the BP activities is to identify sites where interventions can be considered successful and that could possibly serve as examples of best practices associated with efficient water use in the sector for wider dissemination and training. The selected sites cover the full range of technologies under different Agro-Ecological Zones (AEZ) in Egypt's conditions.

A fact sheet and details on each of the identified and recommended BP sites were used following standard formats given by the PMU. Maps of the AEZ and definitions or properties that are used in the country were considered to provide a list of selected CMI, PPMI and WH schemes and an inventory of organizations involved including type of intervention and location.

The definition of small-scale, medium scale and large-scale irrigation and water harvesting, within the country are provided for the possible BP sites. The classification adopted is in agreement with the nationally accepted criteria and indicates the level of involvement of public, community and private sector in each considering ownership, management, O&M and crop production. For the case of Egypt, the following classification is used to differentiate the scale of irrigation scheme as small, medium and large scale irrigation:

- Irrigation Scheme ≤ 450 Ha. is considered small scale irrigation scheme;
- Irrigation Scheme ≥ 450 ≤ 4500 Ha. is considered medium scale irrigation scheme;
- Irrigation Scheme ≥ 4500 Ha. is considered large scale irrigation scheme.

The PMU has developed draft criteria for defining best practices. In general this includes those sites that are sustainable and could be used to show a wider scope of the technical, management, economic and social issues involved. A simple matrix is prepared showing why the schemes have been selected and a ranking process developed to reach the priority list of BP sites.

3.2 Study Outline

The study will focus on the following points:

- Inventory analysis using the design format
- Full characterization of sites and associated problems.
- Review of available information on water/land use efficiencies.
- Review of current policies and institutional setups.
- Field assessment at selected locations (CMI, PPMI and WH), to generate data required for modeling Water and Land productivity and sustainability, and observe the gaps in the available information for improvement.
- Evaluation monitoring and assessment of the adoption and impact of potential options and intervention.

3.3 Selection Criteria

The main criteria for consideration of a BP site:

- The case study from where BP are profiled have delivered proven successful results to the agricultural production in terms of benefits both to the local population and to the ecosystem and demonstrating the level and extent of community participation in the operation of such project.
- The BP should enhance the understanding of the potentials and constraints of CMI, PPMI and WH for improving the agricultural production.
- The BP selection process should consider/involve different AEZ environments to capture (to the extent possible) the range of variation that may exist in a given region.
- The BP selection process should be supported with the availability of baseline data which could be used to assess and verify the changes/improvements realized in productivity of water and land due to the interventions.
- The BP activities should have the potential for scaling up.
- The BP should be well adopted and owned/operated by the local community and have a proper link with the local Government (if any).

3.4 Selection process

Principal steps for Identifying BP Sites:

1. Initial analysis of the current operational situation;
2. Identification of current land and water control systems and possibility of improvement;
3. Value-oriented stakeholders and institutional assessment/needs;
4. Participatory assessment of problems and opportunities;
5. Expected participatory impacts of project's sustainability;
6. Evaluation.

Table 2. Identification of BP Sites (CMI, PPMI and WH)

Step	Description	Purpose
Step 1	Initial appraisal of the current operational situation	• To identify problem areas within and outside the site area, to describe the issues and provide first evidence of their severity and magnitude; • To approach the problem areas taking a multi-disciplinary perspective.[1]
Step 2	Identification of current land and water control systems and possibility of improvement.	• To identify landscapes and control systems that affects or is affected by project's activities.
Step 3	Value-oriented stakeholders and institutional assessment/needs.	• To identify the current stakeholders and institutions and its resolution. • To identify stakeholder values associated and measure the level of their involvement in the process according to their level of interested.
Step 4	Participatory assessment of problems and opportunities.	• To identify/analyze a core problem, its causes and effects on landscapes and control systems performance either for small or large scale projects • To identify/describe opportunities and possible water management and land interventions taking into account the technical, managerial and institutional aspects.
Step 5	Expected participatory impacts for project sustainability	• To anticipate current and future changes concerning landscapes (natural resource and functions) and control systems categorized as primary, secondary and higher order to improve water/land use in the site • To investigate possible extension and the proposed link with local government.
Step 6	Evaluation	• To assess the impact of proposed water/land management interventions and identified changes on economic, marketing, social, health and environmental values of the stakeholders and the expected return to beneficiaries. • To appraise the appropriateness and social acceptance of proposed interventions against goals of the society.

[1] Disciplines involved include natural resource management, staff, institutional aspects, agronomy, socio-economics, and environmental aspects.

3.5 Main Activities

The following activities were considered within the context of the study objectives:

- Review the given draft criteria of potential for BP (by PMU) in the context of Egypt's case using the three main project components and finalize criteria for BP to prepare the required prioritized list of sites and schemes for different sizes for (CMI, PPMI and WH);

- Collection of the required basic data from different sources to support the preliminary identification of the sites and to confirm the long list of best practice sites;

- Identify the range of technologies and criteria in each site as BP to establish a long and final shortlist for the country including the three components as for training purposes both nationally and within NBI;

- Evaluate impact of the techniques on overall efficiency of water use in agricultural production by providing support data and assessments (if needed);

- Prepare a detailed description (fact sheet) for the agreed format. The sheet covers basic technical and physical details of the site, before and post project intervention situations including such key indicators as water use and productivity, management, operation and maintenance of the systems. The sheet also answers why this site has been successful, and why it has been chosen to illustrate BP and the lessons learnt that can be applied to other areas. The target is to observe the BP site from the real-picture in the ground field and its application/operation and obtain real opportunity and constraints for possibility of up-scaling this practices (national and regional);

- Analyze and identify any gaps within existing sites on WH, CMI, and PPMI either in its implementation or operation and institutional set-up and suggest proposals for completing the guidelines to be BP example;
- Evaluate limitations and opportunities of the described techniques for scaling up;
- Following the workshop proceedings, finalize the details on best practice sites taking on board the results of the workshop discussions and the review of the initial reports and presentations made by EWUAP-PMU; and
- Identify, list, and describe potential institutions to be used in organizing and conducting capacity building activities in the fields of water harvesting and irrigation listing their experiences and possible cooperation with EWUAP.

The following table summarizes these activities:

Table 3: Outline of main activities during identification of BP sites

Activities	Remarks
Preparation of detailed work plan	Tasks carried out through literature survey, discussions with all stakeholders; review of data and reports and as a desk study.
Review the draft criteria of potential for best practices	
Finalize criteria for BP in country and prepare a system for ranking and prioritizing of sites and schemes;	
Collect additional basic data from secondary sources	
Identify range of technologies/best practices and criteria to be included in BP sites	
Evaluate impact of the techniques on overall efficiency of water use in agriculture production	
Evaluate limitations and opportunities of the described techniques for scaling up;	
Discussions on potential BP sites with responsible organization and donor	
Site visit to selected BP Sites	Visits to the selected number of key BP sites for different techniques & conditions for CMI, PPMI and WH.
Confirm short list (fact sheet) of each BP sites & prepare a final shortlist of potential sites by Component (WH, CMI, and PPMI) & prepare detailed description for each of the short listed sites according to an agreed checklist.	The given format guidelines (excel sheet) are followed and used.
Analyze and identify gaps within existing guidelines on WH, CMI, and PPMI and considering the in-country experiences;	Direct contact with different stakeholders and local Gov.
Identify, list, and describe potential cooperating National (public and private) Institutions for field level demonstrations and dissemination of technologies/best practices	
Prepare data, findings & draft	Finding were presented during the Inception workshop
Finalize the NC report (supported by annexes) with details on BP sites taking into considerations the results of discussions and EWUAP/PMU feedback.	

3.6 Study Targets

The following points summarize the outcome of this study:

- Documents that identify and prioritize (with respect to water/land resources) the constraints to optimum utilization and sustainable production;
- effectiveness on existing policies on allocation and efficient use of scarce resources in the selected sites;
- Find out the gaps in information that need to be bridged by the project activities;
- Impact of potential options/interventions of introduced techniques;
- Providing information that will be used for developing package recommendation to increase water productivity; and
- Assessing the impacts and consequences of alternative policies on water use efficiency, institutional impact, food security and social impacts with possibility for scaling up these activities (national and regional).

4. AGRO-ECOLOGICAL ZONES IN EGYPT

4.1. Conditions of Egypt Case

The rapidly growing country population puts considerable pressure on the scarce natural resources, and there is an urgent need to develop more efficient and sustainable agricultural production systems in the country. This should be based on an initial assessment of the physical and biological potential of natural resources, which can vary greatly. The hydro-ecological zonation (HEZ) and the agro-ecological zonation (AEZ) approach presents a useful preliminary evaluation of this potential, and ensures that representation is maintained at an appropriate bio-geographic scale for regional sustainable development planning.

The UN Food and Agriculture Organization produce this AEZ in each country to assess the crop production potential and length of the growing period zones. It is very useful as it describes an area within which rainfall and temperature conditions are suitable for crop growth for a given number of days in the year. These data, combined with the information on soils and known requirements of different food crops, can be used to assess the potential crop productivity. Some perspectives on AEZs and crop production potential are presented by describing the manner in which production potential can be integrated with present constraints. Efforts to intensify production should place emphasize on methods appropriate to the socio-economic conditions in a given AEZ, and on promotion of conservation-effective and sustainable production systems to meet the food, fodder and fuel needs for the future.

4. 2. Desertification in Egypt

Egypt has total area of about one million kilometers, under arid and hyper arid climatic conditions, of which only a small portion (3% of total area) is agriculturally productive. The country is endowed with 4 main agro-ecological zones having specific attributes of resources base, climatic features, terrain and geographic characteristics, land use patterns and socio-economic implications.

Such zones are identified as follows:

1. North Coastal Belts: including North West Coastal Areas and North Coastal Areas of Sinai.
2. The Nile Valley: Encompassing the fertile alluvial lands of Upper Egypt and the Delta and the reclaimed desert areas in the fringes of the Nile Valley.
3. The Inland Sinai and the Eastern Desert with its elevated southern areas.
4. The Western Desert, Oases and Southern Remote Areas: including East Owenat Tock and Drab El Arabian Areas and Oases of the Western Desert.

Since significant variations in the environmental characteristics are apparent in each agro-ecological zone, the active factors and processes of desertification, and their impacts are necessarily variable. It is of interest to note that baseline data, essential for proper monitoring of programs and projects and its contributions to combat desertification in Egypt are already available. Mapping areas affected by soil erosion and some other desertification causes will be presented. Such approach would facilitate the investigation and identification of appropriate techniques, capacity building needs, stakeholder participation, required legislation, economic tools, incentives, finance, as well as social implications.

This approach would also help to define institutional setups and responsible parties. It would also facilitate the identification of suitable indicators for desertification processes, as well as, appropriate techniques for monitoring ongoing and future desertification processes in each of these agro-ecological zones. This approach will also ensure that the identification of projects, research needs and public awareness campaigns is geared and tailored for the needs of each agro-ecological zone.

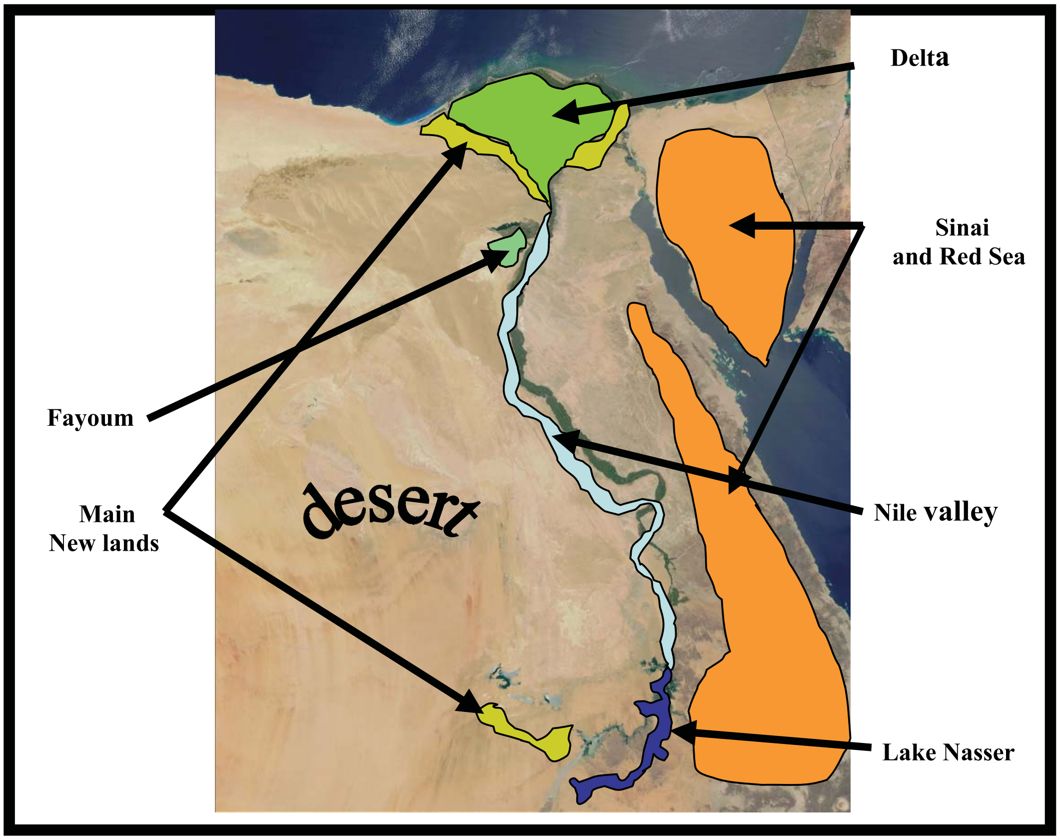


Figure 6. Agro-ecological zones in Egypt

Table 4. Hydro-Ecological Zones and Agro-Ecological Zones

Name	Typifying land parameters	Typifying water parameters	Main management concerns
Lake Nasser	n.a.	volume; water level;	• storage and release of water; • spilling peak flow
Nile Valley	rather flat clay soils impervious subsoil	artificial water supply; medium groundwater depth; fresh groundwater;	• pump irrigation • Preventing drainage to river • new crop Varieties
Fayoum	Steep slope ; clay soils	shallow and stagnant groundwater; inflow of surface irrigation water;	• irrigation by gravity • drainage to lake Qarun • water quality • Environmental activities
Delta	flat; clay soils;	fresh to saline groundwater most surface water from Nile	• pump irrigation • Improvement of old land • On-farm management • sub-surface drainage • water quality management • salinity control • water depth for navigation
New Lands	flat to heaving sandy soils	• saline groundwater • all surface water from Nile	Main management concerns
Sinai and Red Sea	hilly to mountainous; steep slopes; sandy/rocky soils	• some rain • flash floods	• storage and release of water; • spilling peak flow
Desert	sand dunes	• deep ground water	• deep wells for irrigation; bottled

		• fresh or saline	water • Industrial activities

4.3. Basic Features of Main Agro-ecological Zones

North Coastal Areas

The North Coastal areas of Egypt are composed of two major sub-zones; Northwest Coast and the North Coastal Areas of Sinai.

a) Northwest Coast

The Northwest Coast of Egypt forms a belt about 20 Km long, which extends for about 500 Km between Amria (20 Km west of Alexandria) and El Salloum near the border with Libya.

Main Climatic Features

The North West coast (NWC) is characterized by dry Mediterranean climate, with average high and low temp of 18.1 C^o and 8.1 C^o in the winter and 29.2 C^o and 20 C^o in the summer, respectively.

Rainfall in the Northwest Coast ranges between 105.0 mm / yr at El Salloum and 199.6 mm / yr at Alexandria; data from eight stations situated near the coastline show that most of the rainfall (70% or more) occurs within the winter months (November to February), mostly during December and January .

There is significant variation in rainfall from one location to another, which is attributed mainly to the orientation of the coast at these locations. The prevailing rainfall gradient from north shows that the average mean decreases sharply from 150 mm near the coast to 50 mm at 20-70 Km inland.

The NWC area has the highest average wind speed in Egypt in the winter where wind speed could reach 18.5 Km/hr. Wind speed drops gradually inland.

Soil and Water Resources

Soil types and properties are highly influenced by geomorphic and pedogenic factors. The main soil units can be summarized as follows:

- Coastal oolitic sand dunes.
- Soils of the lagoon depressions.
- Consolidated dunes.
- Deep sand and clay loam soils.
- Moderate to limited depths of sandy to clay loam. Wind blown formations.
- Soils of the alluvial fans and outwash plains over the plateau.

Water resources are mainly that of rainfall, groundwater resources are limited and usually of low quality especially with respect to varied salinity content.

b) North Coastal Areas of Sinai

Physiographic characteristics

The northern strip to a length of about 5 Km from the shore line has a very gentle slope in south / north direction reaching about 20 m ASL in the southern parts. Then a medium slope develops towards inlands reaching elevations of 90 m ASL. Physiographically North Sinai sub-zone is characterized by the Tina Plain in the east which is formed of Nile alluvial deposits in the lowest lying areas of Sinai. In the middle is the Bardaeweel lagoon (Shallow Lake). South of Bardaweel extends desert plains with large areas of sand dune belts and sand sheets. The eastern parts of the coastal areas have the highest average rainfall in Egypt. It is dissected by the largest wadi in Sinai, Wadi Al Arish, which emerges from elevated gravelly plains and terraces in the south to a distance of about 20 Km till the Mediterranean Sea coast.

Climatic Features

North Sinai areas are characterized by the dry Mediterranean climate type with relatively rainy, cool winters and dry hot summers. Air temperatures are similar to those of the NWC but with large variations diurnally, seasonally and geographically. The annual wind speed is around 14.0 Km/hr and the prevailing wind direction is north- west and north.

The amount of rainfall in Sinai decreases from the north-east towards the south-west with the greatest amount of rainfall being found in Rafah (304 millimeters / yr.) in the north-east. The annual average along the Mediterranean coast amounts to 120 mm / yr. Rainfall decreases in the uplands to the south to about 32 mm / yr. On the whole, the average annual rainfall in the entire Sinai Peninsula is 40 millimeters , of which 27 millimeters are estimated to come from individual storms that may provide 10 millimeters at a time.

Rainfall occurs in Sinai mainly during the winter season (November to March) and during spring or fall. Rainfall is practically absent from May to October. Along the Mediterranean Coast, 60% of the rain occurs in the winter, while 40% falls during the transitional seasons. Due to differences in water availability, growing seasons differ in the different parts of the Governorate of North Sinai.

Soil and Water Resources

The desert soils of northern Sinai, are of three different origins: Aeolian, alluvial and soil formed in situ. The latter is related to land form and is found in the plateau region of Wadi Al-Arish on either calcareous or volcanic parent material.

The majority of alluvial soils were formed under recent climatic conditions. They constitute the present wadi beds and they are characterized by a granulometric differentiation according to flood intensities and sedimentation times. As a consequence, soil in the upstream of the wadis is coarser in texture than the soils further downstream. In the dune area the soils are generally different than in the gravel plain. The dune area is dominated by soils with almost no signs of soil forming processes. Saline soils are found exclusively in the coastal zone. Haplic calciosols are dominant in the desert region in the gravel plains . The Tina plain in the west was formed of alluvial Nile deposits as a natural extension of the old Nile Valley. The soils are heavy textured with high salinity contents due to water logging condition attributed to the near-sea and low lying location.

Water resources are varied with Rainfall runoffs if the rainfall exceeds 10 mm per rainy storm. When runoff occurs wadi beds will begin to carry water depending on the amount and duration of rainfall. It is estimated that 60 percent of the mean rainfall in Sinai is lost to evpotranspiration.

Groundwater in Sinai may be classified into two types. Shallow groundwater, occurs mainly within weathered layer of igneous and metamorphic rocks, quaternary rock, recent deposits such as wadi fill or sediments and sand dunes. Deep groundwater mainly occurs as semi – confined aquifers of per-Quaternary formation. Groundwater resources in the North Coastal area are limited in nature and in general of low quality. A third water resource is being introduced to the area, namely " Al Salam Canal" which will convey mixed Nile and agricultural drainage water across the Suez Canal to reclaim 400,000 feddans in Northern Sinai

Socio-economic Constraints

There is little organized marketing of agricultural commodities produced in this zone. Private traders are able to exploit the situation to their advantage. The principal agricultural outputs are lambs, cull stock, fig, and olive oil. There is little structure of the market system and producers tend to sell on an individual basis to a trader. Wool producers receive a poor price because wool is presented for sale in a dirty and upgraded condition and frequently contains sand and foreign matter. There is also an urgent need for small – scale industries to process the rapidly expanding production of fruit, vegetable, and olives for oil. Agriculture development in the governorate Marsa Matrouh has been constrained due to insufficient financial support. The extent of credit for agricultural activities remains minimal.

The Nile Valley and the Reclaimed Desert Fringes

This agro- ecological zone represents the greater majority of cultivated lands of the Nile Valley, as well as, most of the reclaimed desert lands , mainly, on the western and eastern fringes of the Delta in addition to relatively limited areas on fringes of the Valley in Upper Egypt; (Total area over 7.5 million feddans).

The Nile Valley system is one of the most ancient agricultural systems in the world. It represents the most fertile lands in Egypt and probably in the whole region. It is also the most densely populated area in the Middle East region. Agricultural products are highly diversified and intensive cropping system is practised all year around. Despite the high significance of this sub-zone to food security, trade balance and economics, yet it has been the subject of several desertification factors and processes through the last few decades. Some of these factors and processes have been dealt with through technical and legislative measures which resulted in significant decline of adverse impacts.

Geomorphology

The Nile Valley system extends from the Mediterranean shores of the Nile Delta to the North till Aswan in the south over an area extending from 22 - 32 latitude North under arid and hyper-arid conditions.

Soil and Water Resources

The most pronounced feature of this agro-ecological zone is the Nile River which provides Egypt with 55.5 billion m^3/year with its magnificent High Dam providing perennial storage of excess Nile water and Lake Nasser Nabia representing the largest man-made fresh water lake which is about 500 Km south of Aswan beyond the Sudan. The old Nile water conveyance system is still functioning with additional major canals conveying fresh Nile water to the newly reclaimed desert soils in the fringes of the Valley which are of relatively higher elevations. Sizable amounts of the agricultural drainage water of the old Valley are recycled in the conveyance system and mixed with the fresh Nile water to be used for horizontal expansion of cultivated areas. Groundwater (mostly recharged by the Nile water) is of relatively limited use in the Valley but is specially used in the desert fringes.

Soils vary but include the fertile deep alluvial soils of the old Nile Valley, soils of the river terraces at different reliefs which are deep soils with gravelly and reddish sub-soils in addition to the soils of the fringes including desert calcareous soils of varied textures and non-calcareous soils characterized with low soil fertility and inferior soil physical, chemical and biological properties.

The Inland Sinai and the Eastern Desert

It extends to north of the southern region, from which it is separated by a huge depression stretching in a N- SE trend as far as about 60 Km. This depression which averages 10 Km width opens from northwest . It is influenced by several drainage systems. These systems include Gulf of Suez system at the western and south western sides. Gulf of Aqaba system at the eastern and south eastern fringes. Perennial channel overflow takes place at several wadis dissecting the western and south western fringes of El Tieh table land.

It occupies the central portion of El Tieh table land. To the west, it is limited by the upstream portion of W- Al Arish and its tributaries. This excavation stretches in a NW-SE direction for about 40 Km attaining about 15 Km width at bir El Malha area. Due to this depression both Egma and El Tieh table lands are completely separated. The surface of this table lands is intensively dissected with drainage lines, flow towards north, and joining together into W. Al Arish.

The eastern desert is comprised of the following landforms.

- ✓ The high Rocky Mountains: Generally, the surface of the Eastern desert is very rugged and rises in some places to more than 2000 m ASL especially in the southern areas.
- ✓ The desert floor: it is covered with countless sounded highly- polished pebbles of brown flint or white quartz, materials brought down by ancient streams and spread out near the former shore-line.
- ✓ The drainage channels: They are intensely dissected by valleys and ravines and all their drainage are external. Most of the drainage lines run along major fault lines, and it is noticeable that while the eastward drainage lines run to the Red Sea by numerous independent wadis, the westward drainage lines run to the Nile Valley . Coastal mountains form the water divide.

The plains Soils

They represent the plain that covers the whole area of Sinai; El Gifgafa, El Qaa and the plain located east of Suez Canal. They have a fine to moderate, texture, moderately saline and have agriculture utilization potential. The soils of Eastern Desert differ widely according to their contribution in the landforms.

Water Resources

Despite the very low rainfall over this zone the geomorphic factors combine with the intensity of infrequent rain showers to form flash floods which have definite adverse environmental impacts on infrastructure, soil- erosion and installations before being lost to the adjacent marine areas.

The Western Desert, Oases and Southern Remote Areas

The available land resources in this zone are of weak characteristics and low resilience with wide spread physical, biological and chemical limitations. Most of these resources are located in a closed fragile ecosystem which is isolated from the Nile Valley System. Management practices and utilization of those resources for agriculture and desert development should maintain these ecosystems free from invading pests and non desirable weeds and plant species, through the application of proper and integrated conservation practices. Conservation of the indigenous flora and fauna with the preservation of the valuable genetic resources and species adapted to the harsh environment and hyper-aridity of this zone represent an important means of combating desertification. Rational use and reuse of water resources is imperative due to the enclosure of the ecosystem and the need to deal with excess drainage water in non-conventional ways, other than the traditional systems of the old Nile Valley, would be of paramount significance to prevent the presently prevailing conditions of water logging and salinization of soil and water resources.

Geomorphology

The Western Desert extends from the southern boarders towards the Northwest Coastal areas in the North as a massive plateau with a general slope towards the north , starting from an elevation of about 1000 m asl to the extensive Qattarah depression at 134 m below sea level. The western plateau is distinguished with a uniform flat surface 40% of which is covered with sand dunes and extensive areas of sand sheets (The sand sea). Several depressions of varied areas are scattered in the western desert including the famous oases of Siwa in the north, Baharia and Frafra in the central section, Dakhla and Kharga in the south. These Oases that are distinguished with artesian wells of large discharge of fresh water are mainly closed, and fragile ecosystems where population is concentrated.

Climate

This ecological zone is characterized by hyper-arid climatic conditions with rare rainfall and extreme temperatures. The winds over the western desert in north western or northern direction extend from the Mediterranean over the western desert with fallen speed.

These winds are the major factors of erosion and deposition processes in the western desert. A clear evidence of these processes is the formation of the great sand sea by the eroded sediments of the Qattarah depression located in the north.

Soil Resources

The soils have been classified as weakly developed Red Desert soils which have higher chrome than typical Red Desert soils and they have a very thin or no A-horizon. The formation of these soils is from a number of parent materials, indicating that the hot dry climate was the main soil forming factor that is responsible for the characteristics of these soils as Red Desert soils. The soils are formed of sand and are calcareous in nature.

Water resources

Water resources are mainly those of the huge Nubian sandstone aquifer that extends with varied thickness in the majority of the Western Desert area. This major water resource is of excellent qualities in most areas. The renewability of the resource was investigated extensively with conclusions confirming a non-renewable or very slowly renewable status. However, in view of huge water resources available in this aquifer a macro developmental plan of East Owenate area is being implemented.

Socio-Economic Constraints

The present population and communities are scattered with low educational background. Although skills and handcrafts are available, however, technological skills to address the needs of development activities are rare. There are definite needs to create incentives to reverse the present migration trends toward urban centers of the Nile Valley in addition to the attraction of human resources to migrate to the newly developed areas in the Western Desert.

4.4. Conservation of Water and land Resources

The long standing traditions of rotational use of fertilizers in the old fertile valley soils was altered after the construction of the High Dam under the wrong impression that the lack of sediments load in the Nile water due to the construction of the High Dam will lower the fertility of the Nile Valley soils. This wrong impression led to the extensive use of chemical fertilizers, pesticides and agrochemicals amendments.

The extensive use of nitrogenous fertilizers led to excessive leaching of nitrates to the water table and further to the groundwater resources. The produced food products could be contaminated with pesticide residues and rejected as export commodities. Health and environmental hazards are serious threats to the humans, animals, flora and fauna with adverse effects extending to the main areas where drainage water is discharged.

The Ministry of Water Resources and Irrigation has been involved in continued activities to achieve improvement of drainage conditions, conservation of irrigation water in quantity and conservation of the shorelines. The following is a summary of the major activities bordering on the implementation of projects of open and tile drainage to prevent the degradation and desertification of the productive soils. These projects are of particular significance after the construction of the High Dam with perennial irrigation and cropping patterns of more than one crop per year.

Conservation of water resources

- Establishing numerical and geographical databases for ground water and water resources of relevance.
- Development of innovative techniques for water harvesting and conservation of flood waters in varied locations in Egypt.
- Formulating regulations for the reuse of wastewater and means to protect ground water and other water resources from pollution.

Combating of seawater intrusion

The following activities are being carried out to protect the shore-line areas of the Delta and certain important locations along the North-Western Coastal areas from sea water intrusion for the prevention of salinization of the productive agricultural soils and the conservation of the sea shore-line.

- Protection of Rashid shore-line.
- Protection of Balteem shore-line

One of the main constraints facing efforts to combat desertification is the lack of national or local financial resources to pay the highly needed financial support to these activities. Even the provision of seed money in many cases would secure the initiation of local action by the local stakeholders.

Special consideration and field activities should be geared towards conservation and utilization of the highly valuable genetic resources.. Such activities are the subject of considerable financial support from donors concerned with environmental issues. The integration of such activities with appropriate resource management and utilizations practices could provide considerable boosting of the income of local stakeholders and alleviate poverty, and provide added job opportunities, in addition to provision of export commodities produced by the multipurpose plants of high economic returns.

4.5. Institutional and Participatory Aspects

Within the last five years several environmental laws have been passed concerning pollution of land, water and air in addition to the environmental impact assessment for all developmental activities. - In general adequate legislations were passed; however, appropriate mechanisms to improve and enhance the adherence to this legislation are needed.

Formulation of activities of the National Development Strategies is based on adoption of the integrated approach to address the main factors of desertification involved in addition to securing and adoption of the participatory approach of the pertinent stakeholders in the varied stages of execution including planning, initiation and implementation with possible financial contributions of the beneficiaries. To successfully achieve the objectives of the previous item, activities for combating desertification are based on the objectives to be achieved within each of the agro–ecological zones.

This is based on the interrelationship of the factors and processes of desertification within a given agro-ecological zone (National Action Plan for Combating Desertification, Desert Research Center-April 2002).

prioritization of the future action plans to combat desertification for the short, medium and long term based on the definition of hotspots, significance of adverse impacts on productivity of resource base, economic losses and social implication especially with respect to alleviation of poverty and enhancement of the role of women and youth and their participation in the coordinated efforts to combat desertification is essential.

Coordinate and complement the activities of the several national institutions having the capabilities, equipment and expertise to carry out the badly needed efforts for proper assessment and monitoring of desertification processes in the four agro-ecological zones in Egypt.

4.6. Other Environmental Conventions in Egypt

Other main activities are the erosion of coastal line of the Mediterranean Sea, cleaning up of the northern lakes, conservation of biodiversity and ecological system of representative islands (Over 150 islands) in the River Nile of Egypt and lately the combined programs for capacity building and training for the three major conventions.

To cope with the national development strategies, it is of significance to point out that among the main functions of the National Coordination Committee, after its reformulation under the leadership of executive authorities, is to incorporate where appropriate, the various activities for combating desertification in the national development five years plans on the short, medium and long term basis.

It was very useful to integrate these activities in terms of time, location and scale. Analyses and lessons learned from the on-going activities and the hotspots pointed out the gaps to be covered by future activities.

5. IDENTIFICATION OF BEST PRACTICES AND TECHNOLOGIES IN IRRIGATION

5.1. On-Farm Water Management Experience in Egypt

The Egyptian farmer is habited to practice, by experience, some of the OFWM activities of long time ago, such as using some indicator plants to decide when to irrigate, cutting his field small enough to have few centimeters difference in elevation within any basin in order to improve water distribution of his fields. The activities for the improvement of delivery systems to facilitate continuous flow in the main supply system include the construction of improved sub-branches (Meskas) with single point lifting at head and developing the Irrigation Advisory Service (IAS) within the institutional organization of MWRI and (WUA) for the site. Small attention was focused on some modifications of the water management practices especially land leveling and some improved agronomic and soil practices ex. using improved crop varieties and soil improvement practices.

In 1997, the OFWM program was started within the second phase of the IIP in Egypt. This program includes comprehensive activities such as laser land leveling; suitable furrow lengths and border sizes; crop management activities include suitable seedbed preparation, planting time, optimum pest control, use high yield and short term varieties, optimum fertilizer application; soil improvement practices and training activities. These practices lead to, in general, an increase in water use efficiency reaching 5%, crop yield increase in some cases reaching 10 % and reducing time of irrigation by 17.5 % in some of the project areas in Kafr El-Sheikh and Damanhour as shown in the presented results. Needs arise for dissemination of the activities in selected sites, not only as single activity but as a package of activities depending on farm conditions. Some of the activities need to be verified before disseminating them in the farmers' field demonstrations.

In the year 2002 with the German fund another OFWMP project started targeting the physical improvement of hydraulic infrastructure of the IIP (from the side of MWRI) and introducing modern technology for soil preparation and leveling, optimum furrow lengths, improving irrigation uniformity by optimizing irrigation scheduling, planting short-cycle varieties etc, (from the side of MALR). Active participation of farmers and water user's organizations was heavily involved in the project activities.

The project has launched a campaign to measure stream flows and water volumes at different levels between intakes of the branch canal until the farm turn out on farm ditches (Marwas).
These measurements together with yield data are the start of water productivity calculations. Because of such activities Bahr El-Nour site in Delta region was selected as BP for large scale irrigation practice.

5.2 Traditional System of Water Scheduling

The current delivery schedules of MWRI served by the distributary canals are divided either into two equal areas with water delivered by a two-turn rotation or into three areas with water delivered by a three-turn rotation. Different space and time allocations were applied on this system according to the type of soil, cropping pattern, season and boundary conditions for example.

Two-turn rotation 4 days on and 4 days off (rice)

	7 days on and 7 days off (cotton)
Three-turn rotation	4 days on and 8 days off (general crops summer)
	5 days on and 10 days off (general crops winter)
	7 days on and 14 days off (general crops winter)

Under rotation deliveries farmers especially growing vegetables occasionally irrigated both at the beginning and end of an on-period to be certain that there would be adequate soil moisture until the next on-period. Farmers are used to irrigate within the on days of water, in the mean time farmers commonly use plant symptoms as an indicator of when to irrigate.

5.3 The Proposed On-Farm Water Management Activities

Although Egypt has experiences for most of items related to on-farm water activities yet did not have clear packages of practices including water, soil and crop management. In the mean time packages introduced for application vary according to need assessment and analysis for each site.
The on-farm water management activities in Egypt should include:

- ***Water management Practices*:**

Switching of the operation of distributaries canal by continuous flow from the current rotation system between them
Rotation flow among sub-branches (Meskas)
Irrigation scheduling along Meska
Land Leveling
Ditches Improvement (Merwa)

- ***Crop management practices:***

Demonstration of main activities can include:
Alternate cropping systems
High crop yield varieties
Short-duration varieties
Alternative methods of cultivation
Possibility of using machines from planting and harvesting
Improved integrated pest management strategies.

- ***Soil management practices:***

Demonstration can include:
Alternative tillage operations
Fertilizer recommendation to match crop requirement (type – amount – timing).
Improve soil quality parameters (salinization – alkalinization - compaction).

- ***Awareness, training and capacity buildings:***

Changing the on farm management practices of farmers depend on the effectiveness of the awareness and training. The programs proposed include:

Emphasizing the role of farmer participation in every detail concerning the implementation of the component activities
Programs related to knowledge and skills of the perception of irrigation improvement activities. (ex. Using the operational valves along the Meska)

5.4 Rotation of water among Meskas

After improvement, water will be delivered continuously to the distributary canals, but the flow may not permit the operation of all Meskas at the same time. So, irrigation rotation among Meskas needs to be followed for better management. Irrigation rotation among Meskas will be managed by irrigation district engineer with the cooperation of BCWUA. AT the time of full transfer of management of distributary canals to BCWUA, the association will take the full responsibility of handling the task of effecting the irrigation rotation among Meskas; these activities are recommended in the next step of improvement during IIIMP.

Irrigation Scheduling Along Meska

Improved Meska is designed according to the criteria that certain number of Marwa outlets is operated jointly. Meska design discharge will not allow for all Marwa outlets to be operating at the same time. According to the irrigation & drainage law irrigation scheduling between Marwa outlets is the full responsibility of Meska water users association with the cooperation of Marwa leaders.

Irrigation Scheduling

One of the main objectives of the target Integrated Irrigation Improvement Management Project in Egypt is to develop a framework of integrated water management planning and programming in selected areas, considering water quantity and quality management through inter-agency and stakeholder agreement. Within the OFWM project component the preparation and implementation of integrated command area water management plans will take place. Within the package included the "on demand' water supply as a main issue with project targets. Thus the rehabilitation renovation of the canal cross sections and structures took place in order to achieve the continuous flow that brings water on-demand for farmers.

5.5 Farm Ditches (Marwas) Improvements

Deficiencies of Existing Marwas

1. Inadequate (farm Ditch) Marwa capacity to hold the discharge especially in cases of improved Meskas where discharges of Meska are bigger than those of individual pumps.
2. Overtopping of water from Marwas in cases of insufficient Marwa sizes and with low banks.
3. Loss of water through seepage due to long Marwas.
4. Runoff of water at the tail ends of Marwas to drains.
5. Water loss due to vegetation in Marwas.
6. High costs of maintenance of Marwa channels.
7. High costs of maintenance of individual pump unitsat the Marwa head.
8. Loss of land occupied by Marwa cross sections due to excessive cleaning of Marwas from weeds.
9. Water loss through holes in Marwa cross sections caused by some harmful insects.

Alternatives of Marwa Improvement Technologies

A number of alternatives for ditch (Marwa) improvement technologies are used. It must be kept in mind that since Marwas are private property and the farmers pay the improvement costs (recovery costs system), so they must decide what kind of improvement they want. They should be consulted in all phases of implementation, starting from survey to handing over the improved system to WUA.

Thus, the approved Marwa alternatives can be technically, economically and socially approved. The following table gives the two used improvement technologies.

Ser No.	Marwa improvement alternative	Description	Advantages
1	Open ditch lining	Lined Marwa takes water from improved Meska (lined or piped) in IIP areas	o Less seepage losses. o Increase conveyance efficiency. o Less weed problems. o Decreased water losses due to overtopping. o Less land than unimproved Marwas. o Easier to maintain. o Less maintenance cost than unimproved ones o Farmer pride. o Better health and environment conditions. o More crop production in the areas next to Marwas
2	Piped Marwas (buried & non-buried)	- Only non buried pipeline will be used in IIP areas off taking from either raised lined Meskas, or buried piped Meskas	o No weed problems o Land savings especially in case of buried pipe o More crop production o Water savings o Better management

5.6 Water Distribution Plan to the Field

After construction, the farmers have to use the valve to get water from the pipeline. However the number of valves is limited because if each farmer had requested a valve, the construction fee would be higher than just one. Then, if they open all valves at the same time, the water flow from each valve would be very low because pump discharge is limited. It means that a valve schedule is necessary. Therefore, a plan to realize a fair and effective water distribution system is required. Also the water application efficiency will be increased by using an appropriate plan. Illegal water usage and excessive water usage must be stopped.

Valve schedule

Basically, the number of opened valves should be the same as the number of operating pumps. If only one pump is operating, only one valve should be opened. Because if two pumps are opened, the water flow from the valve is cut in half by the pump discharge. The discharge of most of the pumps installed is 30 liters/second; if two valves are opened, the water flow of each valve is 30 liters/second. It is the same discharge with the private pumps that are used. Each valve covers a larger area than a private pump needed. From April to August, water requirement is large (summer season). For (winter season), September - March; the maximum water requirement in the winter season is 7.2mm/day in September. So it is recommend 7.5mm/day as the maximum amount of water to be pumped.

Irrigation interval

On the average, an irrigation (application) interval in the winter season is more than 2 weeks. This means that a quantity of one time irrigation is 105mm. A quantity of water flow from each valve will be 630 liters (There are some exceptions.). The basic maximum pump operation time par day is l0 hours as to avoid over loading the pump operator. If only two valves are opened at the same time, the pump operator responsible for valve operation must make members (farmers) respect this rule. If someone opens more valves, water flow will be decreased. After one week of pump operation, it can take one week of rest, and during this time the other unit will be used. Maintaining this unit could be done during this time. This plan was formed to cover the maximum water requirement during the winter season. The most important point is that the schedule for opening the valve is kept and respected. After all members are accustomed to operating the pump and valve then the planner can modify the operation plan by meeting with WUA.

For summer season the maximum water requirement is about 24.5 mm in April (rice transplanting), so a farmer irrigates a paddy field every 3 days; this means the quantity of one time irrigation during transplanting season is 75 mm and for normal seasons it is 45 mm, and the quantity of water flow from each valve is 60 liters (with some exceptions). The basic maximum pump operation time is about 16 hours/day *(these roles are followed in the Bahr El-Nour BP site in Kafr El-Shiekh).*

5.7 Basic Irrigation Methods as BP Technique

Border irrigation method

When irrigating rice, wheat, berseem (clover) or maize, the entire surface of the field is covered. This method is called the border irrigation method. The difficulties of this method are as follows.

- Necessity of a flat field to avoid salt accumulation before sowing or transplanting, the field must be leveled as much as possible. If the leveling is not done, some parts will remain higher than others. In this case the higher parts are not covered by water and the risk of soil damage increases as in figures 7 and 8.

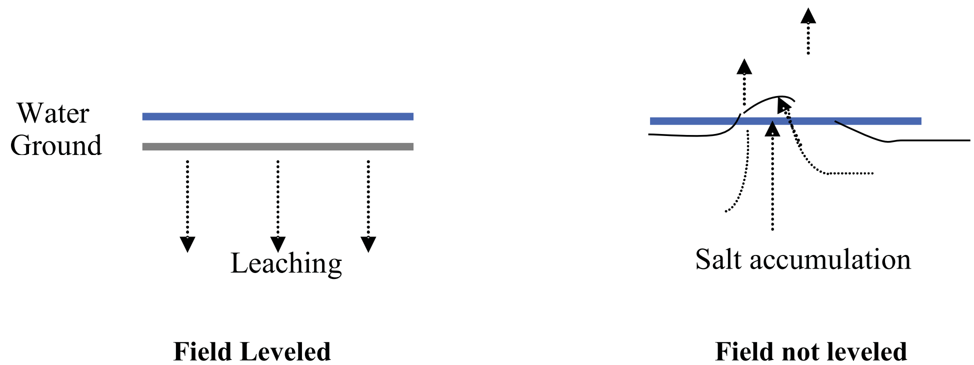


Figure 7. Salt damage at higher parts

- Necessity of a flat field to avoid wasting water, farmers require to cover the entire field with water. This causes a lot of water to be wasted if the field is not flat.

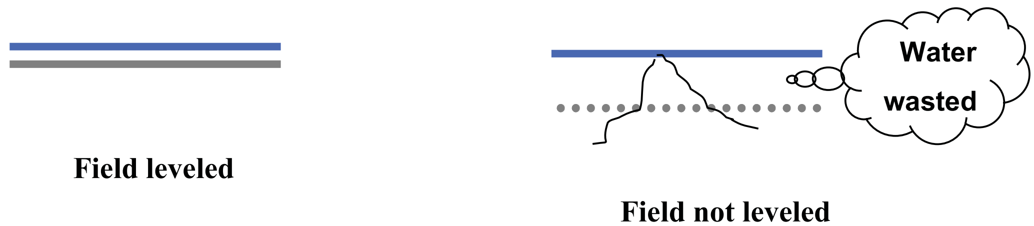


Figure 8. Water wasted without levelling in border method

Furrow irrigation

For cotton, sugar beet, maize or different kinds of vegetables, the farmers make ridges to irrigate between them. This irrigation method is called the furrow irrigation method. This method also has difficulties; necessity of a flat field to avoid wasting water.

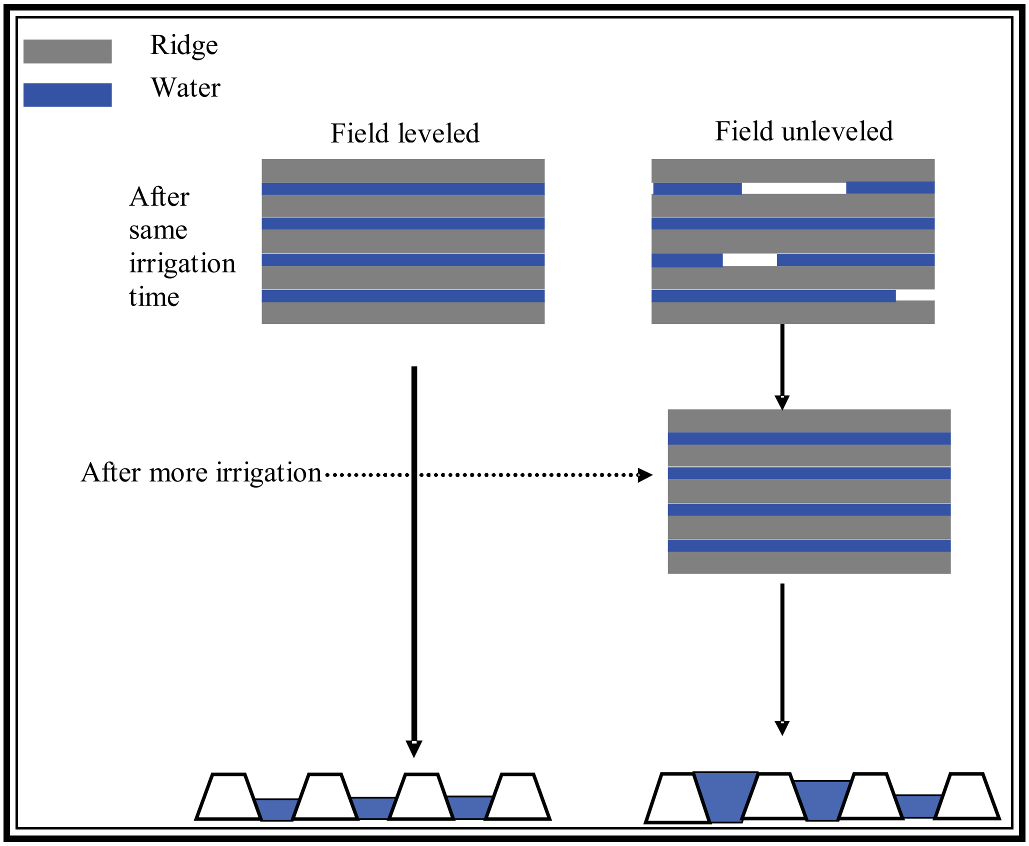


Figure 9. Water wasted without levelling in the furrow irrigation method.

Irrigating a field that has not been leveled for the first time, some seed can be washed away by the overflow of water as seen in the next figure.

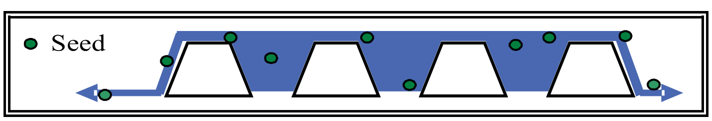


Figure 10. Waste of seeds by overflow water

5.8 Choice of crops and cropping patterns

The main crops in the Bahr El Nour area are rice, cotton, and maize in the summer season and in the winter season, wheat, Berseem and sugar-beets. Especially, rice cultivation is inevitable for small size farmers because it is necessary for self consumption. Then, almost all of the farmers raise some kind of domestic animals and therefore, forage crops like maize and Berseem are necessary. Finally, the land use efficiency is 200% per year. These facts suggest that a large change in crop and cropping pattern is very difficult especially for small size farms. However a partial alteration is possible. Anyway after the completion of all the improvement construction works, freedom of using water and cultivation will be better and the proposed cultivation scheduling will be more successful.

Table 5. Prospect of gross income of some vegetables in BP site of Bahr El-Nour

Vegetable	Yield (ton/feddan)	Price (L.E./kg)	L.E./feddan
Carrot	9.0 – 10.0	1.50	13,500 – 15,000
Cucumber	3.0 – 7.0	1.25	3,750 – 8,750
Eggplant	9.0 – 13.0	0.80	7,200 – 10,400
Tomato	4.0	1.50	6,000
Cantaloupe	8.0	2.00	16,000
Potato	8.0 – 9.0	0.80	6,400 – 7,200
Onion	17.0	1.00	17,000
Cabbage	5.0 – 8.0	1.50	7,500 – 12,000

Source: Prior investigation Report on The introduction of Horticultural Crop into the Area of Bahr El Nour

The gross income from vegetable cultivation is higher than that of main crops in the Bahr El- Nour area; however as known, vegetable cultivation is more difficult than grain crops because of insects, pests, disease, injury, preservation and harvesting.

5. 9 Cost summary

An estimated cost for the implementation of OFWM activities reaches about $ 900 per hectare whereas the improvement activities at Meska and branch canals could reach about $2700 per hectare.

5.10 Expected Benefits

As an output of the current M&E of the OFWM activities, the expected benefits can be summarized in the following:-

Increase in pumping and operation cost up to 37% and 30 % respectively, Meska maintenance cost up to 40 %, amount of water saving to reach 10.3 % with reduction of irrigation time by 50 % and water use efficiency to increase by 25 %. Crop production average expected can increase to 15 % with a total increase in farmer income by 20-25%.

6. ASSESSMENT OF BEST PRACTICES IN CMI AND PPMI IN EGYPT

6.1. Main BP System Management Innovation

The major activity from an engineering/technical perspective was the problem/opportunity analysis that identified the existing problems related to water management and elaborated on the underlying causes of those problems. In this context, the work focused on the quantification of the changes that are anticipated by the technical interventions through a set of criteria at delivery, on-farm and drainage levels e.g. equity of water distribution, water availability/sufficiency, agricultural practices, project management, agricultural productivity, farm income, etc. The quantitative indications of the changes by the technical interventions were, to the extent possible, validated against the fieldwork exercise which was carried in the project area, through field observations and stakeholder interviewing.

The following system management innovations should be addressed:

- Sustainability of water sources (Durability, Quantity and Quality)
- Physical improvement of the delivery system
- Implementation of Integrated Water/Land Management
- Improve agronomic practices
- New operational techniques
- Farmers participation (WUAs), and Institutional reform
- Decentralization of decision making
- Improve socio-economic return and marketing
- Improve farmer health conditions and general awareness

Table 6. Analysis of BP of land use

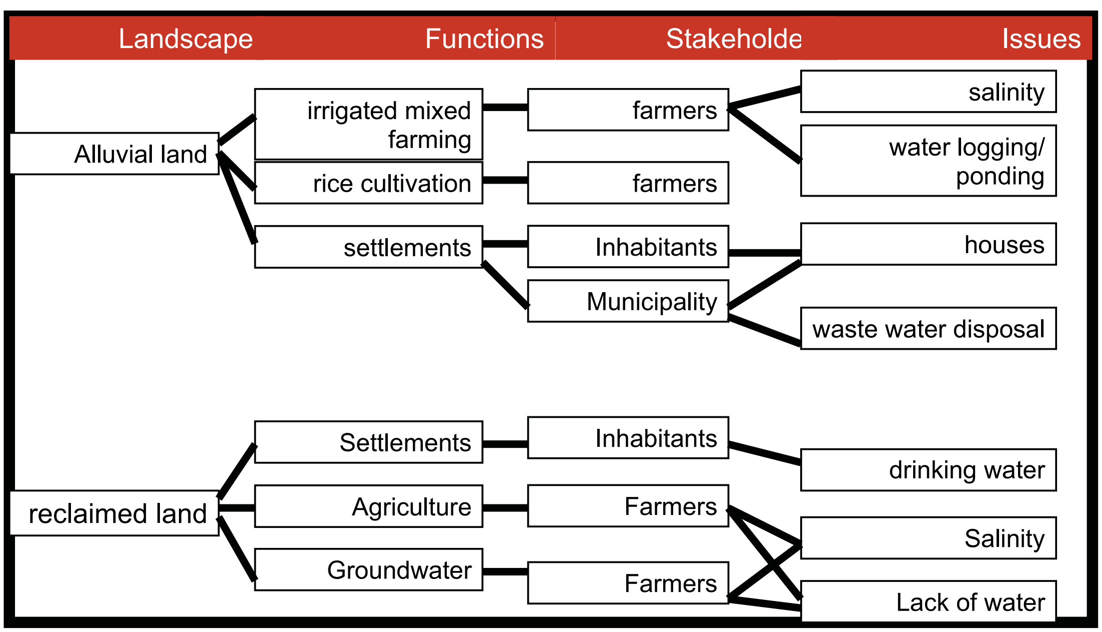


Table 7. Analysis of BP of canal water use

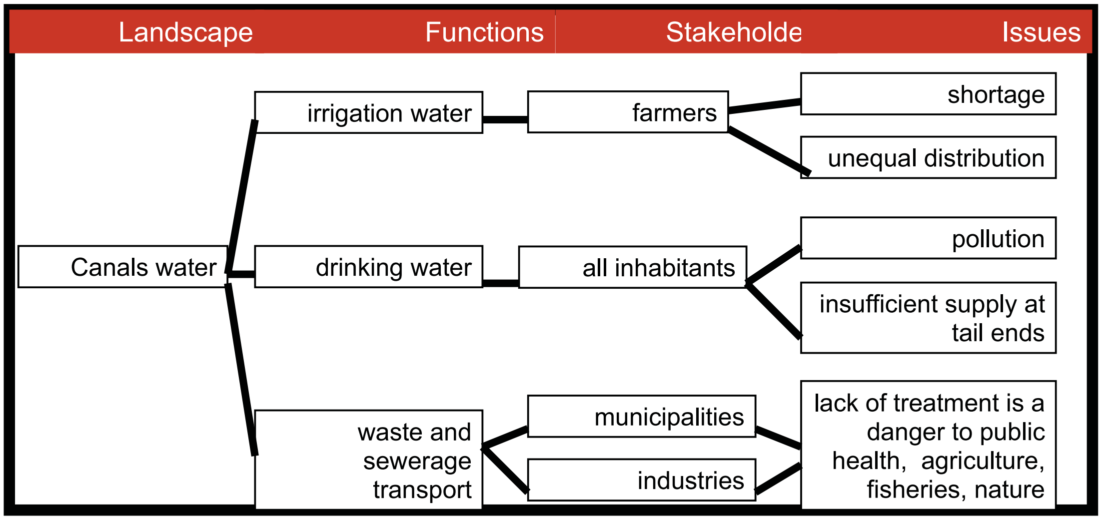
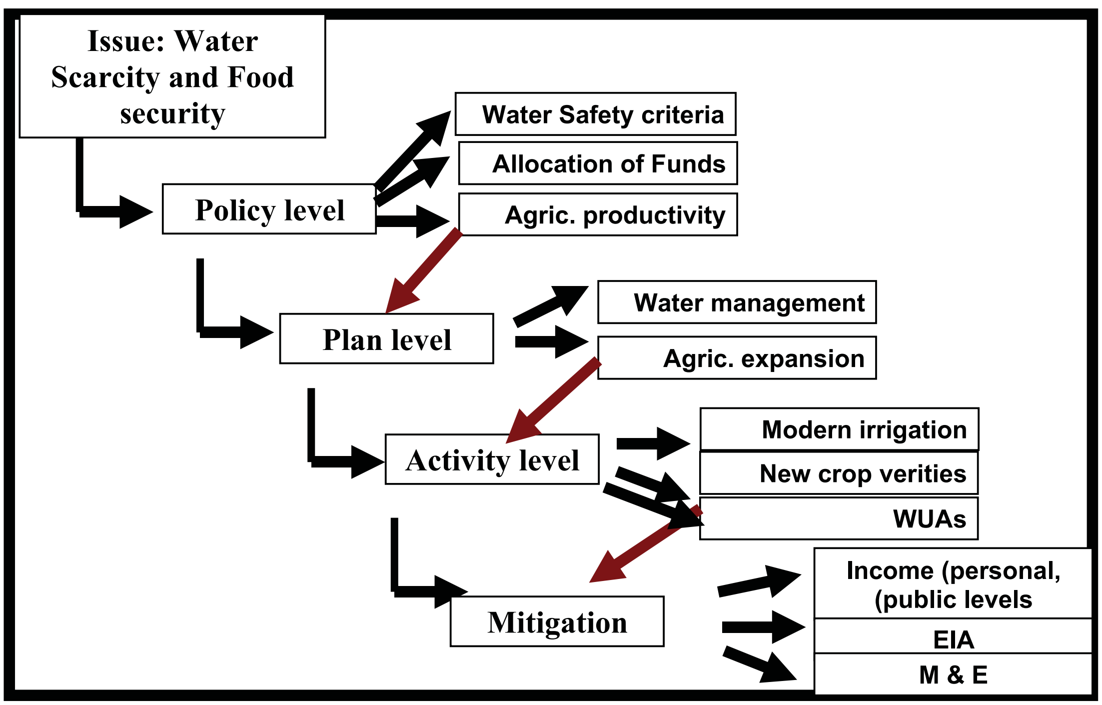


Table 8. Levels of improving and alternatives of BP of water and land



6.2. BP Activities at Main Water System

The operation of the existing irrigation system is based on rotational water deliveries to individual branch canals. The main feeder canals flow continuously and the off taking branch canals head regulators are opened according to a rotation schedule, which consists of a three-turn rotation with 5 days on and 10 days off in winter and a two-turn rotation with 5 days on/ 5 days off in summer. The introduction of continuous flow (as an example of BP for PPMI), represents probably an important single intervention that will improve the equity between head and tail areas at the branch canal level.

This intervention will not only help to overcome the inequity problem but will also offer new opportunities. The following 2 figures give an example of the innovation of the control structure for water delivery in the main or branch canals in Egypt.

Figure 11. Old Control Gate in Branch Canals

Figure 12. New Control gate in Main and Branch Irrigation Canals

6.3. BP Activities at Sub-branch Water System

At a particular lifting point, different farmers may take turns to irrigate using different pumps. Farmers with fragmented holdings may use a single pump which is moved between their different plots. Figures 13 and 14 give an example of the innovation of the control structure for water delivery in the sub-branch canals (meskas) in Egypt.

Figure 13. Old water delivery system at Meska level

Farmers practice irrigation, traditionally receiving knowledge and advice mainly from the agricultural extensions, in the area but with limited knowledge on cultivating techniques, e.g. long furrows, dry planting Berseem, planting rice using machine, etc. Investigation showed that farmers are aware of laser leveling and its important benefits, and they are willing to apply it.

Figure14. New Meska as BP Activity

However, practicing is not common due to its expensive cost and the limitation of field size, i.e. field size is too small. It is suggested to introduce electric pumps instead of the prevailing diesel pumps in the new improved project areas as the cost of both types is not considerably different, but the impact on the environment is very much different. Electric pumps generate cleaner energy. The new technology is under testing at BP site of W/10 area in Kafr El-Shikh.

BP Activities at Meska Level: Measuring of discharges at the head of Improved Meska with exact knowledge of unit (pump) operation time and measuring the used electric energy to facilitate the cost recovery procedure with beneficiaries.

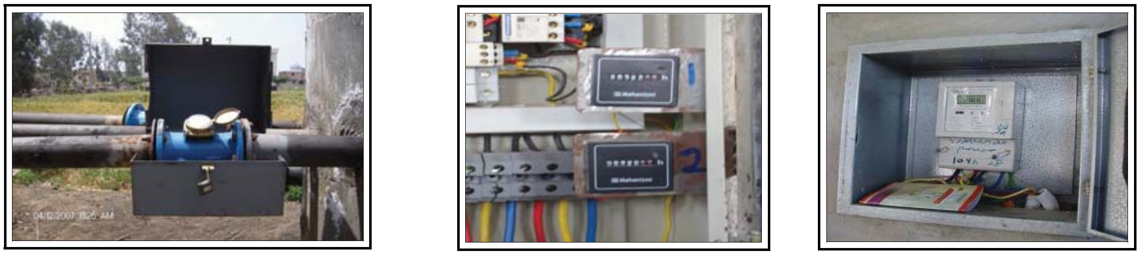


Figure 15. New system of farm water delivery

6.4 BP Activities at On-Farm Level

More efficient use of irrigation water can be achieved when farmers irrigate larger basins and increase irrigation furrows. Optimizing furrow length and size of basins can be achieved through land leveling and water flow control influenced by discharge and infiltration rate characteristics of the soil. Water application in fields can be achieved through flexible hoses when using buried piped Marwa. The following Pictures give a good example of the benefits of improving the old Marwa at On-farm level. They also show some activities on land preparation as well as water and land conservation processes.

Improved open marwa | **Lining stages** | **Marwa before lining**

Surface reinforced Concrete pipe | **Gated pipe** | **Mortared white bricks**

Figure 16. New system at farm level

Figure 17. Sample of new farming technology

6.5. Identification of BP in Agriculture

Ninety seven percent of fresh renewable water resources are controlled at a single location (Aswan High Dam). Flows target a single sink, which is the Mediterranean Sea. Between the two points no significant storage or disposal facilities can be found except numerous canals, pumping stations, culverts, control points, water reuse stations, drainage facilities and disposal points. The travel time from A to B is about 12 days. The current complexity of the water control systems evolved for centuries. It was governed by different technological ages, political systems and social values. In the absence of operational rules and regulations for the operation and management of individual pumping from mesqas and branch canals, many farmers have adopted a coping strategy which involves the re-use of water from open drains even if the drainage water is saline. This practice is well documented as un-official water reuse which needed to be avoided.

At the sub-branch (Meska) level, the improved works have reduced the problem of water inequity and supply shortages effectively through a mix of technical and institutional interventions. Current technical interventions are simply a change of the water supply systems from rotational to continuous flow in combination with gravity flow in raised open meska canals or buried pipes operated at low pressure. However, during the site visit it was observed that the target of applying continuous flow conditions had not been reached, which provides the assessment of that intervention as incomplete. As future (as BP activities) on-farm irrigation practices may change during the IIIMP, there is a need to maintain the awareness on the part of farmers for soil salinity control and leaching processes. In the same time, the activities of improvement at on-farm level (merwa) are going to improve water delivery to farms (as in W/10 site).

In the year 1995 Keller et al. (1995) published their results of a strategic research program on the effective irrigation efficiency of Egypt's Nile System. Their main findings suggest that the effective irrigation efficiency of the Nile basin between the High Aswan Dam and the Mediterranean Sea is

94.8%, which is nearly two times as much as the classical irrigation efficiency (57%), the classical irrigation efficiency ignores that water is recycled and re-used. The concepts of effective irrigation efficiency take account of water recycling. Conceptually the recycled portion is added to the water supply side. Their conclusion is that the classical irrigation efficiency concept is not well suited to make water allocation and policy decisions. Accordingly Egypt's planners are advised not to make the mistake of justifying and authorising irrigation improvement projects that are designed to raise the classical irrigation efficiency.

6.6. Other BP Water Use Activities in Egypt

Desalination of Sea Water 6.6.1

- Desalination of seawater in Egypt has been given low priority as a source of water. That is because the cost of treating seawater is higher compared with other sources, even the unconventional sources such as drainage reuse. The average cost of desalination of one cubic meter of seawater ranges between 3 to 7 L.E (Egyptian pound) *(Egyptian National Committee on Irrigation and Drainage (ENCID))*. In spite of this, sometimes it is feasible to use this method to provide domestic water especially in remote areas where the cost of constructing pipelines to transfer Nile water is relatively high.

- Egypt has about 2,400 km of shorelines on both the Red Sea and the Mediterranean Sea. Therefore, desalination can be used as a sustainable water resource for domestic use in many locations. This is actually practiced in the Red Sea coastal area to supply tourism villages and resorts with adequate domestic water where the economic value of a unit of water is high enough to cover the costs of desalination.

- The future use of such resource for other purposes (agriculture and industry) will largely depend on the rate of improvement in the technologies used for desalination and the cost of power needed. If solar and wind energy can be utilized as the source of power, desalination can become economic. It may be crucial to use such resource in the future if the growth of the demand for water exceeds all other available water resources. Nevertheless, brackish groundwater having a salinity of about 10,000 ppm can be desalinated at a reasonable cost providing a possible potential for desalinated water in agriculture.

- The amount of desalinated water in Egypt now is in the order of 0.03 BCM/year.

Non-conventional Water Resources 6.6.2

There exist other sources of water that can be used to meet part of the water requirements. These sources are called non-conventional sources, which include:

- · The renewable groundwater aquifer in the Nile basin and Delta
- · The reuse of agricultural drainage water
- · The reuse of treated sewage water

These recycled water sources cannot be considered independent resources and cannot be added to Egypt's fresh water resources. The sources need to be managed with care and their environmental impacts evaluated to avoid any deterioration in either water or soil quality.

- ***The renewable Groundwater Aquifer in the Nile Valley and Delta***

The total available storage of the Nile aquifer was estimated at about 500 BCM but the maximum renewable amount (the aquifer safe yield) was estimated to be only 7.5 BCM. The existing rate of groundwater abstraction in the Valley and Delta regions is about 4.5 BCM/year, which is still below the potential safe yield of the aquifer.

- ***Reuse of Agricultural Drainage***

The amount of water that returns to drains from irrigated lands is relatively high (about 25 to 30%). This drainage flow comes from three sources; tail end and seepage losses from canals; surface runoff from irrigated fields; and deep percolation from irrigated fields (partially required for leaching salts). None of these sources is independent of the Nile River. The first-two sources of drainage water are considered to be fresh water of relatively good quality.

The agricultural drainage of the southern part of Egypt returns directly to the Nile River where it is mixed automatically with Nile fresh water which can be used for different purposes downstream. The total amount of such direct reuse is estimated to be about 4.07 BCM/year in 1995/96. In addition, it is estimated that 0.65 BCM/year of drainage water is pumped to the El-Ibrahimia and Bahr Youssef canals for further reuse. Another 0.235 BCM/year of drainage water is reused in Fayoum while about 0.65 BCM/year of Fayoum is drained to Lake Qarun. Moreover, drainage pumping stations lift about 0.60 BCM/year of Giza drainage from drains to the Rossita Branch just downstream of the delta barrages for further downstream reuse, (*Egyptian National Committee on Irrigation and Drainage (ENCID)).*

Drainage water in the Delta region is then emptied to the sea and the northern lakes via drainage pump stations. The amount of drainage water pumped to the sea was estimated to be 12.41 BCM in 1995/96. This decreased and will continue to decrease in the future according to the development of the reuse of agricultural drainage water.

- ***Reuse of Treated Waste Water***

One way of augmenting the irrigation water resources is to reuse treated domestic wastewater for irrigation with or without blending with fresh water. The increasing demands for domestic water due to population growth, improvement in living standards and the growing use of water in the industrial sector due to the future expansion of industry will increase the total amount of wastewater available for reuse.

Wastewater treatment could become an important source of water and should be considered in any new water resource development policy; however proper attention must be paid to the associated issues with such reuse. The major issues include public health and environmental hazards as well as technical, institutional, socio-cultural and sustainability aspects.

6.7. Selected BP Sites in CMI and PPMI

The definition of BP sites varies according to the purpose for selection as BP. In general the concept of best practice in the areas of interest of EWUAP relates to five main issues (i.e. Site properties) includes:

- Technical
- Economic
- Social
- Management, Operation and Maintenance
- Institutional

Physical Steps for Identifying BP Activities in Selected Sites (Integrated Planning)

- ✓ Define area of intervention: basin approach.
- ✓ Describe natural resources: land & water.
- ✓ Identify stakeholders: more than farmers.
- ✓ Ask stakeholders what the real issues are.
- ✓ Find solutions in a participatory manner.
- ✓ Take transparent decisions and provide information.

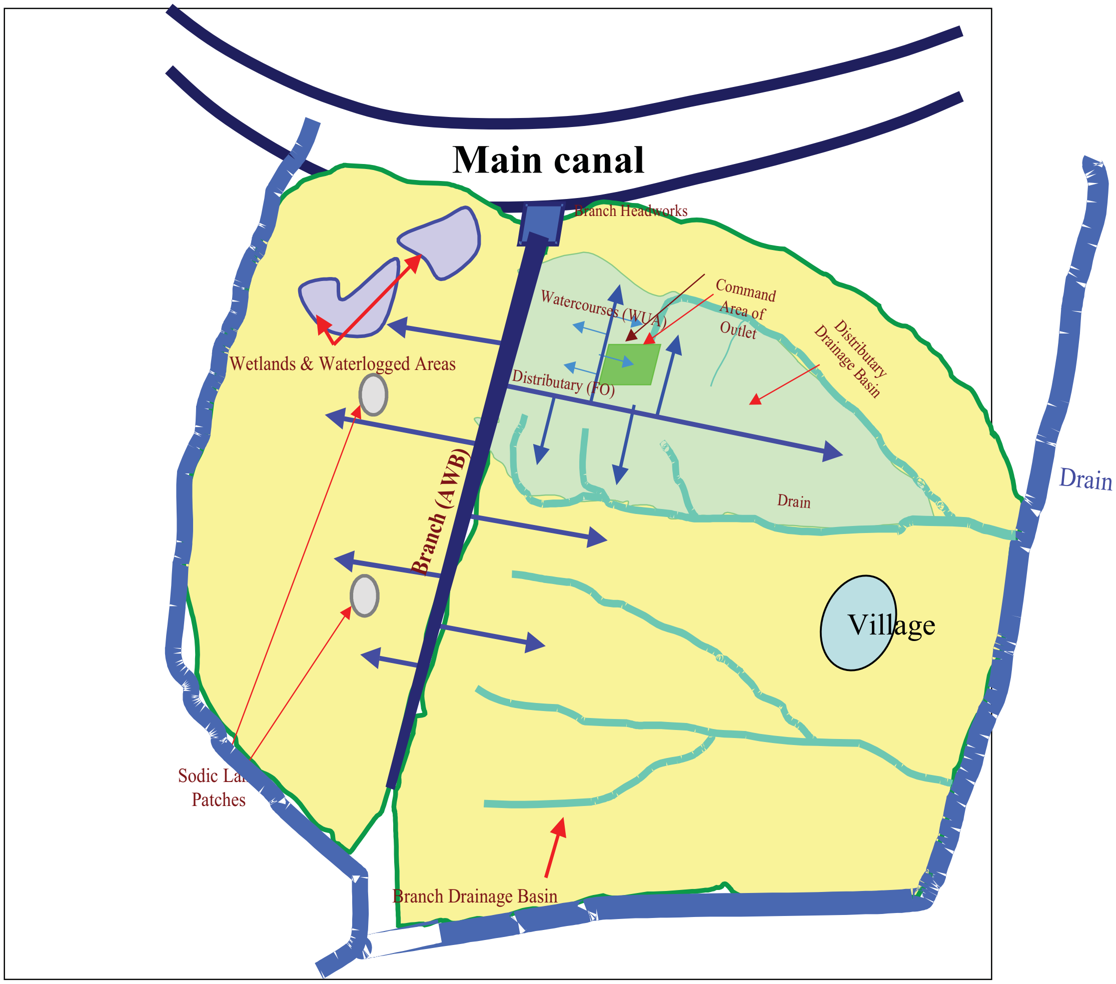


Figure 18. Typical Layout of water and land system in old lands

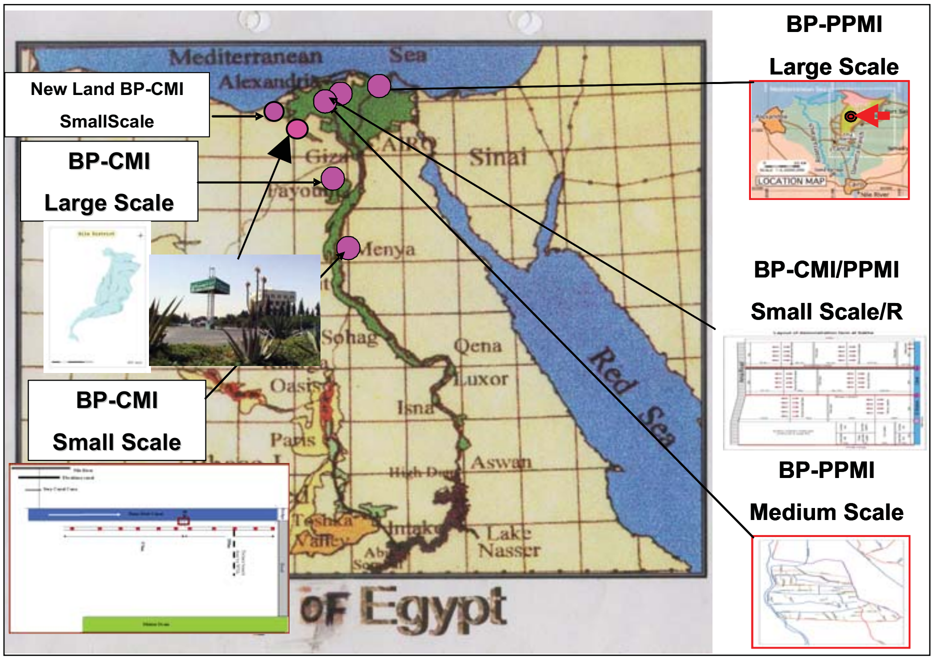


Figure 19. Selected Best Practice Sites of CMI/PPMI

Table 9. List of final short-listed CMI/PPMI BP Sites in Egypt

Site Name	Reason for Selection	Site Properties
Bahr El-Nour (Delta Area)	Controlling water supply from the water source (PPMI-Large scale)	- Example of BP for controlling irrigation water at main canal by (automation),and for the sub-branch canal by (one lifting point) - Strong formation and operation of WUAs in all levels - Good management at farm level and economically supported
W/10- Sefsafa (Old land-Lower Egypt)	New operation technique from level (CMI-large scale)	- **New design/operation** criteria at sub-branch and tertiary canals (Meska and Merwa), by (electric pumps and improving ditches) - Using of fresh and drainage water for irrigation (at the end/D.S of the irrigation system in Egypt) - Pilot area for testing the new irrigation and agricultural practices with good link with different agencies and stakeholders
Sakha (Research Unit-Delta)	Research center with cooperation with stakeholders (small scale)	- Good example for the **link between users and research** activities to help overcoming region's problems - Place where irrigation and agricultural engineers can test proposed new design/operation criteria. - Mainly the unit is supporting the local beneficiaries for different new practices like new rice verities and crop rotations
Sela District (Middle Egypt-Fayoum)	Example of cooperation between Gov. and users in district level (WUA-large scale PPMI)	- Activities of large scale operation WUA at district level with proposed cooperation with other agencies and local Gov. - Example of self-managed organization at all levels of operation. - The place represent the cropping/irrigation condition in Middle Egypt - Issue of protecting the ecosystem in the area is essential
Bani Abad (Upper Egypt-Menya)	BP in Nile valley AEZ with strong WUAs (Small scale)	- Good example of small scale and sustainable WUA in tertiary level (operated for 15 years) - self-finance organisation - The site represents the lower part of the Nile valley where different cropping pattern is found (case of Sugar-cane, and no rice).
Dina Farm	BP in New lands (Private sector) (small Scale)	- Example of new technology of farming and irrigation system in new reclamation lands - Fully controlled by private investors and serve the local and outside market - Economic aspects and environmental considerations - integrated in terms of agricultural and animal production

The proposed BP sites will be considered for wider dissemination of practices in the home country-Egypt and if possible within the Nile basin, listing the strengths and weaknesses of the systems and the areas where opportunities exist. The information collected will form part of the process of sharing positive experiences and information, and to encourage the wider support from governments, private sector and donors in integrated catchment management involving water harvesting and irrigation.

Details of these BP sites according to the finding of the field visits are given in ***Annex 1*** (List of selected BP sites of CMI and PPMI).

Some expected results of BP at selected sites:

1. Improved crop yield and values of land/water
2. Labour costs for irrigation are reduced, due to more efficient water delivery (Crop Budgets)
3. Hours per irrigation reduce
4. Night irrigations reduce
5. Head farmers use less water
6. Use of drainage water reduces with irrigation improvement
7. Area under certain improved crop varieties increases
8. More significant differences between the ‘before’ and ‘after’ IIP improvement cases occur over time.
9. improved cropping patterns and rotations
10. Crop patterns also reflect external influences such as prices.

6.8. Functions of Water User Association in BP Sites

Water Users Associations were a recommendation of Egypt’s Water Use and management Project funded by the USAID. The main objectives of the project included that farmers should be involved in improvements to the water delivery system and they must play a role in ensuring more efficient operation and maintenance of hydraulic and irrigation structures.

The main functions of Water Users Associations (WUAs) are:

- ❖ Participation in planning, design, and construction of improved sub-branch Meskas and ditches (Marwa).
- ❖ Operation, maintenance, and follow-up of the improved system.
- ❖ Improvement of water use activities at the meska level.
- ❖ Identification of roles and responsibilities of the meska’s head and setting up rules to resolve conflicts.
- ❖ Establishment of linkages for coordination with other agriculture and irrigation concerned agencies.
- ❖ Establishment of linkages for coordination with other WUAs.
- ❖ Development of financial resources in order to improve operation and maintenance.
- ❖ Participation with higher-level organizations of the branch canal and cooperation with the district engineer.

WUAs through regular meetings and discussions identify roles and responsibilities of meska heads and set up rules to resolve conflicts, establish linkages for coordination with other agriculture and irrigation concerned agencies. Members of a WUA also help in the development of financial resources of the association in order to improve operation and maintenance.

Nevertheless, legislation is still required to define the structure of the Water Boards and their responsibilities, especially when members are not only farmers.

6.9. Importance of Farmer Participation in System Operation

WUAs Technical Implications 6.9.1

There are several technical implications of users' participation in water/land management. The next table lists some of the technical aspects related to users' participation in irrigation system management. It deals mainly with the irrigation system operation and maintenance activities that are have reported in Egypt (data of BP site on-farm level activities).

Table 10. Technical implications of irrigation management transfer in Egypt

Aspect	Issue-values
Size of area served by WUAs	Meska (private sub-branch at 10-1000 feddans Branch and secondary canals at 1000- 12000 feddans
Efficiency increase (as BP)	Raised by 30%- 40%
Hydraulic works	- One lifting point - Elevated or piped meska - Automation of flow at branch canal head work
Energy consumption	Pumping hours reduced by 50%-60%

(Ref. Overview of Decentralization and Participatory Irrigation Management-Paper, Water demand management Forum-February 2003)

Importance of Participatory Approach

- Enforced current regulations through top-down institutional structure
- Less effective social problems due to dilemma between group and private interests
- WUA as voluntary organization to become MWRI partners in water management
- Create ownership among water users of infrastructure and its regulations
- Replace policing of canals by social control irrigation communities/WUAs
- Operation regulations require participation and state enforcement
- Water distribution at secondary, branch or main canal level.

Figure 20. Maintenance activities at local level (BP Sila site)

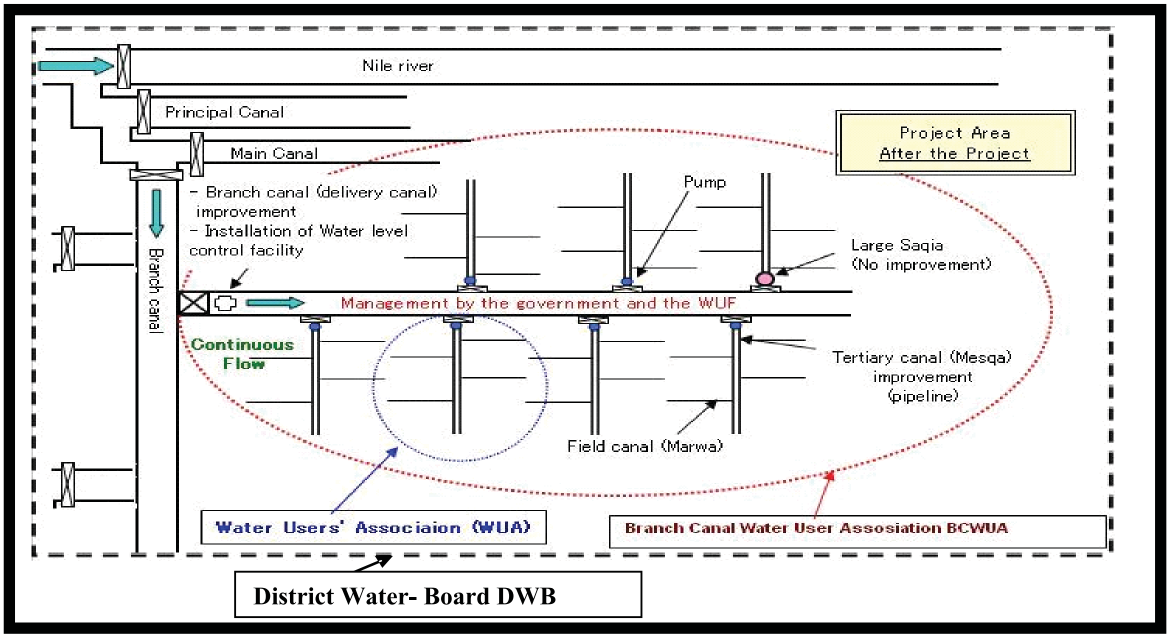


Figure 21. Levels of participatory approach in system operation

Farmers reported that they have never been consulted as regards the type of improvements executed under the first improvement activities in old land (this is not the case of the current BP activities). The recent projects are more effective in developing a well-tailored mechanism for public consultation of all stakeholders in the project command areas, not only farmers.

Some Guiding principles for up-scaling WUAs activities:

- WUAs working areas according to hydrologic boundaries: interdependency in water distribution.
- It is fully recommended that implementation and monitoring can be combined at the lowest level.
- Administrative boundaries only used where more options for hydrological boundaries exist.

Gender Participation in WUA 6.9.2

Women can participate through the introduction of BP in the operations of WUAs at different system's levels in agricultural operations such as rice transplanting, threshing and storing, harvesting cotton, cut maize and irrigation when the other members of the family are busy. Despite being aware of WUAs, no women are participating in these associations. It is also quite difficult for a woman to be elected as a head of the board in WUAs as customs and values in the area prevent that.
There are women members in the operational committee. These women represent resident areas rather than farmers. They are involved in the activities dealing with increasing the awareness of women about environment and how to protect it from pollution.

6.10. Institutional Development of BP sites

The Integrated Water Resource Management (IWRM) concepts in institutional arrangements that are based on water user participation and which are widely valued by all stakeholders are involved. The scope for practical institutional building at all levels is considerable, starting from the meska and branch canal up to main and sub-regional level. The study identified an apparent need for strengthening of water users associations Existing water user associations lack important management skills such as planning, prioritizing of works accounting and financial management.

The analysis identified a need for much improved coordination of water resource allocation and management at the strategic regional planning level involving stakeholders from various sectors. The establishment of a body for Integrated Water Resource Management would require substantial capacity development in order to define its direction, role and responsibility. Integrated Water Resource Management should be introduced at all appropriate levels reaching from field to basin level. Current efforts in irrigation supply management improvement need to be accompanied by improved water demand management measures. There is a need for integrating agricultural improvement. In fact better infrastructure, which include water supply at large, is required to support this agricultural-production market development. At this stage still the traditional decision makers thinking dominates and individuals (beneficiaries) seeking quantity rather than quality. Such life style somehow is also limiting efforts of water supply source development. So far there is no charge/regulation to control arid environment damage in general. It is also easier to control environmental impacts through setting environmental regulation that has alternative mitigations that could be strict to control pollutions; proper institutional development for the implementation and operation of the project would support this target goal.

7. IDENTIFICATION OF WH PRACTICES

7.1 Introduction

In Egypt, some water harvesting structures built in the Roman era have been cleaned and/or smoothed and put back into use. At present, practicing one or more water harvesting techniques in such W.H sites in order to collect and store rainwater for use in meeting plant cultivation, human and animal needs is done. Awareness of the role of water harvesting (WH) in improving crop production was raised throughout the world in the 1970s and 1980s, when widespread droughts in Africa threatened agricultural production.

Water harvesting is an ancient method of obtaining water. A water-harvesting system is the complete facility for collection and storing precipitation runoff or increasing the efficiency use of water by different means. It is composed of catchments or water-collecting area, a water storage structure, and various other components.

The techniques utilized for collecting, storing and using rain and flood waters are very diverse. There are consequently a dozen different definitions and classification of water harvesting techniques. The terminology of water-harvesting used at the regional and international levels has not yet been standardized. In general, WH can make water available in regions where other sources are too distant or too costly, making water harvesting able for supplying water for small villages, households, livestock, and agriculture.

The main occupation is subsistence small-scale rainfed agriculture and livestock production, which normally compete for the limited water resources. The main challenges to improving the livelihoods of the small-scale farmers are how to upgrade rainfed agriculture to improve the livelihoods and conserve nature, and upgrade upstream land use in balance with water needs for human and ecosystems downstream. There is an increased interest in opportunities of improving rainfed agriculture through adoption of rainwater harvesting technologies. However, there is inadequate knowledge on hydrological impacts and limits of up-scaling rainwater at a river basin scale. Rainwater harvesting has a potential of addressing spatial and temporal water scarcity for domestic, crop production, livestock development, environmental management and overall water resources management.

No single method or system is best suited for all sites or water needs. In the Northwest Cost Zone of the Arab republic of Egypt, there are two main storage structures, i.e. Cisterns and Reservoirs, depending on the type of soil as well as the environmental conditions. The cisterns are constructed below the ground at the lowest level of a collection basin or of a small stream to entrap surface or stream runoff, while the concrete reservoirs are constructed in friable soils not suitable for cistern excavation.

7.2 Constraints of WH for Agricultural Development

Agriculture in the country is characterized by reduced water availability and growing demand for food and thus for higher agricultural productivity it is important to improve the efficiency of water use in agriculture. This must include efficient management of rainwater through utilization of effective water harvesting techniques. Instead of allowing runoff to cause erosion, it must be harvested and utilized. Governmental and non-governmental agencies, supported by local leaders of the beneficiaries, take the responsibility for the implementation of successful water harvesting systems.

Rain WH

WH can improve agriculture by directing and concentrating rainwater through runoff to the plants and other beneficial uses. It was found that over 50% of lost water can be recovered at a very little cost (such as the case in the presented BP WH sites at Matrough and Siwa Oases). However, socio-economic and environmental benefits of the practice are also important like the agricultural water productivity.

Traditional techniques of harvesting water are still being used in all the Middle East and North of Africa countries. FAO experts of the soil and water conservation group believe that there is a need to improve the efficiency of traditional techniques.

The most significant problems and constraints hindering the integrated use of water and land are:

- Technology inadequate to the requirements of the country/ region/ area;
- Lack of adequate hydrological data and information;
- Inadequate institutional structures within beneficiary organizations (associations, cooperatives); and
- Absence of a long-term government policy.

7.3 Importance of WH

The facts that rainfall is very meager in such semi-arid regions and that one millimeter of harvested rainwater is equivalent to one liter of water per square meter, suggest the importance of water harvesting apart from the quantity of rainwater collected for cultivation of barley and fruit trees in wadis and depressions where water can be harvested and utilized. Water harvesting also plays a role in people’s social life.

The whole issue of land management by Bedouin tribes has recently been of great importance. Degraded land around the tribal sites can be improved only if the communities themselves come to grips with land use management issues. One of the techniques that can be of assistance in rehabilitating degraded land is water harvesting.

Most water harvesting systems adopted by farmers in the region consist of four main components; catchment area for collecting rainwater, a means of diverting runoff, a water storage installation, and appropriate means of using the water.

The Bedouins are experienced in selecting the most appropriate water catchment areas for collecting rainwater. As would reasonably be expected, the area they select as a catchment does not permit the water to infiltrate into the soil, is cleared of all vegetation, shaped, and smoothed. A beneficiary decides the size of catchment's area and storage tank on the basis of their personal experience in the past.

The Bedouins in the region use two different kinds of earthen reservoirs. The first are lined reservoirs built according to engineering principals and utilizing materials from outside the region, e.g. concrete, or iron. These kinds of reservoirs are extremely expensive and are usually built by the local administration of Matrouh governorate. The second kind of reservoirs is what Bedouins call “Nashou”.

These are established cisterns under the surface of a plateau. Because of the topographical soil conditions, the selection of a suitable place for building such a cistern is of great importance. The Bedouins have sufficient experience in this. Material and labor are of primary concern when selecting a water-harvesting farming scheme. For most Beduins (people living in Egyptian Desert), keeping livestock is not only a source of income, but a way of life. Farmers' prestige is closely correlated with the size of their herd.

Farmers consider livestock almost like a bank, enlarging their herd when they have surplus money, and converting it to cash when they need money. At the same time, the increased profitability of orchard enterprises enables farmers to invest more in water harvesting structures and thus indirectly reduce the threat of land degradation.

7.4 General Considerations for BP in WH

The collected runoff from rain or snow is stored in some types of tank to supply drinking water for animals and humans or for supplemental irrigation of crops.

A water-harvesting system must supply the quantity and seasonal distribution of water required. No single method or system is best suited for all sites or water needs. Variability of climate, soils, topography, and water requirements requires that each system be specifically designed to fit local site conditions.

There are many different elements in the design of a water-harvesting system. A change in any one of the system components can change the selection or performance of the other components. Accordingly, in the process of making preliminary choices prior to final design, all system design components must be given simultaneous consideration.

Other factors must also be considered. Accessibility and availability of equipment, materials, and labor will often determine choices that can be made. General land topography and distance to alternative water sources will influence final system design and should be included in preliminary considerations.

The effort required to prepare a catchment's site can often be minimized by locating the catchment to take advantage of natural surface topography. Shallow natural depressions draining to a central location are such one topographic feature that is usually desirable (such as the case in Siwa Oases). Approximate size of the water-harvesting system should be considered in preliminary site surveys.

7.5 Egyptian Experience in the Northwest Coast

Rainfed Agriculture in Egypt is concentrated mainly in the North West Coast region which has a rather special climate that differs from the inland desert area of the south.

Location:
The North West Coast of Egypt extends westward about 600 km from Alexandria in the east at longitude 29o 50' to El-Sallum (the Libyan border) in the west, at longitude 25º 10' .It is bounded on the north by the Mediterranean Sea and on the South by The Sahara Desert, some 50 to 80 km in land.
The area is composed of a narrow, almost uninterrupted strip of coastal and inland sand dunes and an interdunal plain, of an alluvial plain which slopes gradually upwards to the Libyan plateau and part of the plateau itself.

Climate:

The climate of the area varies from a moderate Mediterranean coastal climate in the north to a desert climate in the south. The rainfall of the area is low. The average annual rainfall along the coast and inland for about 20 km ranges from about 170 mm in the east to 100 mm in the west. Beyond 20 km from the coast it drops to about half that amount.
Through the area, rainfall is characterized by extreme annual variations.

Topography:

The region is bounded in the north by the Mediterranean Sea and in the south by an escarpment of 200 m elevation .The region consists of a narrow, almost uninterrupted, band of coastal and inland sand dunes and interdunal plains. Further inland there is an alluvial plain that slopes gradually upward to the Libyan plateau. The area is bisected by numerous wadis formed by runoff water from the northward sloping plateau and eroded escarpment.

Soils:

Soils suitable for agriculture are found in small areas isolated by unsuitable land.
Generally the soils are underlain by cliché or rock determining the depth of the soil.

7.6. Water Resources and Utilization for WH

The main source of water is rainfall and natural watering is the main system. This natural watering is very irregular, depending mainly on the topography. At the same time there is an artificial watering done on small scale by water harvesting as follows:

- Constructing dikes to prevent the flow of the runoff of wadis to the sea.
- Constructing dikes, in the spreading zones, diverting the runoff of the wadis. In some cases, spreading is facilitated by the opening of small channels by which the runoff water reaches some isolated fields.
- Constructing traversal stone or earth barrages in the beds of the small wadis to facilitate sedimentation and create terraces which, in general, receive abundant runoff from the wadis.
- Constructing small dikes (earth, stone and/or cemented) parallel to the contour lines to retain the surface runoff.
- Storage of Sheet Runoff in Cisterns and/or Concrete Reservoirs.

Also, sheet runoff in the area can be stored in the numerous cisterns, existing in the coastal region, once they have been cleaned and repaired. Large numbers of cisterns dating to the Roman period exist in the region. These cisterns have been excavated in the rock and their capacity varies from 100 to 3000 m^3.

There are also many new cisterns that have been excavated in the last forty years. There are also the cement constructed water reservoirs in the areas not suitable for cisterns excavation i.e in friable soils.

The stored water can be used for human and animal consumption and, in some cases, for establishing tree plantations. Some small dikes or ditches are sometimes necessary to lead the sheet runoff into the cisterns.

Cisterns: The cisterns are constructed below the ground at the lowest level of a collection basin or of a small stream to entrap surface or stream runoff. Cisterns are excavated near the houses within the primary farm unit. The excavation is done with chisels and hammers or other hand tools in hard to rocky soils. Care is taken not to fracture the surrounding rock and to avoid cracks or fissures in the cistern's walls.

Concrete Reservoirs: These cemented water reservoirs are constructed in the areas not suitable for cistern excavation i.e in friable soils. These reservoirs are excavated and encased with concrete or masonry walls. The floor is made of concrete and reinforced concrete is used for the covering. The cover is slightly elevated from the ground level so that water can be captured in the reservoir through small windows. The capacity of these reservoirs is assumed to be the same as of the cisterns i. e. in average 300 m^3. On the other hand, some of these reservoirs are of a capacity of 20000 m^3.

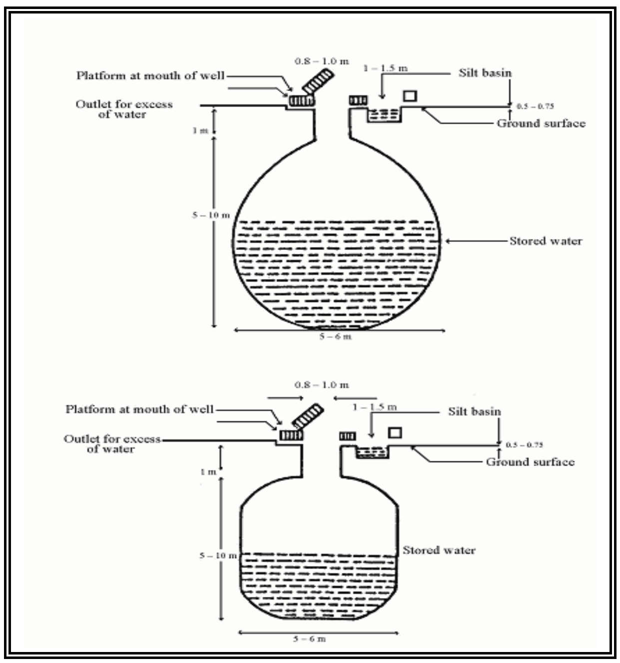


Figure 22. Typical WH Practice by Cistern

7.7 Indication of BP activities in WH

There are some indications of one or more types of land degradation here and there e.g overgrazing and/or soil erosion, but these processes are temporary, and the soil's ability to regenerate itself is very high, particularly in wet years. The overall development is positive, since the cultivated area in the region increased by 40% between 1980 and 1996 (such as Matrouh BP site). Thus, the ecological consequences of human activities remained relatively insignificant or were concentrated within a limited area, because the population densities of both men and cattle are sufficiently low in areas threatened by desertification.

Traditional "water harvesting" techniques can achieve significant improvements both in agricultural production and environmental rehabilitation. These techniques have contributed to the rapid restoration of vegetation cover and helped to reverse erosion in degraded areas in the north-west coastal areas of Egypt. Intensified establishment of water and soil conservation facilities has led to desertification control and desert reclamation activities and thus an increase of 15% in newly cultivated areas at surveyed farms. Effective coordination of governmental, non-governmental, and donor efforts is required to ensure the necessary investments, research, and extension work.

Water Productivity

On-farm water-productive techniques, if coupled with improved irrigation management options, like better crop selection and appropriate cultural practice, and timely socio-economic interventions will help to achieve this main objective. In dry areas, (such as the case of the selected WH BP site at Wadi Wateir-Sinai) water not land, is the most limiting resource for improved agricultural production. Maximization of water productivity, and not yield per unit of land, is therefore a better strategy for dry farming systems. Under such conditions, more efficient water management techniques must be adopted within these areas.

Farmers are increasingly aware of the problems associated with overgrazing, of the need to strengthen the vegetation cover, and to intensify work against soil erosion. Windbreaks and plantations of fruit trees have increased by 30% among the surveyed farmers. The trend toward increasing crop yields in conjunction with diminished use of chemical fertilizers indicates the success of human efforts to sustain productivity.

Table 11. Overview of the main WH techniques in Egypt

Water source	Objectives	Water Harvesting Technique	Example places
Rainfall	• To increase rainfall effectiveness • To conserve water/soil	• Terraces • Terraces Contour-ridge • Dams	• Matrouh • Wadi Wateir
Local runoff	• To collect water • To store harvested water (also used for domestic supply)	• Micro-catchment • Cisterns	• Sinai Desert Oasis
Wadi flow (flood and base flow)	• To divert water for irrigation • Protect the environmental condition • To protect land against floods (soil erosion control)	• Earth dykes (spate irrigation and small-head pumps & earth canals) • Wadi- bank enforcement	• Fayoum • Sinai read sea mountains
Spring Water	• To deliver water to participants within water • Right limits • To store limited quantities of water for short periods (also used for domestic supply)	• Earth canals • Cisterns	• Sinai oases • Material
Ground Water	• To abstract water from • Shallow aquifers (also used for domestic supply) • To exploit ground water • Stored in the coastal sand dunes	• Shallow dug wells and pits • Galleries	• Desert areas • Siwa Oasis

7.8. Selected BP Sites of WH in Egypt

The definition of BP sites varies according to the purpose selection as BP. In general the concept of best practice in the areas of interest of EWUAP relates to five main issues (i.e. Site properties) includes:

- Technical
- Economic
- Social
- Management, Operation and Maintenance
- Institutional

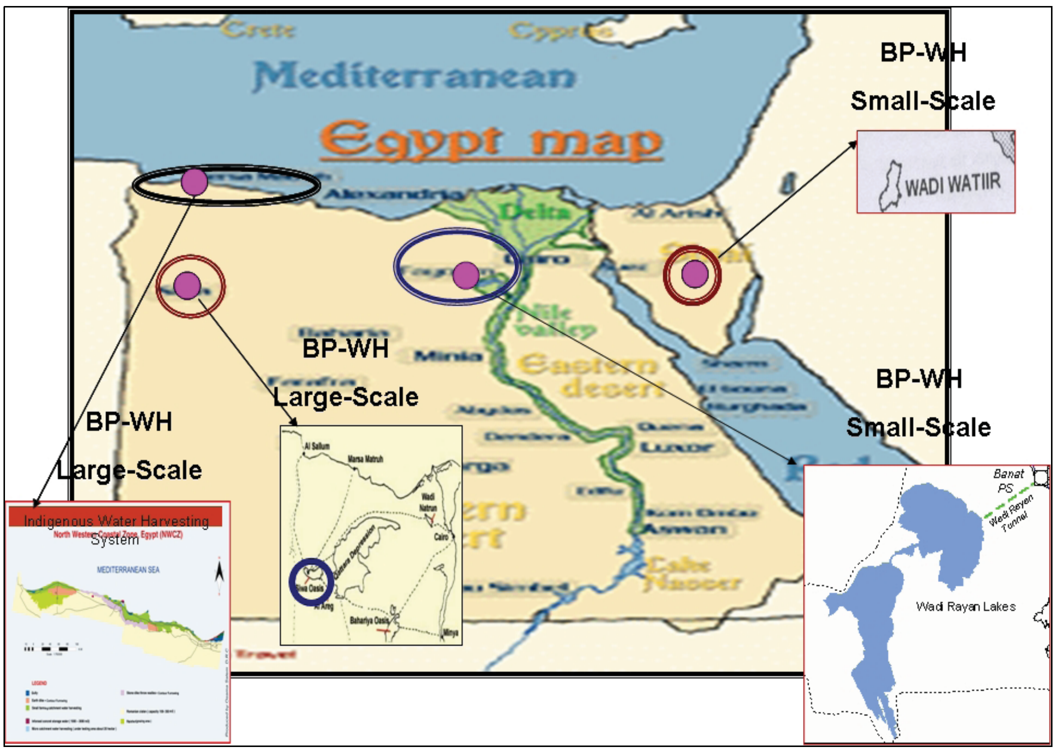


Figure 23. Selected Best Practice Sites of WH

Table 12. List of BP of WH Sites in Egypt

Site Properties	Reason for Selection	Site Name
Matrouh (North West Coast)	Harvesting of rain water	- Good example for WH of rain water to assist the new community and cultivation. - Well equipped site with good communication with local beneficiaries - The site got a well established O&M system supported by regional project - The local Gov. is trying to establish a small WUA from different local beneficiaries
Wadi Watier (Sinai)	Harvesting of floods/storms	- Practice of small scale WH of mountain area to harvest flood water for agriculture activities and livestock - The local farmers is helping the O&M staff (Gov.) - The project's activities help the beneficiaries to increase their income from the new cultivation and other small projects. - Problems of available funds for construction of new structures/wells.
Siwa oasis (West Desert)	Harvesting of groundwater and natural springs	- Example of large scale WH as a practice of harvesting/capturing the available low level groundwater in the area to sustain the existing community. - The established WUA is responsible for the operation of the system with strong support from the Local Gov. (MWRI) - The current activities supported the society for improving the living conditions
Wadi Rayan (Fayoum Protected Area)	Harvesting of drainage water for protection the ecosystem	- Another example for WH activities by harvesting/capturing the suitable water and reuse of agriculture drainage water for new cultivation and fish-farming to protect Qaroun Lake (Protection region) - Until now the operation and activities is full controlled by the Gov. MWRI, some assistance from the local farmers and fisheries. - The project support the fish farming in the area and encourage the cultivation of new crops that sustain the saline water - It is planned to establish some industrial activities in the area with the beginning of this new community

The proposed BP sites will be considered for wider dissemination of practices in the home country-Egypt and if possible within the Nile basin, listing the strengths and weaknesses of the systems and the areas where opportunities exist. The information collected will form part of the process of sharing positive experiences and information, and to encourage the wider support from governments, private sector and donors in integrated catchment management involving water harvesting and irrigation.

Table 13: illustrates the used legend for main activities of WH schemes in the selected BP Sites for this study. Details of these BP sites according to the finding of the field visits are given in ***Annex 2*** (List of selected BP sites of WH).

The site selected for a water- harvesting system will significantly affect the installation costs, performance, and utilization of the facility. Factors to be considered in Water Harvesting with Special reference to Egyptian Experience when selecting a site are: alternate water sources, quantity of forage, soil type and depth, land topography, accessibility, and precipitation patterns.

Figure 24. Sample Activities of WH in Wadi El-Rayan

Table 13. **Legend for Water Harvesting schemes in the Selected BP Sites**

Name of Site	Wadi Watiir- Sinai	Siwa Oasis- West Desert	Um Ashtan- Matrouh	Wadi El-Rayan-Fayoum
WH Activities	1. Open Pond - excavated in natural conditions	1. Manage the open Ponds from the natural springs conditions	1. Open Pond - excavated in natural conditions	1. Open Pond - excavated in natural conditions (Qaroun lake)
	2. Crescent shaped dam/Water Ponds/Pans	2. Sub-Surface irrigation,	2. Crescent shaped dam/Water Ponds/Pans systems	2. Water Ponds
	3. Small Dam - earth embankment	3. Surface drainage system	3. Small Dam - earth embankment	3. WH for fishing and new community
	4. Sub-Surface drainage	4. Groundwater Well - shallow	4. Spring Development and other uses	4. Runoff Water Harvesting (Agricultural/Homestead Use)
	5. Roof Water Harvesting (Domestic Use)	5. Spring Development for other uses	5. Runoff Water Harvesting (Domestic Use)	5. Agricultural drainage water harvesting (diversions) for small scale irrigation
	6. Runoff Water Harvesting (Domestic Use)	6. Runoff Water Harvesting	6. Runoff Water Harvesting (Agricultural/Homestead Use)	6. Spate Irrigation
	7. Runoff Water Harvesting (Agricultural/Homestead Use)	7. small stream water harvesting (diversions) for small scale irrigation	7. Rock and other surface catchment systems	7. Recharge Structures (diversion canal water to fish farming)
	8. River water harvesting (diversions) for small scale irrigation	8. Spate Irrigation	8 River water harvesting (diversions) for small scale irrigation	8. Water harvesting Measures/ Soil and Water Conservation
	9. Spate Irrigation	9. Soil conservation	9. Spate Irrigation	
	10. Water harvesting Measures/ Soil and Water Conservation techniques on arable rainfed lands		10. Recharge Structures	
			11. Water harvesting Measures/ Soil and Water Conservation techniques on arable rain fed lands	

Figure 25. Sample Activities of WH in Wadi El-Rayan

The WH system:

Soil type is one of the main criteria of site selection. If the required soil type is not present within the general area the catchment soil must be treated. Before installing a catchment's treatment, the soil surface should be cleared, smoothed, and compacted, dikes should be constructed around the edges; and soil disinfection should be applied to prevent any plant re-growth.

Dike construction:

Dikes around the perimeter of the catchment area are usually necessary to contain the collected water and direct it to the catchments outlet.

Smoothing and compacting:

A smooth surface makes installation of the treatment easier, improves the runoff efficiency, increases the life of the treatment, and reduces potential problems of mechanical damage. Following the initial clearing and raking, the catchment's surface and dikes should be smoothed and compacted.

The Storage Tank:

The storage tank is the component of a water-harvesting system that stores the collected water until it is needed. Any container that prevents water loss by seepage is a potential means of water storage. Typical storage tanks are earthen reservoirs, lined pits, and various steel, plastic, concrete, or wooden tanks. The tanks may be completely enclosed or, as on many installations, open at the top. Open-top tanks for water harvesting system usually require some means of reducing or preventing water loss by evaporation. Typical evaporation control measures are roofs over the tanks or covers floating on the water surfaces.

7.9 Socio-economic Indicators of Successful WH

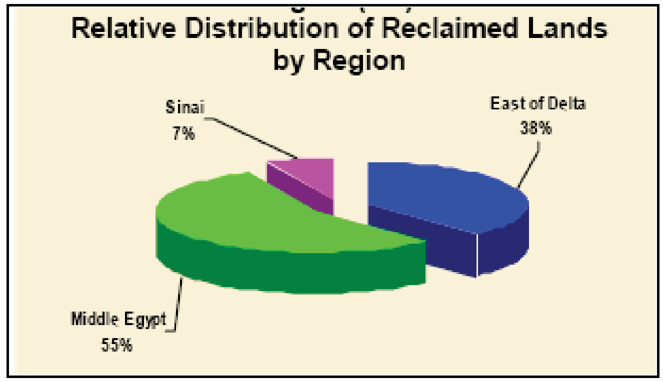
The socioeconomic indicators of agricultural development relating to rainwater harvesting techniques should be considered. These indicators include the land tenure system, land management, cropping patterns, farm income and sources of farm revenues, the gross margins of selected agricultural products and livestock, animal nutrition management, and the rate of profitability of farm production.

A recent study (“Estimation of Development Costs for the Area of Qasr Rural Development Project (QRDP) at Marsa Matrouh”, Internal Report of GTZ/ QRDP, Marsa Matrouh, Egypt, 1993.); estimated the investments required to upgrade the arable land in the study area at $ 1485/ ha, assuming that the work was performed by private contractors. Governmental overheads and supervision costs were not considered. The most important activities proposed to upgrade this area were: landscaping (terracing, leveling, etc.), water provision (dikes, dams, cisterns, etc.), groundwater wells including pumping facilities, and feeder roads. The implementation of these improvements might be feasible within a period of five years.

8. ECONOMIC AND SOCIO-ECONOMIC ASPECTS IN BP SITES

8.1 General

Investments in this sector reached about LE 7.5 billion in 2006/07. Private sector contributed an estimated investment of about LE 5.4 billion accounting for 72% of the total, while public investments were in the order of about LE 2.1 billion, constituting 28%.



The agricultural product amounted to LE 68.6 Billion in 2006/07 compared to LE 66.2 billion in the previous year. This implies an Unprecedented growth rate of 3.7%. {*Social and Economic Development-Ministry of Economic Development A Follow-Up Report for the Year (2006/2007)*}

The main achievements throughout 2006/07

- Reclaiming about 53.5 thousand feddans during 2006/07, of which 55% in Middle Egypt (see figure above)
- Finishing the implementation of irrigation and drainage infrastructure for 137 thousand feddans in the district of Sahel El Tina, and South of Qantara Shark.
- Completing irrigation development works for about 190 thousand feddans.
- Executing covered drainage networks for 91 thousand feddans.

8.2 Economic analysis of BP activities

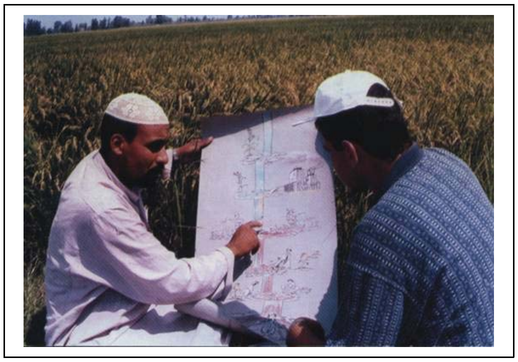
The target is to identify costs and benefits of water/land in agricultural project analysis.

"With" and "without" analysis

An extremely useful rule of thumb approach to identify the overall return arising from an agricultural project is to know what will be the impact "with" and "without" the new approach technique as BP. The difference is, in general, the net additional benefit arising from the project. You can then proceed to verify that the specific costs and benefits you have identified to add up to the difference "with" and "without" and that none are missing. Note that the question is not posed as the difference **"before"** and **"after;"** it is easy to miss some of the less obvious costs and benefits if the question is asked in that form. In economic analysis, certain prices may be changed to reflect better true social or economic values.

The methodology of comparing costs and benefits is the same whether we are seeking the economic or the financial return. Only what is defined as a "cost" and what is considered a "benefit" is different.

One of the main objectives of the Socio-Economic Assessment, and Institutional Strengthening is to prepare appraisals of new BP projects as well as to evaluate the impacts of previously implemented activities and to consult/cooperate with beneficiaries in all project's stages; also issuing a policy document on transferring responsibilities of irrigation/agriculture management to the stakeholders or private sector.



8.3 Cost and Benefits of Agricultural Projects

Costs in Agricultural projects

In almost all project analysis, costs are easier to identify (and value) than benefits. In most agricultural projects the land where the development is to occur already produces some amount of agricultural produce. An area to be irrigated may now be cropped on a dry land basis or an area to be converted to fruit may now be planted to wheat. The situation is not the same as "before" and "after," the introduction of new technique as BP.

Benefits of Agricultural projects

Benefits in agricultural projects can arise either from an increased value of output or from reduced costs. The specific forms, in which benefits appear, however, are not always obvious and valuation problems may be exceedingly difficult.

Increased value of production can most obviously arise from increased physical production of a crop or livestock product—provided the market and price relationships are such that the greater physical volume does not simply trigger a more-than-offsetting fall in price. Since most agricultural projects are not large enough in themselves that they will significantly affect price relationships, the interrelation of prices and production increases is usually not a problem in project evaluation. It can be, however, where projects are large relative to their proposed market or where there may be a rapidly growing supply of the commodity to be produced by the project's new activities.

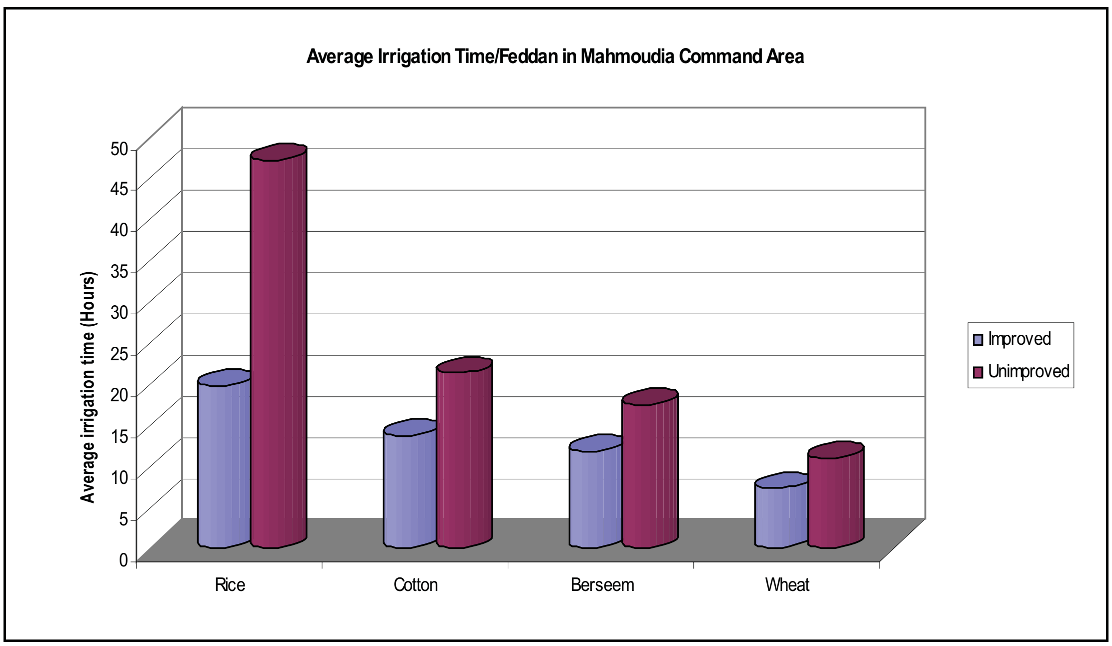
8.4 Case study of improvement activity as BP technique.

It is important to assess the impact brought by the improvement activity on on–farm irrigation practices and general farmer perception of the improvement. A sample survey of farm holders was carried out in the select BP sites (W/10 and Bahr El-Nour sites) (M&E of IIP in Old land in Egypt IIS-2006).

The results of the study showed that farmers considered water supply was adequate in winter season in the improved areas in both sub-projects. However, in summer season surprisingly a large percentage of farmers in improved areas thought that canal water was inadequate. Overall water shortage problem still existed in improved areas since continuous flow has not been effectively applied in the branch canals which feed the improved meskas. However, this problem existed in improved areas with less rate of severity than that in unimproved areas (more additional work to satisfy the water needs in summer and to minimize rice cultivation are recommended).

The purpose of the farmer surveys was to assess the potential impact of the irrigation improvement project on socio-economic conditions in the project area. For this purpose, the collected data was analysed with respect to status of meska improvement. The analysis has been concerned with farmer attitude and perception of the irrigation improvement project.

Some of the findings as BP activities are given in the following Graphs.



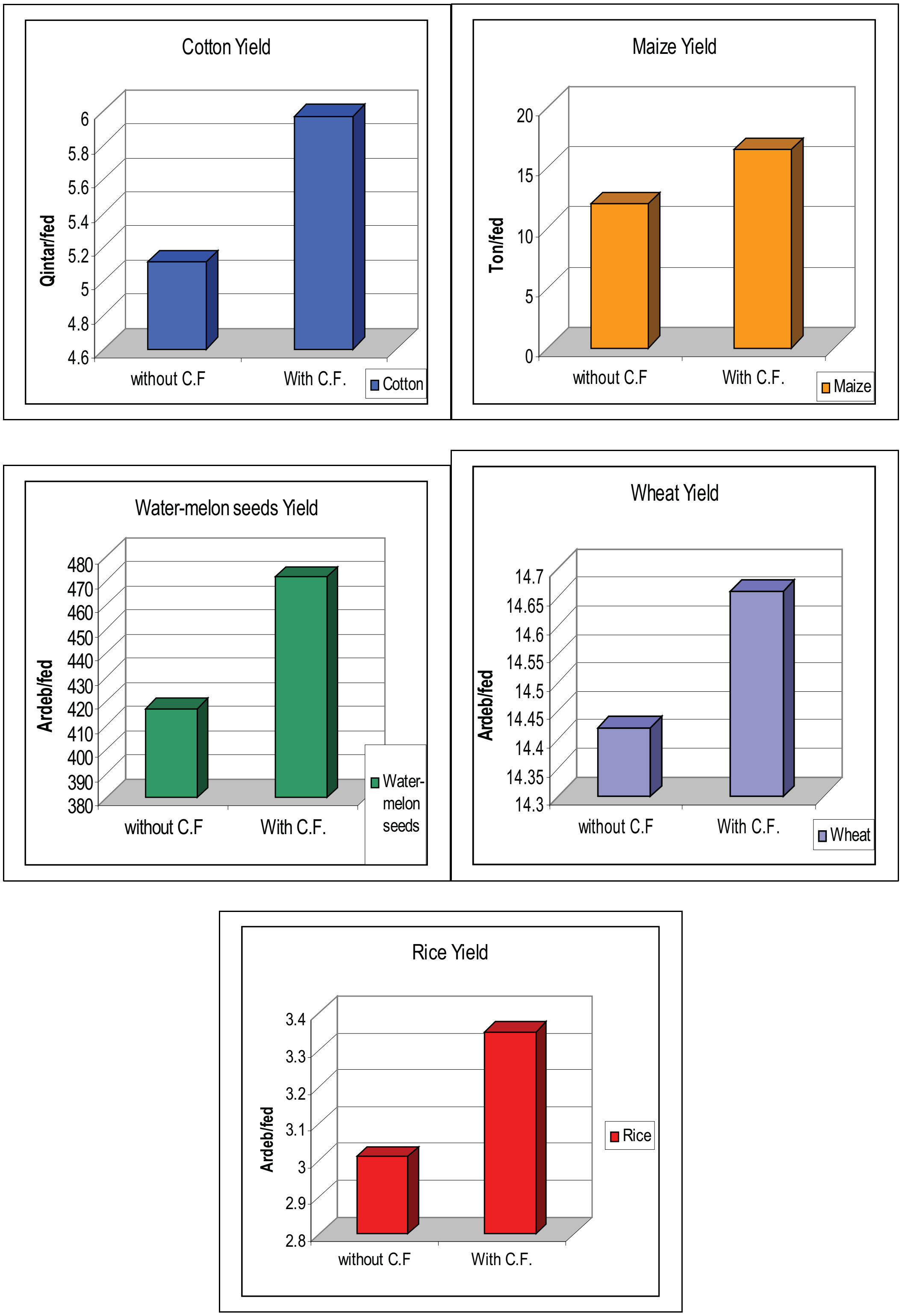


Figure 26. Sample of results of benefits of BP activities

8.5 Socio-Economic Analysis of Agriculture Practices

Most irrigation canals run through villages and other levels of farming communities with the irrigation waters flowing under pollution conditions and of low water quality. This pollution and low water quality will impact negatively on both production of crops (quantity and quality) and the health of human beings.

All these negative impacts will affect the sustainability of socio-economic development as well as the environmental conditions and the new practices as these small scale irrigation communities try to improve these conditions.

It is important to develop a functioning mechanism among stakeholders to protect water quality of the system. This objective enables the NGOs to play an effective role in controlling the pollution loads from the sources. The long-term development results of such a strategy will lead to the sustainable socio-economic development in an environmentally safe manner.

It was noticed that agriculture is the main source of income for most inhabitants even some of them are working in different government jobs. The main crops cultivated are wheat, Berseem, Broad-bean and winter vegetables (Tomatoes, pea, squash, etc) in winter and rice, maize, cotton and summer vegetables (Tomatoes, potatoes, cabbage etc) in summer. On the other hand, livestock seemed the most important source of milk production and its other sub products.

Table 14 summarizes the area cultivated by different crops, total costs and returns per feddan and the average yield per feddan in the presented BP of W/10 site. From this table, it can be said that the average yield per feddan for most crops are acceptable to the average of Delta area; the average yield for wheat is about 13 ardab, 5.5 kenter for cotton, 17 ardab for maize, 8 ardab for Broad bean and about 3.5 ton for Rice.

Figure 27. Sample of new cultivation techniques at BP sites

Table 13. Area, Total cost and Returns of some crops in BP sites

Crop	Yield		Total cost US$/Hectare	Total return US$/Hectare
	Unit	Main product		
Wheat	Ardab	13	636	1296
Berseem	Cutl	4	318	1789
Cotton	Kantar	5.7	1409	914
Maize	Ardab	17	714	984
Rice	Ardab	3.5	891	1441
Bean	Ardab	7	627	694

According to the socio-economic analysis, the following achievement indicators can be presented in BP sites:

- The increase of stakeholders participation
- The percent increase of charge collection (self-finance).
- Decrease of conflict between villagers.
- The success of such mechanism and its publicity in the project area will motivate other neighbors to imitate and create their own mechanism.
- Increase of the environmental awareness through knowledge transfer of success cases around the pilot area of the project.
- Increase the number of job opportunities due to the spread of success cases all around the nearby villages and small communities
- It is expected that some percent decrease will be achieved in utilization of chemical fertilizer.
- Yield per hectare for different crops cultivated will be improved and so, farm income will be increased.
- Decrease of the prevalence rate of diseases amongst villagers. Increase in the number of healthy inhabitants will help improve the active life span and thus and increase their family income.

Accordingly, it is recommended that monitoring and follow up of stakeholders through WUAs need to be expanded. Flyers, posters, media and dissemination tools have to be deeply applied around the pilot area and neighboring areas to up-scale these BP activities.

8.6 Impact of BP activities for Socio-economic Situation of Farmers

The appraisal of the socio-and agro-economic effects of the improved irrigation suggests that increased availability of water has augmented the productivity of irrigated crops on average by 12 to 15%. At the same time the water productivity is increased. Such gains in water productivity are primarily attributable to improvements of the agricultural production technology. For example, farmers from the study area report that they have widely adopted the use of short duration rice varieties. This has shortened the time from transplanting to harvest by up to four weeks. It also has helped to save a considerable portion of irrigation water.

However, the shortening of rice cultivation by four weeks has created a window of opportunity for the cultivation of an additional crop, which takes advantage of freed land and water resources. The net effect of water savings through the adoption of short duration rice varieties is hence balanced by an intensification strategy on the part of farmers.

It can be assumed that improved irrigation has augmented the income of farmers, although gains probably fall short of expectations assumed at project design stage*; (Economic Evaluation of Irrigation Projects in Egypt, July 2007).*

8.7 Main Characteristics of Agricultural Investments in Egypt

- To guarantee unlimited areas for growing all kinds of crop; liberalization of crop composition
- To ensure that the Private Sector is free to produce, market and import.
- To guarantee the free marketing of main crops (ex. cotton)
- To advocate rural development through small enterprises relying on local services.
- To guarantee that the Private Sector is free to export/import agricultural commodities.
- To develop a solid agricultural infrastructure.
- To provide land suitable for cultivation and reclamation.
- To provide and conserve water by using modern methods of irrigation.
- To provide cheap and skilled labor.
- To create opportunities for agricultural exports.

9. POTENTIAL COOPERATING NATIONAL INSTITUTIONS FOR DEMONSTRATION OF BP

There are many centers of excellence which are helping in the development of Egyptian economy. These centers belong to different ministries. The most important ones are those that belong to; ministry of water resources and irrigation, and ministry of agricultural and land reclamation. The following is a brief description of these centers.

9.1 Water and Land Research Centers

National Water Research Center (NWRC)

The national water research center (NWRC), is a pioneering institution for various water research activities in Egypt. It was established in 1975 as a research organ of the Ministry of Water Resources and Irrigation (MWRI). Under the jurisdiction of NWRC, twelve research institutes exert concerted efforts to implement a comprehensive research plan serving ongoing MWRI projects and national development in general. Each of the twelve institutes is concerned with one research discipline in the field of water engineering and related issues. Besides, NWRC established a Strategic Research Unit, Central Water and Soil Laboratory, Geographic Information System and an Information and Documentation Center. Via its twelve institutes and in the light of future plans of water resource development and management, the ultimate objective is to maximize water use and minimize losses.

Objectives of NWRC

- Study, outline and propose long-term policies for managing water resources in Egypt.
- Solve the technical and applied problems associated with general policies for irrigation, drainage and water resources.
- Carry out investigation and research work connected with expansion of agricultural lands.
- Find the means for utilizing the water resources of the country in the most efficient and cost – effective way.
- Propose measures for environmentally sound development of the irrigation and drainage systems.

Provide necessary research needs to the twelve Research Institutes, the Strategic Research Unit, and the Central water and Soil Laboratory.

Name of Institute	Logo	Objectives
Water Management Research Institute (WMRI)		It deals with researches relevant to distribution of irrigation water, modern irrigation systems, assessment of plant water requirements, and improvement of the irrigation delivery network, increasing irrigation efficiency and minimizing water losses. Monitoring and Evaluation of irrigation/agriculture schemes and Socio-Economic analysis; (i.e. CMI, PPMI activities)
Water Resources Research Institute (WRRI)		It works in the field of water resources development conducting studies on the possible projects to be implemented in the upper tributaries of the Nile River and in the Sinai Region, in addition to the establishment of a complete network of recording devices to be used in designing dams and other control structures, also water harvesting activities in the arid regions; (i.e. WH activities)
Environment and Climate Research Institute (ECRI)		It established in 1994 to perform high level research on the impacts of both environment and climate change on natural resources, in particular water resources. The Institute activities are:- ❖ To Study the environmental impact assessment on water resources and other water development projects. ❖ To investigate short and long-term effects of climatic fluctuations on the environment and on water resources

The Agricultural Research Center (ARC)

The Agricultural Research Center (ARC): The Agricultural Research Center (ARC) was created in the early 1970s. Over the past two decades, numerous achievements have been realized, including the development of new varieties, improved agronomic practices, livestock development, maintenance of the national herds and better food processing techniques. New crops and animal breeds have also been introduced and research has been dedicated to problem- solving, side by side with basic science. The overarching goal is to maximize the economic return per unit of land and water.

Name of Institute	Logo	Objectives
Field-crops Research Institute		The main goal of the institute is to increase crop productivity and quality to ensure food security, optimize use of natural resources (land & water); and use up-to-date technology to reduce input cost and increase net returns to the farmers; (i.e. CMI, activities).
Soils, Water & Environment Research Institute		Conducting studies and researches on: - Soil-water-plant relations, Soil survey and classification, Improvement and conservation of cultivated soils, Soil fertility and plant nutrition, Organic farming, Crop water requirements, Water suitability for irrigation, Designing and evaluation of field drainage networks, Reuse of marginal water in irrigation and Environment; (i.e. CMI, activities).

9.2 Academic Research Universities

Cairo University Faculty of Engineering

The Department of Irrigation and Hydraulics is responsible for the following programs:

- Fluid Mechanics
- Hydraulics
- Irrigation and Drainage
- Hydrology and Water Resources
- Harbor and Coastal Engineering.

To provide well equipped facilities required for post graduate research with particular emphasis on topics related to the River Nile, irrigation systems, conjunctive use of Egyptian water resources, open channel and closed conduit flows, water quality monitoring and analysis, and also the environmental impacts of industrial processes.

Ain Shams University Faculty of Engineering

The Irrigation & Hydraulics Department is one of the oldest departments in the University. It is one of the important departments as it deals with certain branches of science that are related to the society and environment. Among these branches are Irrigation Works, Drainage, and Land reclamation, Underground Water, Harbor Engineering, Coastal Engineering, Inland Navigation and the Environmental Science relevant to the above branches. The main aim of the Irrigation & Hydraulics Department is to graduate qualified Civil Engineers, in accordance with the country's policies that pay much attention to the big water Projects. This is reflected in the courses that are taught in the department such as Fluid Mechanics, Surface Water Hydrology, Irrigation & Drainage and the applied science such as Hydraulics, Irrigation Works, and Harbor Engineering & Inland Navigation. Also, among the courses taught in the department are Water Resources, Methods of Irrigation and Drainage and Big Irrigation Projects benefiting from the Nile water as main source.

9.3 Sample Private Consultants

NILE CONSULTANTS

Nile Consultants is an Egyptian consulting firm specialized in Water Policy and Management, Agricultural Development, Environmental Assessment, and Socio-economic and Institutional Strengthening.

Nile Consultants is working primarily with MWRI/MALR and its different sectors, research centers and authorities. The firm is successfully implementing different consultancy contracts (Land/Water development projects, Socio-Economic, WUA-participatory approaches).

In 1995, Nile Consultants had implemented a water harvesting study for Fum Mulgha and Wadi El Raml region in Tarhouna mountains, Tripoli, Lybia. The study area has a size of 475 km2 and consists of four wadis. The annual rainfall in the study region was 275 mm in average. Geomorphologic studies were performed to identify the catchment boundaries, tributaries, slopes, drainage areas, and geologic formations of each wadi. Hydrologic models were applied to determine runoff volumes, peak flows, time to peak and flood frequency based on comprehensive analysis of available meteorological data. Sediment loads were estimated for each wadi at the potential sites for control works.

Sample of Water Resources Development Projects

A water harvesting study for Fum Mulgha and Wadi El Raml region in Tarhouna mountains, Tripoli, Lybia was conducted. The study area has a size of 475 km^2 and consists of four wadis. The annual rainfall in the study region was 275 mm in average. Geomorphologic studies were performed to identify the catchments boundaries, tributaries, slopes, drainage areas, and geologic formation of each wadi. Alternative plans included small flood control and storage reservoirs, diversion structures, underground reservoirs, gabions, and retaining (protection) walls.

Sample of Agricultural Development Project

One major project carried out is the design of pump stations, pipelines and underground reservoirs and a land reclamation project of the order of 26,000 feddans at El- Ayat district, Giza governorate. The project relies on River Nile for irrigation, as water is lifted by a number of pump stations then transported through pipelines to storage reservoirs to be lifted by boosters to the land. Another project for the private sector along the Cairo-Alexandria desert road was planned and designed by Nile Consultants. In this project, groundwater wells for irrigation were designed and tendered along with modern irrigation systems (drip and sprinkler systems).

Sample of Environmental and Socio-Economic Management

An assessment of the impacts of Nile River protection projects in Aswan, Qena, Sohage and Assuit on the environment and on the socio-economic conditions of project beneficiaries.

We may recommend the following four main institutes for further cooperation with EWUAP regarding the BP activities in Egypt:

- WMRI- NWRC- MWRI
- WRRI-NWRC-MWRI
- SWERI- ARC-MALR
- Nile Consultants

10. CONCLUSION

The conceptual framework for this multi-disciplinary rapid assessment of best practice study is based on the provided format for identification of a range of technologies and criteria to be included in BP (CMI, PPMI and WH) sites selection approach (PMU-EWUAP); *National Consultation ToR are given in **Annex 4***.

The given checklist provides a coherent framework of thinking that can assist in the formulation of project's component (WH, CMI, and PPMI) and adequate water resources/land management interventions. It implies an iterative, circular process of descriptive and diagnostic steps at various landscape levels. It is based on proposed active participation of stakeholders (people and relevant institutions), and it appreciates the diversity of water resource use and management situations that exist in each site.

The main goals of current EWUAP project's activities are:

(a) To improve operational, institutional, financial and environmental sustainability of water/land services through intensive user and private sector participation in the investment, operation and maintenance at deferent levels and improved water and land management practices; and

(b) To increase farm incomes through improved agricultural production based on efficient, more equitable and sustainable use and management of water and land resources in each of the Nile Basin Countries.

Right from the beginning of the current National Consultation study, it was realised that the proposed approach needed to be conceptually translated in the context of a "real life situation at the selected BP sites" which implied a conversion of the theoretical approach into a practical and real life-oriented methodology. Most importantly, the methodology needed to be adjusted in order to more visibly accommodate institutional aspects in the analytical process according to the existing management criteria.

Egypt is a large country with many regions e.g., Nile Delta, Nile Valley, Western Desert…etc. Many demands are placed on a unique water resource that is the Nile River, with too many people, agencies or institutions trying to manage this limited resource. While water systems are integrated resources, the human response – in development efforts – is often not integrated. At the national level the (MWRI) and (MALR) are not the only actors in the field of water resources/agriculture policies. Several ministries have responsibilities related to water resources management. Stakeholders at Central Government level involve ministries which have a responsibility with respect to the supply of water of sufficient quality or which have a specific task to represent the interests of categories of water users. Other stakeholders are the Public, Private Water Users, farmers (e.g. Water Users Associations and Water Boards). Also, organizations responsible for providing drinking water and sanitation (General Authorities, Economic Authorities and Companies) and public and private industry and eventually all water users of the citizens and the public at large.

Egypt has developed almost all of its renewable water resources. There is not much potential for increasing renewable water resources in Egypt in the future, therefore, Egypt has gone a long way in the use of low quality water, especially agricultural drainage that is mixed with fresh Nile water to irrigate large areas in the Delta region. Treated sewage has been used for specific types of trees and non- edible crops. In addition, Egypt also exhibits the use of desalinated seawater for special purposes in specific locations. Therefore, scaling up the introduced BP activities will help to achieve the proposed target of water and land conservation and to improve the current agricultural practices to increase the agricultural productivity and farmer incomes.

The integration with related policies requires co-operation, commitment and transparency between representatives of different groups, in other words stakeholders' effective involvement. These stakeholders are not to be restricted to organizations of public administration, like other ministries and governorates. The private sector has its own responsibility as water user. This sector should also have a task and role in an efficient and rational use of water resources, the development of new water resources and the protection of water quality. The new MWRI/MALR strategies should contain proposals to enhance the involvement of representatives of all stakeholders' organizations at all levels.

Lack of real-time field information is the main reason. Farmers' cropping patterns and calendars may not be consistent with the ability of the Nile system to deliver adequate supplies when needed; but there is no routine, accurate, and systematic information transfer between farmers, MALR and MWRI, nor is there understanding of system delivery constraints on the part of MALR and farmers. Matching real-time irrigation water demand with water delivery has become a critical issue since the free-cropping policy toward an efficient demand-driven irrigation system. There are continuing urgent research needs concerning the processes that govern water use and irrigation efficiency, crop production, water source dynamics, drainage water quantity and quality, reuse practices.

Economic impacts: One of the main reasons for implementing irrigation improvement projects and establishing user associations is to alleviate the burden of operation and maintenance costs from the government to the water users. In Egypt, the irrigation improvement project and the users' participation in the operation and maintenance of the canals resulted in more agricultural production, more income to the farmers as a result of reliable water flows, especially for the tail-end farmers. It also resulted in reduced cost of irrigation operation as well as reduced costs of meska (private canal) cleaning due to the existence of one large pump at the head of the BP meska where all farmers share in its operation and maintenance costs.

Social impacts: The main social impact of BP activities using available Water/land and user participation is the sense of responsibility that had been generated among the water users. This sense of responsibility led to the operation of the system more efficiently to allow equity in water allocation and distribution among users. Cooperation and coordination among farmers within the users group (association) helped in minimizing the operation and maintenance costs of the irrigation system at the group level.

User participation: It is clear that Egypt has gone a long way in the involvement of water users in irrigation management. Egypt has also issued a law for identification of water users associations (WUAs). The duties and rights of WUAs have been clearly stated. Farmers are in charge of operating and maintaining the irrigation system at the private canal level. However, it is not clear how farmers increase the financial resources of the associations to perform its duties properly. Farmers participation in the activities in the selected BP sites raises the sense of responsibility among farmers and resulted in achieving higher water use efficiencies. Farmers resolve their disputes and cooperate to run the system and save water and financial resources.

In the context of water and land management, the concept of water productivity ("more crop per drop") appears to be too narrow as the use of water in an integrated system creates benefits other than additional agricultural production. It should be replaced by a broader concept of "more value per drop" allowing for the inclusion of beneficial use of water for other uses.

Environmental management is urgently needed in order to control and reduce pollution – especially from industrial sector so as to introduce modern pollution management in these BP sites.

Options for Meeting Future Challenges:

1.Increase contributions from users through self financing of recurrent costs of water/land infrastructure.

2.Reduce the transaction costs and overhead expenditure through decentralizing and improving efficiency in service delivery.

3.Facilitate private sector participation in financing, developing and operating water/land schemes in response to user preference and willingness to pay.

For Successful BP Sites it is recommended that:

1-Political and public support is essential;

2-Realistic investment and service targets are needed;

3-Appropriate allocation of risks and responsibilities between different parties is required;

4-Allocation of legal land ownership and water rights is effected;

5-Appropriate institutions, legislations and regulations are put in place; and

6-Integrated regional development for up-scaling of BP activities is necessary.

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Reference Documents

The following documents would be availed as reference background material:
1- EWUAP Project Appraisal Document PAD.
2- EWUAP Project Implementation Plan PIP.
3- EWUAP Project Implementation Manual PIM.
4- Rapid Base Line Assessment of Agricultural Sector of Egypt RBA.
5- Integrated water Resources Management Strategy development by the International Water Management Institute (IWMI), FAO and other.
6- Country reports/documents prepared in relation to the design and development of the project and available with TAC staff and EWUAP SC member, NPC in Egypt.