1. INTRODUCTION

1.1. Origin of Water Research in Egypt

Due to arid conditions, Egypt depends mainly on irrigated agriculture (99.8 percent of the cultivated area) to produce food and fibre for its large mass of population. The total cultivated area under irrigation is estimated at 8.4 million feddans (one feddan = 4 200 square meters). The average annual cropping intensity reached a value of 1.9 in recent years, which made the agricultural demands amount to 54 Billion Cubic Meters (BCM).

Pressures on water resources of the country come from all sectors of the economy with the highest demand from the agricultural sector. As shown in Figure 1, Egypt's annual water requirements are estimated at 70.0 BCM; if compared with available resources (57.7 BCM), the result would be significant deficit. The per capita share of available water resources in year 2000 was 859 m^3, and expected to decrease to 720 m^3 per year by the year 2017. To overcome this shortage, part of the agricultural drainage is reused, beside the use of shallow groundwater and non-conventional resources.

The Ministry of Water Resources and Irrigation (MWRI) is the official authority in charge of development, allocation and distribution of all conventional and non-conventional water resources of the country. In order to achieve its goal, MWRI realized the role of research in formulating its policy before even having a formal comprehensive water policy. The research and technical studies date back to the nineteenth century. Survey research, hydrologic studies, and Upper Nile expeditions started as early as 1870.

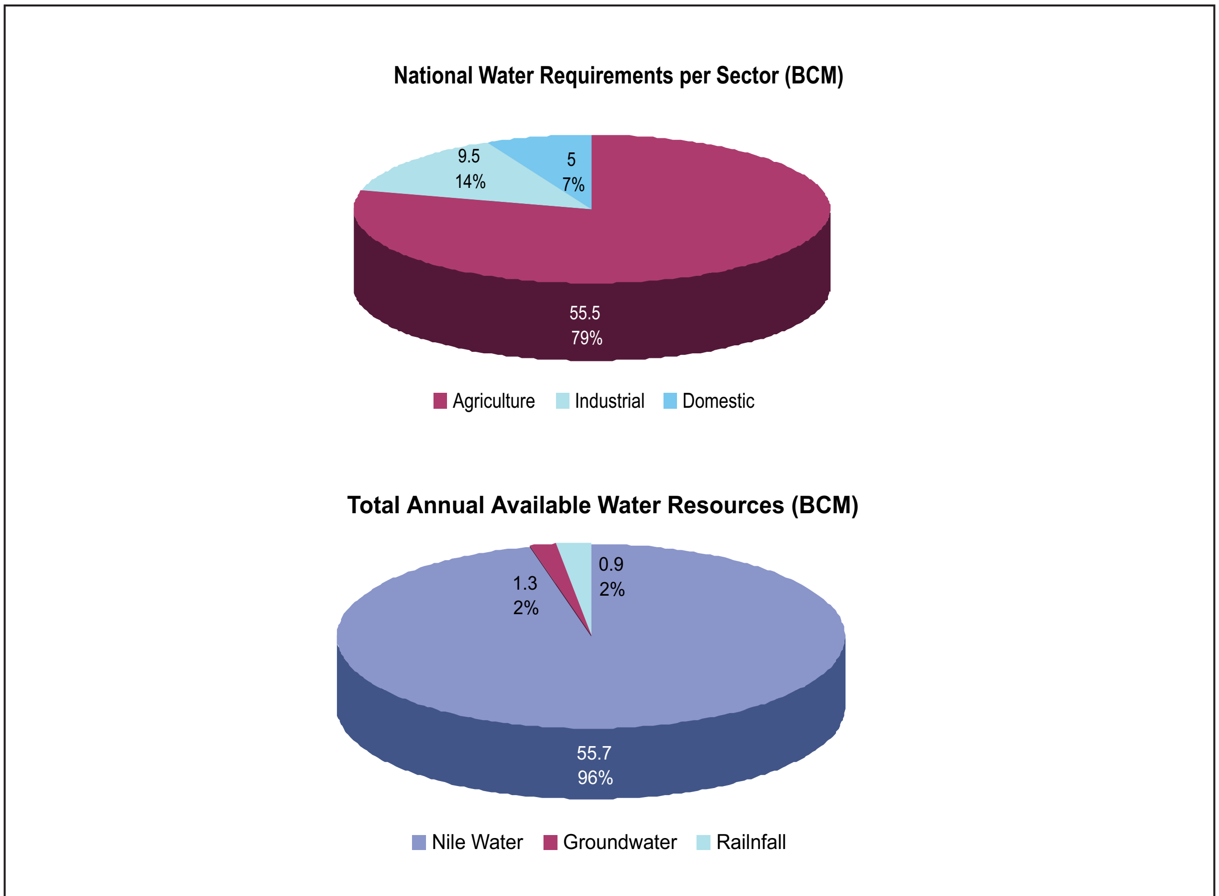
The memorandum titled "Nile control" published by the Ministry of Public Works in 1920, is probably the first documented Egyptian water policy (El-Kadi, 1999). After the completion of HAD, a series of water resources policies had been formulated to improve the management of the available water resources in order to match the current and projected water supply with demands of all sectors. Until 1999, all water policies concentrated on managing the supply side to meet the increasing demands for water and allocate any excess water to land reclamation projects. None of the previous water policies, except the 1999 water policy, took into consideration the use of desalination of seawater or brackish groundwater. Looking to the future and the coming water crises, non conventional kinds of resources may be feasible in the future, due to expected improvement and development of technologies. The Integrated Water Resources Management (IWRM) concept was introduced in the 1999 water policy. Water quality and environmental water related issues started to be mentioned explicitly in water policies.

The memorandum titled "Nile control" published by the Ministry of Public Works (MPW) in 1920, is probably the first documented Egyptian water policy (El-Kadi, 1999). After the completion of HAD, a series of water resources policies had been formulated to improve the management of the available water resources in order to match the current and projected water supply with demands of all sectors. Until year 1999, all water policies concentrated on managing the supply side to meet the increasing demands for water and allocate any excess water to land reclamation projects. None of the previous water policies, except 1999 water policy, took into consideration the use of desalination of seawater or brackish groundwater. Looking to the future and the coming water crises, non conventional kinds of resources may be feasible in the future, due to expected improvement and development of technologies. IWRM concept was introduced in the 1999 water policy. Water quality and environmental water related issues started to be expressed explicitly in water policies.

In 2002, MWRI started to formulated the National Water Resources Plan (NWRP) based on a strategy that has been called 'Facing the Challenge' (FtC) (NWRP, 2005). FtC includes measures to develop additional resources, make better use of existing resources, and measures in the field of water quality and environmental protection. The plan has three major pillars: (1) increasing water use efficiency; (2) water quality protection; and (3) pollution control and water supply augmentation.

The water policy development in Egypt faced a number of challenges; mainly, the mismatch of water supply and demand that resulted from increasing demands for water in all socio-economic sectors. The rate of demand growth is linked directly to the growth in population and, the improvement of the living standards. In addition to that, the available water resources in Egypt are limited and the rate of its development is much slower than the rate at which demands increase. This means that the gap between available resources and water requirements is getting wider over time and Egypt will be facing water scarcity in the near future.

Figure 1: Water Availability and Demand in Egypt



The distribution of Nile water is nearly uniform from Aswan to Cairo with a fairly good quality due to the Nile system of self purification. Nevertheless, the pollution increases in the two Nile branches towards north as they receive nutrients, organic loads, grease and oils from the intensified agriculture, residential and industrial activities in the Delta region. This continuous decline in water availability, in terms of quantity and quality, requires more stringent measures from all users to achieve more with the limited water available. However, what makes the MWRI mission more exigent is the fact that water sector actions in Egypt are shared among many governmental and non-governmental authorities.

Research is deeply rooted in the activities of MWRI, since its establishment in 1864. Prior to the completion of HAD research took a number of facets including: survey investigations and studies; Nile Basin data collection and hydrologic analysis; hydraulic structure experiments; irrigation water duties; drainage rates; and groundwater. Since the establishment of Surveying Authority in 1878, hydrologic research and studies were carried in one of its divisions, while experiments and measurements were conducted by the different inspectorates of the Ministry. In 1915, a Physical Department was created to conduct hydrologic and hydraulic research. It was headed by one of the pioneer hydro scientists, Dr Hurst, who put the research founding stone in MPW. Three years later, an experimental station was founded in El-Kanater on the banks of Damietta branch (the current premises of ten NWRC institutes). The station was considered as a hydraulic laboratory dedicated for solving field problems faced by the different inspectorates. In 1951, the Experimental Station and Physical Department were inserted under one inspectorate, called Water Research Inspectorate. Evolution of research entities, within Ministry of Irrigation (MOI) departments, continued until HAD was completed.

1.2. Study Rationale and Objectives

The operation of HAD in 1970 confirmed the need to develop a national water policy and adopt a new framework for water resources planning and management. The first national water policy post HAD was approved in 1975. It dictated serious institutional reform to cope with newly emerging issues and advances made in water resources planning and management. In the same year, the Water Research Center (WRC) – later the National Water Research Center (NWRC) – was established to carry out applied research in all water resources development and management aspects. The reason was to create a strong research and development component that could support MWRI [in the Nineteenth century MPW; later MOI and Ministry of Public Works and Water Resources] to advance and expedite the implementation of the national water policy.

Since its establishment, the NWRC produced significant mass of research in the different branches of water sciences. The NWRC saved no effort to disseminate its research findings and results as widely as possible through direct contacts with the research end users and stakeholders as well as international conferences, workshops, and scientific journals. Although it carried out all of its research in direct support to the development and management of Egypt's water resources system, there are claims of a gap between research and practice. Generally, these claims are not substantiated either by specific examples or thorough analysis of the research uptake process. Therefore, there is a need to test this typical research-practice gap cliché against a consistent analysis framework. Application of such framework to specific research programs will help to dissect the rich experience of Egypt in the water research field. Revealing strengths and weaknesses in the research uptake process, as well as, dissemination of the analysis results will contribute to the enhancement of water research uptake process in other countries similar to Egypt.

Research knowledge is one of many competing factors influencing policy decisions that can eventually translate into changes in field practices. While better use of research-based evidence in development policy has been covered comprehensively through different initiatives, less has been done to close the gap between research and practice or in determining the impact of the research uptake process on end-users or other stakeholders; this study aims to reduce that gap.

With the objective to identify significant research programs and projects carried out by the NWRC during the last three decades that impacted the national water policies and the irrigated agricultural practices in Egypt, the study will document successful cases of direct and indirect research uptake as well as unsuccessful cases. The effectiveness of the NWRC and MWRI unique set up and relationship and its impact on the development and implementation of the national policies will be analyzed. The reasons for success and failure will be identified in terms of intrinsic and externalities. Specific recommendation for increasing the research uptake and improving the process of wide dissemination of research results especially in countries with similar condition will be highlighted.

While embedded in the process of identification, analysis and documentation of research uptake, it is of importance to assert that the methodology applied by the NWRC for carrying out research uptake is by itself a key objective of the study. Immediate objectives, however, are the:

1) Comprehensive documentation of Egyptian experience in irrigation and drainage research uptake.

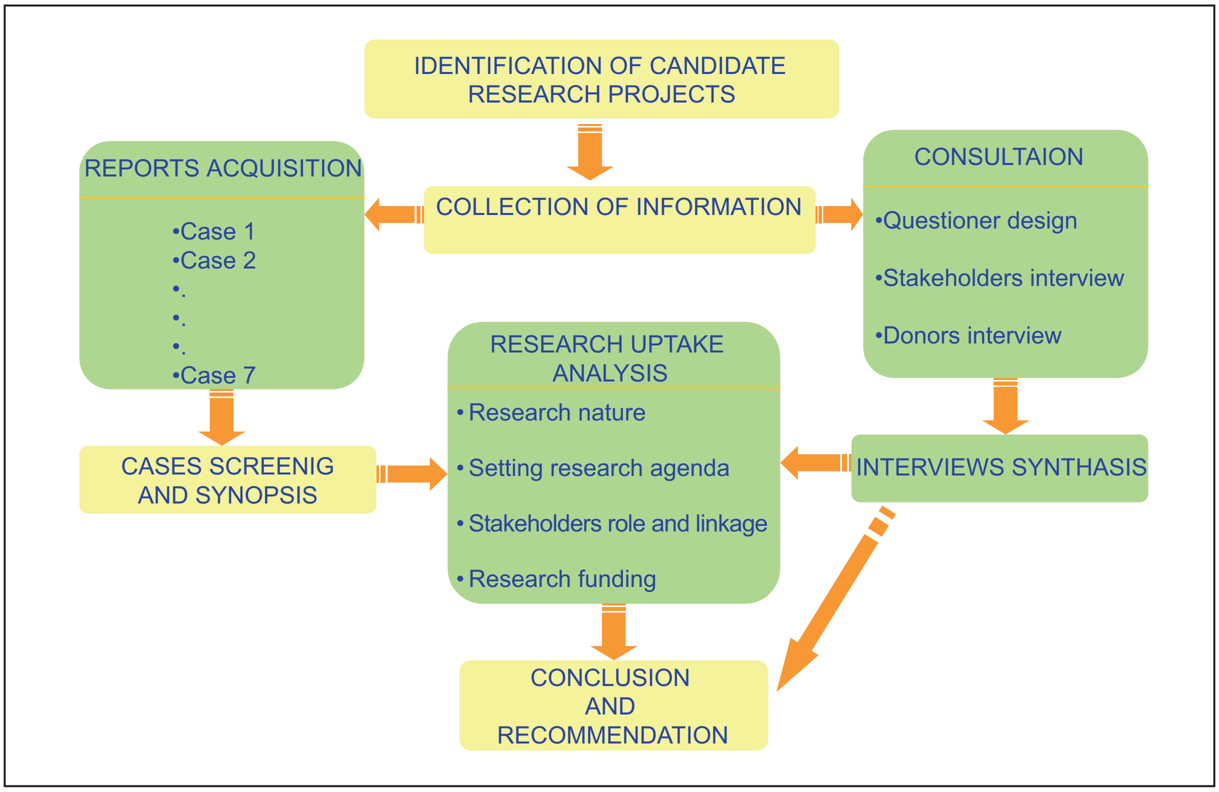
2) Analysis and evaluation of such experience to identify mechanisms and procedures that closes the gap between research and practice.

3) Provision of specific recommendations for taking corrective measures to enhance and encourage the uptake of research results and findings to irrigation and drainage practices.

1.3. Adopted Methodology

The logical framework adopted in the study has been developed according to the inventory of the case studies, documents and acquisition of reports as well as early interviews with the stakeholders. Figure 2 describes, graphically, the adopted methodology and the flow of conducted activities. It starts with identification of a reasonable number of research projects that qualify for analysis. This step is followed by information collection that has two pillars: acquisition of reports on selected research projects, and consultation with research stakeholders and donors. The third step is basically scripting of the collected information that has bearing on the next step; and analysis. It included scripting of the synthesis of interviews and synopses of cases.

Figure 2: Methodology Flow Chart



Before going into analysis, a reference (acknowledged) framework was selected. Finally, the analysis of both the case studies and interviews led to articulation of conclusions and recommendations. It is worth mentioning, that the synthesis of interviews- contributed more directly to the recommendations.

1.3.1. Identification of relevant research

Potential research projects that have impacted the water resources policy and irrigated agricultural practices were identified. In order to reflect the different facets of the research uptake, the following five topics were selected: Irrigation; Subsurface Drainage; Water Quality; Grand Hydraulic Structures; and Weed Control. The selected research projects included those that have resulted in national programs, change in the national water resources policy, or contribution to mega water projects. Good documentation of the research was an important selection criterion.

Irrigation and Subsurface Drainage are the two cases where research resulted in two large scale national programmes: Irrigation Improvement Project (IIP) and National Drainage Programmes (NDP). Both programmes were financed mainly by International donors on grant and loan basis. Research on Weed Control resulted also in national programmes; however, it was fully financed by the Government of Egypt (GoE). The case of Grand Hydraulic Structure has two interesting remarks: the direct research client is not a governmental agency; and the type of research conducted is rather cumbersome and hard to classify.

1.3.2. Instruments

For the five identified cases, synopses were prepared after thorough review of the collected reports on each case. Several reports and documents, especially the final reports, were obtained for each project from the relevant NWRC institutes and NWRC library. Typically, there were more than one report or document for each case; therefore, extracted information was subject to comparative analysis and verification. Some data and information was checked during the interviews.

Based on the selected cases, stakeholder mapping was conducted and a list of interviewees was set up accordingly (**Annex 1**). More than twenty key persons who have direct interaction with the identified projects were interviewed. The interviews were supported by a semi-structured questionnaire to facilitate the interpretation and the consolidation of results (**Annex 2**). Interviewees' answers were compiled and summarized under three items: observations on research, examples of research impacts (positive and negative), and recommendations to enhance research uptake (**Annex 3**).

The experience of the study team was one of the instruments that have been utilized carefully in this study. Forming the local team from a local supervisor (NWRC President), a coordinator (Institute Director), and a senior researcher (Institute Director) as well as five junior researchers gave the study the relevance and depth. The juniors' experience with three decades of research activities was short. Therefore, they were selected to represent the institutes which were involved in each case study; being staff members in these institutes allowed them to gather the information and documents required for the study. It gave them also first hand accessibility to the contacts of the stakeholders and donors representatives. The long experience of the seniors and then holding of several research directing positions have been reflected in the appraised methodology that have been adopted, the quality of the activities undertaken as well as the importance and weight of the recommendations reached. In turn, the international members of the study team have provided knowledge on similar international experiences that helped the formulation of the theoretical analysis framework and the identification of the diverse case studies as well the recognition of the implicit research impacts.

1.3.3. Analysis

The analysis and evaluation of the research uptake process have depended on two pillars: the interviews and case studies synopsis. These case studies provided diverse examples for research uptake, mostly successful. Diversity was clear in their topics, implementation time, motivation, impacts and involved parties. Therefore, such case studies founded the analysis on a wealth of data and information. Information was obtained from stakeholders' interviews that gave reflection on the actual effectiveness of the research uptake process. They also pointed out some research results that have not been, initially, found in the documents of the case studies. Such results were incorporated into the presented case studies. The output of the interviews was rather useful in diagnosing the defects or the drawbacks that could make the current research in irrigation and drainage ineffective. It also provided a set of feasible and practical recommendations to enhance the research uptake process.

Analysis and evaluation of research uptake case studies aimed at highlighting successful mechanisms and procedures that closed the gap between research and practice. The effectiveness of NWRC and MWRI partnership in the research uptake, and its impact on the implementation of the national policies was demonstrated. The analysis also spotted some weaknesses that will require further research, more proven results, or better information dissemination. Recommendations and corrective measures, to enhance and encourage the uptake of research results and findings in water resources protection and development practices, were also provided. The role of donors and cross-sectoral partnership in stimulating integrated research activities has been given thorough attention. Different research funding mechanisms were studied and compared in terms of pros and cons. Marginal or indirect role of the national universities in the research uptake has been evaluated.

1.4 Report Structure

This report consists of four chapters, where Chapter 1 describes Egypt's water research origins, the rationale and objectives of the study, and its adopted methodology. Chapter 2 provides some definitions that establish the reference framework that was used to analyze the research uptake case studies. It also outlines the outcome of applying the reference framework to the selected research uptake case studies. Chapter 3 comprehensively describes each case study and its sub-components. It synthesizes their rationale and objectives, the research conducted under each of them and its findings, and the impact that each case has left on the national policy and practice. In Chapter 4, the current water research strengths, problems and gaps are identified. Recommendations and the way forward are furnished in the same chapter; while the list of people interviewed, the structure of the interview and the questionnaire, and the interview synopsis are given in Annexes 1, 2 and 3 respectively.

2. WATER RESEARCH UPTAKE IN EGYPT

2.1. Research Uptake Framework: Definitions

Analysis and evaluation of research uptake case studies has to be referenced to acceptable definitions and acknowledged processes or frameworks that are typically followed to transfer the research findings and results to the practice and end user. It is also needed to establish common understanding and definitions for the terminology utilized, including those taken for granted such as “research”. Box 1 presents an acceptable definition and classification for research that can be applied to water sciences.

In essence, research in water resources protection and development is carried out to improve the practice of water resources policy makers, planners and engineers. It gives professionals better ways to manage water resources. The nature of water resources protection and development is to be purposeful; therefore, the NWRC was established to conduct applied water research. It seeks to advance the practice of water resources protection and development by means such as:

- Discovery of new materials, theoretical models and processes which can enhance the performance, quality, efficiency, cost effectiveness and sustainability of Egyptian water resources systems.

- Increasing the quality of models by which predictions are made thereby improving process understanding.

- Investigating and defining the properties of new or existing materials, systems and resources so that their use can be more appropriate and reliable to the end-user.

- Developing improved design methodologies so that the resultant outcome is more efficient or reliable, or poses less risk to its end-users.

- Improving control and risk management frameworks around particular families of water problems.

Basic research in water resources is defined as scientific investigation and study which may furnish or facilitate potential future practical application, was thought to be left to universities. It includes:

- Research that seeks to build underpinning theoretical and mathematical models that increase understanding of the mechanisms of either water natural or man-made processes or systems.

- Research that seeks to increase understanding of the unique and potentially valuable properties of novel materials or resources.

Box 1: Research Definition and Classification (Adapted from ESRC, 1999)

Research and experimental development comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

Any activity classified as research and experimental development is characterized by originality; it should have investigation as a primary objective and should have the potential to produce results that are sufficiently general for humanity's stock of knowledge (theoretical and/or practical) to be recognizably increased. Most higher education research work would qualify as research and experimental development.

Research classification:

- **Pure basic research** is to study and investigate on pure science that is meant to increase our scientific knowledge base. This type of research is often purely theoretical with the intent of increasing our understanding of certain phenomena or behavior but does not seek to solve or treat specific problems. In other words, it acquires new knowledge without looking for long term benefits other than the advancement of knowledge**.**
- **Strategic basic research** is experimental and theoretical exertion undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognized practical problems.
- **Applied research** is scientific effort undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives. In other words, it is used to find solutions to everyday problems and develops innovative new technology.
- Experimental development is a systematic process, using existing knowledge gained from research or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

Water basic research does not include the ongoing refinement of risk management or design methodologies, but it includes developing models or knowledge that might lead to substantive rethinking of the methodologies themselves.

Typical research modes that are adopted by research organizations and institutes, in response to socio-political context in which they exist, are presented in Box 2.

Box 2: Research Modes (Adapted from ESRC, 1999)

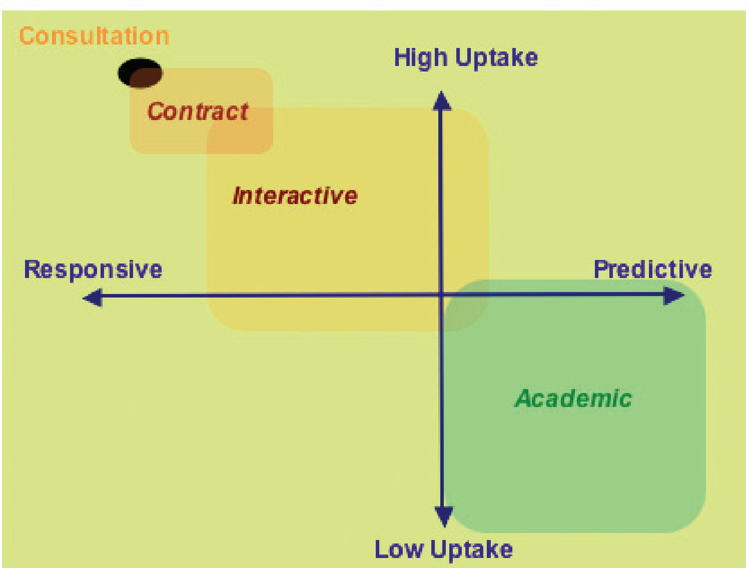
Interactive mode refers to a style of activity where researchers, funding agencies and 'user groups' interact throughout the entire research process, including the definition of the research agenda, project selection, project execution and the application of research insights. Research users may include policymakers, planners, business and governmental or non-governmental organizations.

Academic mode refers to a style of activity where research agendas are defined by academics themselves. Funding mechanisms are driven by academic curiosity, disciplinary values and traditional peer review undertaken by applicants' academic 'peers'.

Contract mode refers to a style of activity where researchers in universities and other institutions already 'interact' directly with users, such as government departments, by accepting contracts to undertake specific pieces of research or by serving in advisory capacities.

Interactive research could be said to blend elements of traditional academic and contract research models, as Shown in Figure 3. However, it is also possible to see it as a distinctive model for research activity in its own right. Interactive research can be distinguished from contract research simply based on the degree of user involvement. While contract research brings researchers into contact with users, it does not meet the definition of interactive research. This is because the research agenda, rather than being jointly determined, is set solely by the 'user'. Goals are often influenced by shorter term considerations and/or immediate policy needs. Therefore, both contract research and interactive research are typical examples of research uptake on the responsive side. On the other hand, academic mode of research is predictive as it is driven by the curiosity of scientists and researchers. Figure 3 demonstrates that this mode of research does not allow for significant research uptake.

Figure 3: Characteristics of Different Research Modes



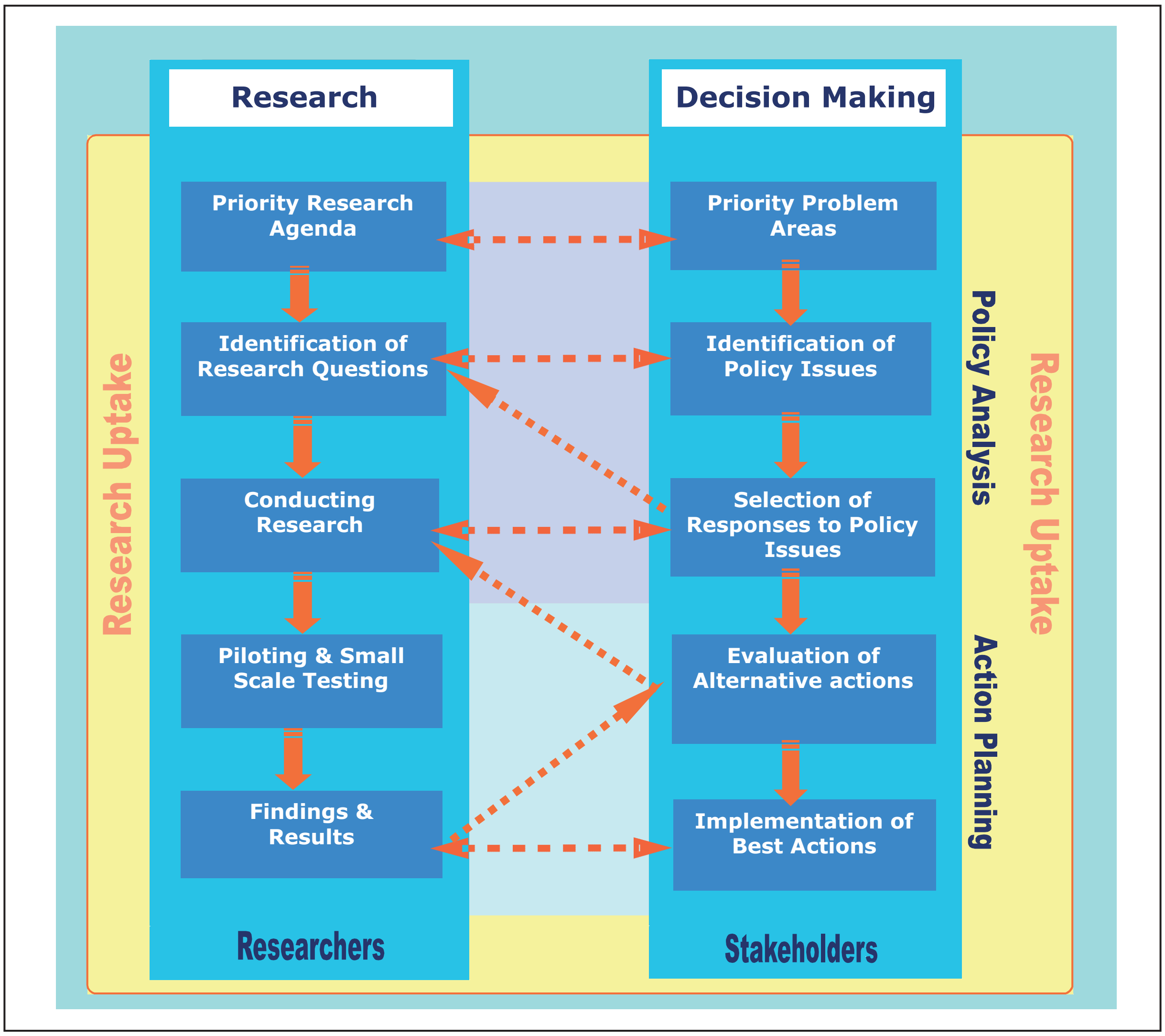
Box 3: Definitions of Research Process-Related Terms (Adapted from ESRC, 1999)

Research user is any entity, representative or organization (governmental or non-governmental) with an interest in the outcome of research**.**

Online research does not exist. Pure basic research, by definition, is always ahead of the society needs and policy requirement. Typically, applied research, either contract or interactive research, follows the issues and problem identification. However, good interactive research may well be conducted ahead of immediate policy needs, which requires considerable visionary researchers and policy makers.

Research versus consultancy which is an assignment commissioned by an organization that knows the answer it wants. Its delivery is typically due according to tight timetables. While research is needed where the answer is not known, or when organizations are under pressure and need to demonstrate that their actions are supported by evidence. Consultancy normally utilizes out-dated research techniques and recycles academic findings freely available in the published literature.

Figure 4: Pathway for Research Uptake (Adapted from IDRC, 2001)



Box 3 provides more definitions and explanations for few terms and issues that will be utilized in the analysis of the research uptake process.

A conceptual framework was developed that represented the pathway for the uptake of research (see Figure 4). Within this framework, two discrete processes go parallel. These are the research and the decision making. The policy analysis and action planning are serially connected elements of the overall decision making process while the research uptake is a perpendicular process that intersects with both research and decision making. The uptake process takes place through the back and forth interactions at multiple stages of the processes.

Research findings and results need not be a single final output at the end of the research process. They may be a series of outputs of a variety of types that occur throughout the research process and inform the next steps in the decision-making process. When the decision making process reaches the step of implementing the best actions, research results are translated into field practice either directly or through research influence on policy formulation. Stakeholders include various groups: national and international research institutions, policy makers, water resources professionals, funding or donating agencies, and end users. Each group has diverse possible contributions to the various stages of the three processes, if they are properly involved.

2.2. Research Uptake Framework: Application to Egypt Experience

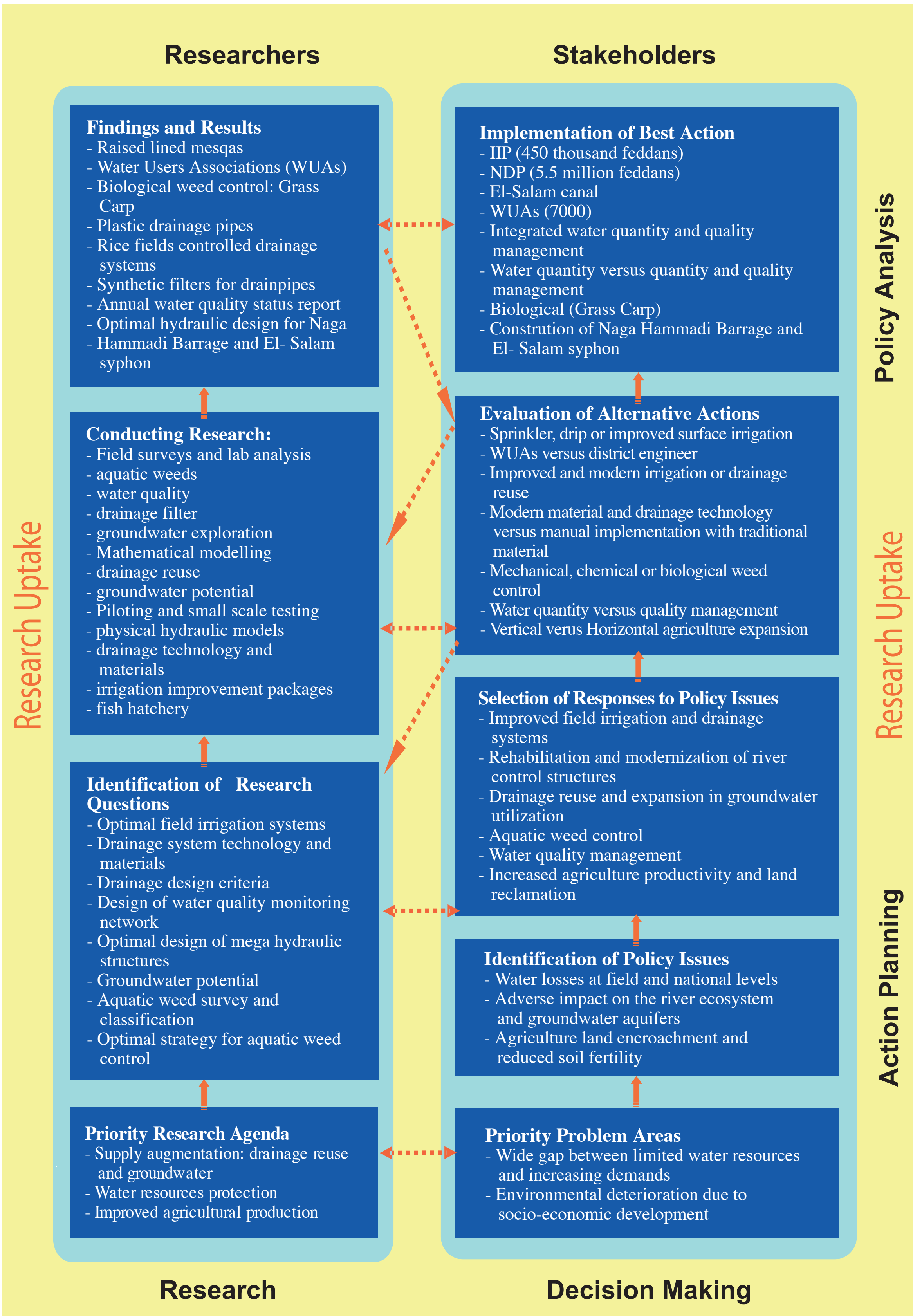
2.2.1. Applied Processes

Research uptake is a very complex process that involves several parties who have different ethos and modes of operation. There are no standard guidelines that make the research uptake effective. In Egypt, the research uptake process was extracted from the analysis of the five case studies. Figure 5 depicts an illustrative application of the theoretical framework for research, decision making and research uptake process as derived from the case studies and their sub-cases.

Since research and decision making are discrete but parallel processes, they are carried out by two distinct bodies within MWRI. NWRC is the body fully responsible for research activities while decision making is the responsibility of MWRI sectors, departments and implementing agencies. The elements of each process are serial connected. For instance, with reference to the decision making process when a national priority area such as the wide gap between limited resources and increasing water demands is identified, at the Cabinet level, a policy issue like high water losses at the field and national level has to be addressed in the national water policy. As a result, drainage reuse, as an immediate response to increase the overall efficiency of the irrigation system and the expansion of groundwater exploitation to augment water supply were considered in the 1975 water policy. As a reflection on the research parallel process, two questions were raised: what was the optimal design for water quality monitoring network and what were the sustainable utilization rates of the different aquifers?

MWRI has founded its 1975 water policy and the consecutive policies on a solid scientific base. As research uptake process is a perpendicular process on both research and decision making processes, research-practice-policy interaction went both ways; as research impacted

Figure 5: Research Uptake Pathway - Application to Egypt Experience



national water projects and policies; they in turn stimulated several research programmes. Water shortages at the Lower Delta led to the drainage water reuse practice which stimulated field surveys and lab analysis to assess the water quality in drains and canals. Research findings and results of these activities made MWRI adopt integrated water resources management principle that embraced both quantity-based and quality-based management alternatives rather sticking to the traditional quantity alternative.

Research findings and results do not need to be a single final output at the end of the research process. Either directly or indirectly the results and findings go into policy and practice. Research on on-farm irrigation efficiency that was carried out through large scale piloting led to the implementation of Irrigation Improvement Project (IIP) in the old lands. It has recommended several physical, institutional and legal interventions that had been applied to more than 450 thousand *feddans*. Recommendations on users' participation became a national policy that resulted in establishment of about seven thousand Water User Associations (WUAs) practicing field water management. More directly, research on subsurface drainage materials and design criteria went to practice by the drainage projects implementing agencies and contractors. More than 5.5 million *feddans* (1 *feddan* = 4 200 m^2) are currently covered by subsurface drainage in accordance with research findings and results. Examples of direct research impacts on hydraulic and structural design of water works and implementation cannot be counted.

For a policy issue like agricultural land encroachment and soil deterioration in old land, reclamation was one of the responses. In the same context, among the best actions the government chose to implement were the two mega rural development projects: Southern Valley Project, and El-Salam Canal. Both projects required the design of sizable non-traditional hydraulic structures that led to physical modelling research activities.

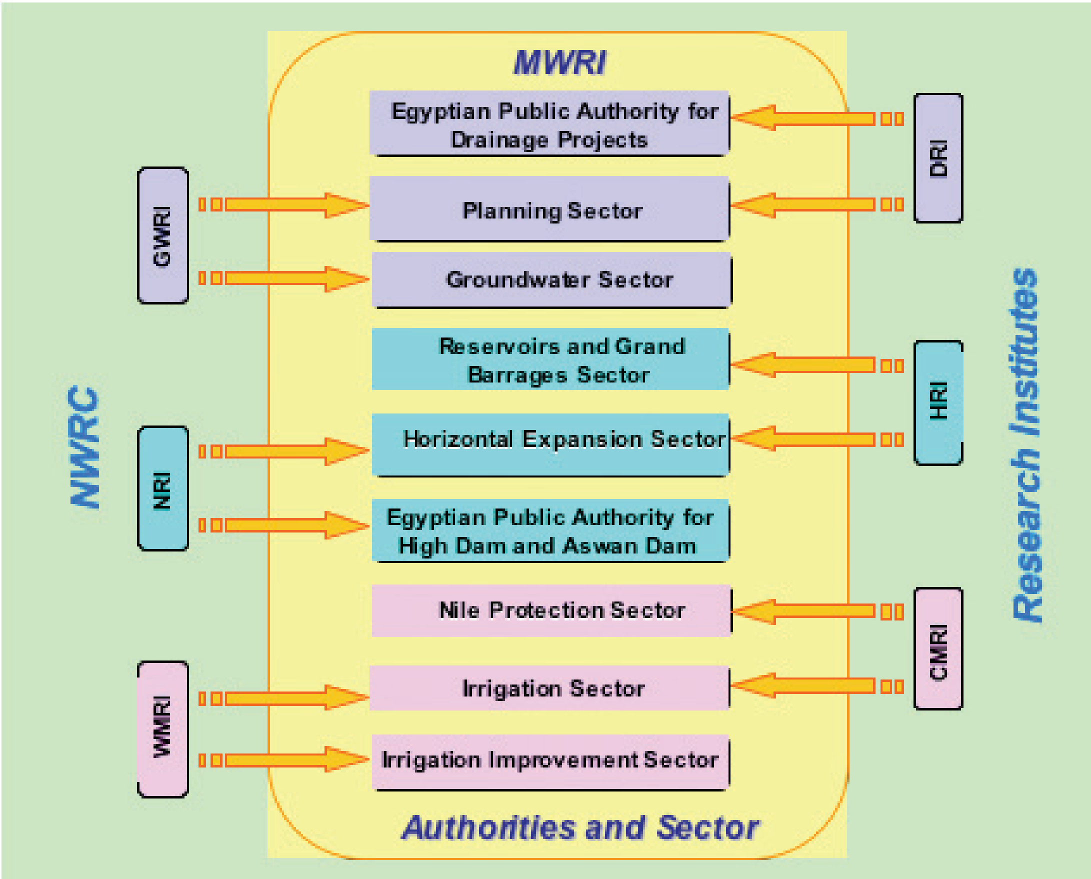
Evaluation of alternative actions may stimulate research as well. When water quality research alarmed decision makers to stop drainage reuse on some main drains, the intermediate reuse was suggested as an attentive action. The resultant research activities has guided the formulation of the current NWRP. On the other hand NWRP, explicitly, calls for research on: new optimal operation rules for HAD, salt and drought tolerant crop varieties, and repeated use of brackish groundwater.

The following analysis, of the research uptake process in Egypt, has been based on four pillars that affect directly or indirectly the research uptake process. These are: institutional context, setting up of research agenda, linkage between researchers and stakeholders, and research funding sources.

2.2.2. Institutional Set-up

The institutional environment has crucial effects on the commissioning and conduct of interactive research. Therefore, the idea behind the establishment of WRC (later NWRC), was to create a strong research and development component that could support MOI (later MWRI) to advance and expedite the implementation of the national water policy. This was associated with an impression, at the national level, that universities cannot support the country's ambitious sectoral development plans through traditional academic research.

Figure 6: Organizational Mapping of NWRC and MWRI



By structuring the NWRC, so that each of its institutes corresponds to one or more of the ministry's major departments or authorities, has ensured research influence on policy formulation and action implementation. Figure 6 illustrates the links amongst the research institutes that carried out the selected cases for this study, with the relevant MWRI sectors and authorities. However, corresponding mapping of the MWRI departments or authorities and the NWRC institutes was not, always, as shown in Figure 6, from the beginning. New sectors and units have been created in response to NWRC intensive research activities and accumulated research findings waiting to be implemented by dedicated departments. Immediate examples are Groundwater (GS), Irrigation Improvement (IIS) and River Nile Development and Protection (RNDPS) sectors and Central Water Quality Unit. Increasing environmental awareness and climate change concerns led in 1995 to the establishment of the most recent NWRC research institute; and Environmental and Climate Research Institute (ECRI).

Currently, NWRC consists of twelve research institutes and two supporting units that read like a list of development needs and problems facing Egypt's water sector. It is structured in a way that each institute corresponds to one or more of the Ministry's major departments or authorities. Figure 6 maps the twelve NWRC institutes to their corresponding MWRI sectors and authorities, based on the direct and obvious links rather than reflecting all existing or potential relationships. Such a unique set up has ensured that research influences water policies and actions on the ground. The impact of research has not only accelerated the implementation of the national water policy, but also contributed in considerable savings to the national economy, increase in food production and public security. The latest techniques which emerged from the research of the NWRC in planning are: design, construction and management of water resources systems which are the day to day practice in the MWRI. The NWRC implements research projects, and provides a wide variety of analytical and advisory services to meet the development requirements of the MWRI and other water related instantiations at the national level. As a national organization, the NWRC is developing in an adoptable manner to the national needs. Nonetheless, it is responsive to the new advances in water since and unite to forms of international cooperation in its field of interests.

2.2.3 Setting Research Agenda

By nature, applied research is a demand driven process. The vision that initiated the NWRC gave it the mandate to be responsive, primarily, to the policy and decision makers in the MWRI. At that early stage and after the establishment of the NWRC, the MWRI was facing serious challenges due to the construction of HAD. With the operation of HAD in 1970, there was need for a new national water policy and to make paradigm shift in water resources planning and management.

The 1975 policy and its successors have raised several non-traditional issues and questions. Although the MWRI has an impressive long history, the available data, information and knowledge were not able to respond to challenging issues and questions. Most of the analyzed case studies were carried out in response to these issues and questions. However, in cases like Subsurface Drainage, Water Quality or Weed Control, where donors and international research institutions were involved, the initiatives did not come directly from the researchers.

The research agenda was neither articulated by policy nor decision makers in the MWRI. In essence, the initiative came from the donors who brought the NWRC institutes with corresponding implementing departments and agencies to formulate research projects and programmes. The process was totally different with respect to the case of Hydraulic Structure Design, which represent the contract mode. In such particular cases the agenda was always very specific and set by an international design firm or consortium. The research objective in each sub case was to confirm the conceptual or preliminary design of a specific hydraulic structure, and optimize its function and performance under different flow conditions.

The current process for research initiation starts with a call from the NWRC President, to the twelve research institutes, to propose a set of research projects under the main themes of water policy. Some institutes, that have direct and good link with their corresponding MWRI entity, reach out and ask corresponding agencies to express their needs and requirement in terms of research and development. The NWRC Vice-President for research work plan affairs collects the proposals for screening and harmonization. In collaboration with the institutes' directors he eliminates conflicts, redundancy, and sometime proposes a joint undertaking of some research projects by multiple institutes. A coherent NWRC research agenda is drafted by the Vice-President, and presented to the heads of MWRI departments, sectors and authorities, in the presence of the twelve research institutes directors. In such a wide meeting the agenda is debated and discussed. It is normal to witness conflicts, controversies and misunderstanding on both sides (researchers and executives) during the meeting. However, the meeting is considered as an internal MWRI affair in which discussions run in a very friendly and open environment. Executives' comments and concerns are incorporated in a modified version of the agenda and disseminated among MWRI sector heads for endorsement. Sometimes a second round of deliberations takes place before the final agenda is routed through its formal upper channels (NWRC Board, His Excellency the Minister).

2.2.4. Researchers-Stakeholders Roles and Linkages

Presented real life cases, either undertaken through interactive or contract research, required collaboration linkage among researchers, governmental agencies, business firms, national and international universities and research centers, people and donors' organizations. Donors in most of the cases played a pivotal role more than just funding the research. Researchers in the research institutes that conducted the case studies had a good understanding of the policy issues. They had a good understanding of water resources professional perspective (working in the governmental implementing agencies) as well as the end users perspective. However, in some sub-cases they could not carry or solicit their results for stakeholders and decision-makers. This may be due to their fear of compromising their integrity; or because they were not good in it.

According to the Egyptian laws, (Agriculture Law, and Irrigation and Drainage Law), the role of MWRI stops at the farm gate, whereas the role of the Ministry of Agriculture and Land Reclamation (MALR) starts. Farmers, therefore, are not the direct end users of MWRI projects. The two exceptions are the Irrigation and the Subsurface Drainage cases. In these two projects, farmers' participation is widely practiced during the implementation. However, during the research phase only selected small farmers were involved through pilot schemes (some of these pilot schemes are 30 years old). In many of MWRI projects and policies, it is very difficult to consider farmers as direct stakeholders. Sometimes impacts of research, which are appreciated by the system operators and managers, are hardly felt by farmers.

The Subsurface Drainage case shows how interactive research can involve a variety of partnerships and collaboration modes throughout the entire research process, from formulating the research questions to communicating and applying the research insights. The partnership between the Drainage Research Institute (DRI) and the Egyptian Public Authority for Drainage Projects (EPADP) is an example to follow. It expedited the implementation of NDP, significantly. However, in other cases the research institutes did not have the chance to create similar partnership. Simply, because when the case study was conducted there was not a corresponding implementing sector in MWRI.

Working with the private sector as opposed to the public sector posed greater difficulties for researchers. This was partially because of differences in culture and in part because researchers were not compatible with industrial approaches and timetables. However, the case study of Hydraulic Structure Design was an exception. The international research community, represented in this case by IHE-Delft, provided the Hydraulic Research Institute (HRI) with both direct and indirect support, so that it reached an international level of accreditation. Such accreditation created a broader contract research market for HRI.

Donors played the role of matchmaker between research institutes and their clients. They made sure that researchers, policy makers, implementing agencies and end users groups interact in developing, executing and communicating research. Such role was demonstrated in the cases of Water Quality, Irrigation and other cases. As funding agencies, donors played undeniable role in the research uptake process to guarantee the cost-effective utilization of their funds. By taking research results to practice and field, donors create more marketing opportunity for their products, instruments and experts. For example, the case of Weed Control and many others witnessed solicitation of foreign consultancies and expertise. Transferring findings and results of Subsurface Drainage sub cases, for installation and maintenance, created a market for the donors' machines, while a case like Water Quality Mentoring furnished a good market for donors' lab instruments and field equipment.

However, donors were sensitive to the country’s own context and needs and established equal partnership with local researchers and professionals. They did not impose “external” agendas, and formulated the research agenda with full endorsement of policy decision makers and researchers. Instead of insisting on the use of external experts to carry out research studies they directed most of the external experts and consultants to capacity building of the national researches and young research institutes. Drainage Research Institute (DRI), Research Institute for Groundwater (RIGW) and Water Management Research Institute (WMRI) are examples of the institutes which received significant help and support from donors who funded their case studies. The capacity building thrust was not limited to the young research institutes, but it was extended to the implementing agencies to ensure better research uptake by policy makers and end users. The idea was that research user should have the capability to interact with the researchers during the whole research process to achieve better management and use of knowledge, and improved communication.

2.2.5. Research Funding

Egypt’s national research funds flow mainly through Ministry of Higher Education and Scientific Research, where water research competes with research in other sectors, such as health, environment, agriculture and others. This puts water resources and irrigation departments at the national universities under financial stress and does not allow them to pursue their applied or basic water research. The NWRC receives its funds through the MWRI. Such separate funding mechanism for water research put an emphasis on water resources protection and development.

With the first comprehensive water policy of 1975, the demand for research leading to action was very high. However, the GoE could not provide enough financial resources for such studies, due to its economic conditions. At that time, national sources of funds were directed to reconstruction, development and economic recovery from the 1973 war rather than research. Most funding sources had given a much lower priority to research compared to tangible developments. Therefore, Egypt had to rely on external sources for funding its water research, without sacrificing relevant research agenda that is effectively linked to its national priority actions. External sources of funding for research have played a crucial role, not only in allowing Egypt to set its own priorities and conduct relevant research, but also in strengthening national expertise and capability.

All presented cases were co-financed by donors and GoE, except for the Hydraulic Structure Design case. A significant part of the Egyptian contribution was in-kind and not in cash. Donors of the different case studies had diverse nationalities: Dutch, Americans, Canadians and International Organizations (World Bank and others) as well. When donors involve large amounts of research funding or intend to support policy changes, they usually demand use of international consultants or imported equipment or instruments, as a condition for loans and grants. Such practice was based mainly on the assumption that the recipient country would benefit more and ensure better-quality and more timely results. Such practice was neither illogical nor without its benefits. Nevertheless, it put the sustainability of efficient research process at risk, owing to the concern that once such external funding sources start to support research they will always be required.

3. RESEARCH UPTAKE CASE STUDIES

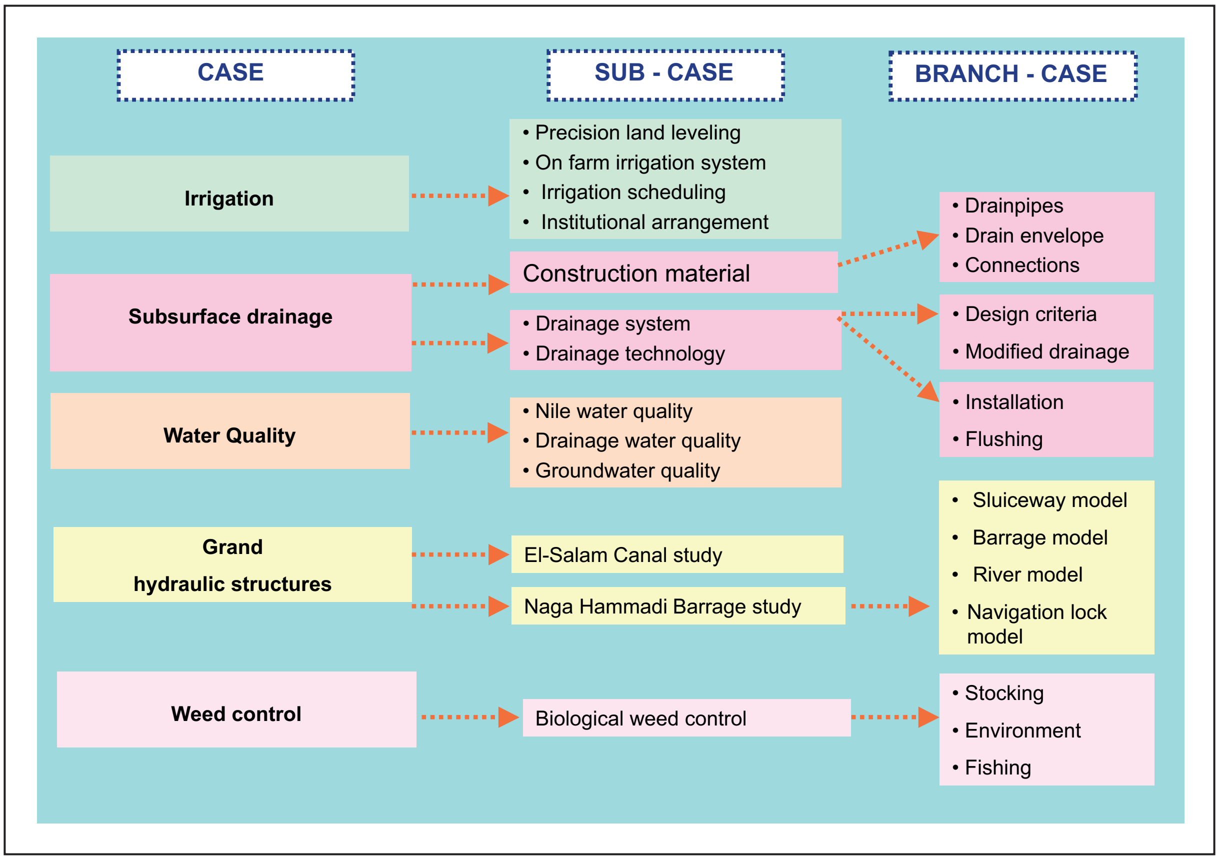
Egyptian irrigation practices experienced radical changes during the Nineteenth century. The old system of basin irrigation and cultivation of one crop per year, which prevailed since the dawn of civilization, has been superceded by perennial irrigation. This has been achieved by Mohammed Ali, who ruled Egypt from 1805-1849. He started and executed an ambitious plan to modernize the Egyptian agriculture. Barrages were constructed across on the Nile in order to regulate its water and provide full control over its flows so as to maximize the profitability and minimize the losses. Since then, Egypt has struggled to cope with the increased irrigation requirements by constructing hydraulic structures and water control facilities along the Nile, including barrages, dams and storage reservoirs. The old Delta Barrages was built in 1861, while old Aswan Dam was erected in 1902, and HAD in 1969.

The operation of HAD in 1970 confirmed the need to develop a national water policy and adopt new paradigm for water resources planning and management. The need for improved field irrigation and drainage systems, at the national level, became more persistent. Urgency for rehabilitation and modernization of control structures on the river itself turned to be a must to save freshwater lost to the sea. Changes of the River Nile ecosystem were observed after the Construction of HAD. Alteration of the water quality, specifically suspended load, led to significant modification in aquatic weed species and behavior. Highly controlled and regulated flows in most irrigation canals created a favorite steady environment for aquatic life. At the same time, more nutrients and chemicals entered the water through increased use of fertilizers in agriculture in addition to domestic and industrial effluent disposal. Therefore, more attention had to be paid to the monitoring and protection of all water resources quality, including groundwater.

The first national water policy, post HAD, was approved by the Parliament in 1975. It dictated serious institutional reform to cope with newly emerging issues and advances made in water resources planning and management. In the same year, the 'Water Research Center', WRC (later NWRC) was established to carry out applied research in all water resources protection, development and management aspects. The reason was to create a strong research and development component that could support MOI at that time (later MWRI) to advance and expedite the implementation of the national water policy.

Within the framework of this study, potential research projects that have impacted the water resources policy and irrigated agricultural practices in Egypt have been identified. Seven topics were considered. These are: Subsurface Drainage; Irrigation; Groundwater; River Nile; Water Quality; Grand Hydraulic Structure; and Weed Control. After a thorough revision of the available reports and a rapid analysis of the seven cases selected first and their thematic relevance to the core of the study, it was decided not to include the two cases of the River Nile Development and Protection and Groundwater Management. The rapid analysis of the River Nile Development and Protection case showed diverse significant research results that did not materialize in consolidated impacts (national programmes and well-delineated national policy). With no doubt, research on groundwater contributed significantly in terms of national policy

Figure 7: Schematic Diagram of Selected Case Studies and their Sub-Components



formulation, but within the context of this study it would have, however, been a redundant example of how research impacted the national policy and practice. It has to be mentioned that both eliminated cases had an important impact on the MWRI institutional reform. They also contributed, partially, to the Water Quality case. The schematic diagram of the selected case studies and their sub-components is shown in Figure 7.

3.1. Case Study I: Irrigation Improvement/Egypt Water Use and Management Project (IIP/EWUM)

3.1.1. Rationale and Objectives

The discharge of water from HAD is under full control. The release of water for irrigation is adjusted throughout the year to provide all agricultural lands with sufficient water for different crop requirements. Perennial irrigation has provided new opportunities for more intensive crop production, but at the same time, it has generated new problems. For example, the use of more water (over irrigation) on a relatively fixed area of land has caused water-logging and build up of salts in the soil profile. The challenge was to minimize or solve these problems while fully exploiting the new opportunities for the benefit of the nation.

Egypt Water Use and Management Project (EWUP) during (1979-1984) emerged out of an understanding of the close dependency and interaction between the irrigation water delivery system and the on-farm water management system. The MOI recognized the emerging need for the on-farm water management in addition to its major responsibility of the main system management in order to improve the efficiency and effectiveness of water delivery.

The overall objective of the EWUP was to improve the social and economic conditions of the Egyptian small farmers through development and use of improved irrigation water management and associated practices which increase agricultural production, promote efficient water use and decrease drainage problems. The Project was designed to raise the institutional capacity of the MOI to develop and implement improved on-farm water management programs (EWUP, 1984).

The EWUP aimed at providing experience and knowledge base which can be used to formulate plans for expanded irrigation improvement programs in Egypt. The knowledge and know-how should have been acquired to achieve:

- Improvement of irrigation water management.
- Reduction of the pressure on the field drainage networks.
- Improvement of water availability at various points downstream of the canals and *mesqas*, specially at the tail ends.
- Improvement and renovation of the irrigation networks.
- Crop production increase.

3.1.2. Conducted Research and Findings

The EWUP was one of the most important irrigation projects funded by United States Agency for International Development (USAID) to promote interdisciplinary approaches to deal with both physical and institutional changes in the on-farm irrigation system (Nashed, 1997). It was implemented through the Water Distribution and Irrigation Systems Research Institute, currently the WMRI of the NWRC, in collaboration with the Agricultural Research Center. The Consortium for International Development, with executive offices in Tucson, Arizona, was the USAID contactor for the project.

The project conducted an applied research with small farmers in three representative pilot areas: Giza, Kafr El-Sheikh and Minya. Through the three project sites, the EWUP succeeded in developing methods for on-farm irrigation system improvement together with packages of practices for better on-farm water use (EWUP, 1984).

The first selected site was El-Mansouriya village in the Giza Governorate with a command area of about 1 600 *feddan*s. It represented the fruit and vegetable producing areas serving the Cairo market. The second site was Abu Raya in Kafr El-Sheikh Governorate with a command area of about 6 300 *feddan*s. This site was selected to represent the tail-end part of the irrigation system and rice producing regions. The third site was Abyuha village in El-Minya Governorate to represent Middle Egypt region with different cropping patterns in the Nile Valley with a total area of about 1 200 *feddan*s.

The programme started by studying the Egyptian farming systems which are highly complex due to the mutual effect between physical, economic and social environments. This study was accompanied by a comprehensive analysis of the main characteristics of the water delivery, drainage and groundwater systems. There were four major interventions that were tested by the EWUP to improve on-farm water management. These interventions included a set of precision land levelling, irrigation system design and management, irrigation scheduling, crop management, and innovative institutional arrangements (see Figure 7).

Precision Land Leveling (PLL)

Project activities focused on re-design of the conventional basin irrigation system. In some cases, this resulted in longer and narrower basin configuration. Length of run from field head to tail ranged from 50 to 150 m. The PLL was necessary for successful irrigation of long runs. Thus, it was concluded that the average value for maximum depth of cut within a field was 6.5 cm. It was also recommended that for smallholdings (1 *feddan* or less), consolidation is preferred to provide enough manoeuvring space. The project team managed to provide an estimate of the manpower and equipment requirement to perform the PLL for up to 15 *feddans*. Together with an estimated cost of 14 *L.E./feddan*, it was possible to clearly estimate the pros and cons of the PLL.

Because the PLL minimized field elevation variation, farmers were able to achieve good field coverage with smaller application depths. Drainage of excess water was consequently reduced. In one of the pilot areas, land levelling intervention resulted in application efficiencies of 70 percent and 75 percent for two long basins of 6.3 m x 133 m and 13 m x 50 m, respectively, while application efficiency on six unlevelled farms averaged 61 percent. Land levelling provided soil for maintaining, aligning, elevating and reconstructing channels. On the other hand, construction of long furrows and basins were made possible by the PLL, reduced *saqia*-to-field conveyance channel length and saved water. As a general trend, land leveling and conveyance channel improvements led to higher on-farm irrigation efficiencies. Higher efficiencies decreased irrigation time and reduced water lifting costs. Also, the PLL activities facilitated replacing *mesqas* with farm-access roads and reshaping fields to provide adequate irrigation from remaining *mesqas*.

On-farm Irrigation System

The United States Department of Agriculture-Soil Conservation Service (USDA-SCS) developed level irrigation system design methods for furrows and borders. These methods were adequate for farm irrigation system design at projects sites. It was possible to determine the dependence of on-farm irrigation efficiency on flow rate for borders and desirable results were obtained for flow rates exceeding 2.5 lit/sec per 100 m^2 of border area. It was also possible to estimate Manning roughness coefficient for broadcast small grains to be 0.15 and 0.04 for furrow irrigation.

A comprehensive analysis of the economic feasibility of lining channels in Egypt was conducted. Three typical channel sizes were specified and the lining costs associated with each size were estimated. The total annual cost (June 1983 values) for 2 500 m of size 1 (structural top width of 0.30 to 1.00 m) varied from 1.05 *L.E.*/m^2 (currently one *US $* = 5.5 *L.E.*) for bricks with concrete lining to 4.40 *L.E.*/m^2 for 35 mil (1 mil = 0.025 mm) butyl rubber membrane. For size 2 (structural top width of 1.00 to 3.00 m), total annual cost for 10 000 m of channels varied from 0.93 *L.E.*/m^2 for cast-in-place concrete to 3.53 *L.E.*/m^2 for 35 mil butyl rubber membrane. For size 3 (structural top width of 3.00 to 10.00 m), total annual cost for 5 000 m of channel varied from 1.02 *L.E.*/m^2 for soil cement to 3.41 *L.E.*/m^2 for 35 mil butyl rubber membrane.

Other improvements were introduced and tested in the field condition such as Elevated *mesqas*, renovation of water delivery system to provide gravity flow, and buried pipelines. The EWUP (1984) provided a thorough analysis of the pros and cons of each intervention. The EWUP water budget studies showed that inadequate hydraulic control resulted in water losses to drains of about 30-40 percent of inflow. Therefore, several system renovations were recommended to the canal head-gates, field turnouts and measurement structures.

Irrigation Scheduling and Crop Management

The EWUP experience involved developing irrigation schedules based on prevailing farmers' practices, measured soil water depletion and consumptive use estimates. Constraints to implementing an irrigation scheduling programme were also assessed. Project work at various field sites exhibited that improvement in crop management was required to gain maximum benefit from irrigation system interventions. Crop yields would be increased by implementing solutions to the prevailing crop management problems. Improved agronomic practices included timely sowing of improved crop varieties, adequate plant populations, plant protection against insects and diseases, and proper rate and timing of fertilizer application. These practices, combined with water management, increased crop production. In general, it was observed that higher yields and greater returns from applied water resulted when farmers followed recommended crop and water management practices.

The EWUP studies showed that irrigation should take place at a soil depletion of 40-50 percent of the available moisture in the effective root depth. This was equivalent to a soil water deficit of 7 cm, which was accepted as a guideline for irrigation time. The PLL also led, indirectly, to yield increases. Cropped area was increased through eliminating ineffective, closely spaced, shallow, poorly maintained field drains. Movement of soil from high to low areas in the field and subsequent soil smoothing improved seedbed quality at least for the next crop.

Institutional Arrangements

The introduction of new techniques designed to improve irrigation from the *mesqa* level to the on-farm operation required adoption of an approach that integrates these new techniques with the farmers' present irrigation practices. The EWUP introduced a mechanism called the Irrigation Advisory Service (IAS). It served as a prototype of an advisory service by helping farmers implement a PLL programme, construct on-farm irrigation systems and operate these new irrigation systems. Another radical concept introduced was the WUAs. This intervention

Photo 1: Water User Association and Improved *Mesqas*

Photo: WMRI, NWRC

stimulated a series of policy changes in MWRI (see Photo 1 for members of Water User Association and improved *mesqas*).

3.1.3. Uptake and Impact

The findings of the EWUP were the basis of the Irrigation Improvement Project (IIP) which was launched in 1988. After being carefully monitored and evaluated by local and international experts, the IIP was considered to be a landmark project that stimulated significant institutional reform and policy changes of the MWRI. The IIP has improved several important components of agricultural production, and water delivery and on-farm water management, in 450 thousands *feddans*. The Egyptian Government has been committed to a long-term improvement irrigation programme, resulting in a series of significant improvement to the water distribution and drainage systems. The IIP aimed at achieving the main goals of the National Master Plan approved by the Cabinet in 1984. Recently, a large World Bank loan is used to finance the Integrated Irrigation Improvement and Management Project (IIIMP) based on the observed and monitored impacts induced by different interventions made under the IIP (IPTRID, 2005).

In 2001, a national study was carried out to update the field survey that was executed in 1998 to determine the level of knowledge and behavior of farmers towards water use (EPIQ, 2001). The study surveyed 2 546 farmers on 317 *mesqas*. The 2001 survey included the same 245 *mesqas* that were surveyed in 1998.

In a recent survey carried out for monitoring and evaluation of the IIP (WMRI, 2007), two samples of farmers were surveyed: 240 farmers in Wassat village, Kafr El-Shiekh governorate and 338 in Mahmoudia village, Beheira governorate. WMRI survey and EPIQ results are reflected in the following sections for each specific IIP measure.

Structural improvements

At the mesqa level, the IIP has effectively reduced the problem of water inequity and supply shortages. This has been achieved through a mix of technical and institutional interventions. These interventions include replacement of the rotational system to continuous flow in combination with gravity flow in raised open mesqa canals or buried pipes operated at low pressure (IPTRID, 2005). Although, continuous flow conditions are not reached, the construction of lined canals and buried pipes has considerably increased conveyance efficiency. Individual pumping has been replaced by a centrally operated pumping system that is managed by members of Water User Associations (WUAs). Notably, the shift from individual to collective pumping has resulted in considerable cost savings in the order of one- third (see Photo 2 for improved delivery systems: radial gates on a hydraulic structure).

According to the preliminary findings of IIP's monitoring and evaluation component, unofficial reuse of drainage water has widely disappeared along improved mesqas. Also, water losses at the tail-ends of the mesqas into open drains were significantly reduced. The positive effect of irrigation efficiency gains at the level of mesqas may be counterbalanced by the loss of the "multiplier effect" of unofficial water reuse at that level; thus creating an opportunity to expand official reuse (Salman, 2005).

Photo 2: Improved Delivery system: Radial Gates on Irrigation Offtake


Photo: WMRI, NWRC

Yet, the effects of the IIP's technical interventions on the performance and functions of existing land drainage are not fully understood. It is assumed that the anticipated effect of improved *mesqa* design, through the IIP interventions, would lead to a decrease in seepage losses, and hence to lower water tables, and reduced drain discharge of the laterals. It was reported that water tables in the improved area have rendered the discharge capacity of drainage systems less effective (IPTRID, 2005).

In EPIQ study (2001), the survey showed that 45 percent of the farmers practiced unofficial drainage reuse due to inadequate canal water. WMRI study (2007) showed that the introduction of continuous flow is still significantly lagging behind other improvement interventions. Continuous flow has been effectively applied only to 18 percent of "Mahmoudia" sample. However, the assessment of farmers' acceptance of the continuous flow showed that all of them were in favour of continuous flow for different reasons. It also indicated that about 83.3 percent of the farmers in Wassat area and 90.8 percent in Mahmoudia area preferred pipeline as improved *mesqa* rather than raised lined *mesqa*.

Socio-economic aspects of the IIP

The appraisal of the socio-and agro-economic effects of improved irrigation suggests that increased availability of water has augmented the productivity of irrigated crops by 12 to 15 percent on average. At the same time, water productivity has increased, which primarily can be attributed to improvements in agricultural production technology. For example, farmers in the project area reported that they had widely adopted the use of short-duration rice varieties. This has shortened the time from transplanting to harvesting by up to four weeks and helped save a considerable amount of irrigation water. The shortening of rice cultivation by four weeks has created a window of opportunity for the cultivation of an additional crop, which would take advantage of the freed land and available water resources. The net effect of water savings through the adoption of short duration rice varieties is hence balanced by the farmers' intensification strategy. It is assumed that improved irrigation has augmented farmers' income, although gains probably fall short of expectations assumed at the project design stage (IPTRID, 2005).

EPIQ study (2001) showed that 75 percent of the sample expressed their interest to join WUAs, while 85 percent were willing to share irrigation improvement costs. In the WMRI study (2007), the increase in crop yield, in the areas where continuous flow was introduced, was significant according to Mahmoudia farmers. Increase in wheat, cotton, maize, and cice were estimated at 10.4 percent, 18 percent, 9.8 percent and 16.9 percent, respectively.

Institutional and legal arrangements

Since the introduction of year-round irrigation in the 1980s, provision of irrigation services at the levels of main and branch canals is the responsibility of MWRI's Irrigation Sector and its Irrigation District Units. The *mesqas* are fully owned and managed by groups of farmers served by the *mesqa*; they were not organized into any formal or informal groups. As a result, Law 12/1984 was issued to regulate the operation and maintenance of *mesqas* and field drains.

Despite the existence of law 12/1984, inequitable water distribution is a common problem along non-improved *mesqas*, and poses a serious constraint to improved water productivity. Inequity of water distribution has led to major conflicts and social unrest among farmers.

Under the IIP, farmers were organized into WUAs that were responsible for water distribution and participation in irrigation costs such as pumping and canal maintenance. In 1994, the irrigation legislation was amended (Law 231/1994) to regulate the establishment and registration of WUAs as a legal entity and to specify their responsibilities. As the owners of pumps, they operate and maintain them and ensure that the costs are covered. More than seven thousand WUAs were established under IIP and other projects. The MWRI has facilitated alternative management models at the branch canal level, including the Branch Canal Water User Associations (BCWUAs) supported by USAID and Water Boards supported by the Dutch Government and similar to those in the Netherlands. The Water Boards Project is currently moving to broaden the domain of water boards to the district level, which includes several branch canals.

Based on the EWUP recommendation irrigation improvement activities have institutionalized under a central administration in 1984. It was later upscaled to become the IIS in 1997. The mechanism through which EWUP suggested improved techniques would be introduced and diffused to farmers became the Central Administration for IAS. The advisory service generally performs two major activities: (1) advises farmers about ways to improve their irrigation practices; and (2) organizes farmers to operate and maintain their watercourses.

3.1.4. Summary

A summary of the rationale and objectives, findings, uptake and impact for the IIP case study is given in Table 1.

Table 1: Summary of Research Uptake Case Study I – Irrigation

Rationale /Objectives:

- Over irrigation on a relatively fixed area of land has caused:
  - waterlogging and build up of salts in the soil profile
  - low field efficiency and ineffectiveness of water delivery
- Emerging need for better on-farm management to improve the irrigation efficiency.
- EWUP's objectives were to:
  - improve the social and economic conditions of the Egyptian small farmers through development and use of improved irrigation water management and associated practices which increase agricultural production
  - promote efficient water use and decrease drainage problems
  - raise the institutional capacity of MWRI to develop and implement improved on-farm water management programs

Sub-Component	Findings	Uptake/Impacts

Precision Land Leveling (PLL)	• PLL minimized field elevation variation:
	  o farmers were able to achieve good field coverage with smaller application depths
	  o drainage of excess water was consequently reduced
	  o reduced *saqia*-to-field conveyance channel length and saved water
	  o with conveyance channel improvements led to higher on-farm irrigation efficiencies
	• Higher efficiencies decreased irrigation time and reduced water lifting costs.
		• Although, continuous flow conditions are not reached yet, the construction of lined canals and buried pipes has considerably increased conveyance efficiency.
		• Individual pumping has been replaced by a centrally operated pumping system that is managed by members of WUAs.
		• Shift from individual to collective pumping has resulted in considerable cost savings in the order of one-third.
		• IIP's monitoring and evaluation component showed that:
		  o unofficial reuse of drainage water has widely disappeared along improved *mesqas*
		  o water losses at the tail-ends of the *mesqas* into open drains were significantly reduced
		• Positive effect on irrigation efficiency gains at the level of *mesqas* may be counterbalanced by the loss of the "multiplier effect" of unofficial water reuse at that level; thus, creating an opportunity to expand official reuse.

On-farm Irrigation System	• Total annual cost for three typical canal sizes was estimated to analyze the economic feasibility of lining.
	• Inadequate hydraulic control resulted in water losses to drains of about 30-40% of inflow.
	• Several system renovations were recommended to:
	  o canal head-gates
	  o field turnouts
	  o measurement structures	

Irrigation Scheduling and Crop Management	• Higher yields and greater returns from applied water resulted when farmers followed recommended crop and water management practices. • Irrigation should take place at: o soil depletion of 40-50% of the available moisture in the effective root depth o equivalent to a soil water deficit of 7 cm, which was accepted as a guideline for irrigation time • PLL made construction of long furrows and basins possible: o cropped area was increased through eliminating ineffective, closely spaced, shallow, poorly maintained field drains o soil smoothing improved seedbed quality at least for the next crop	• Increased availability of water has augmented the productivity of irrigated crops by 12 to 15% on average. • Water productivity has increased, which primarily can be attributed to improvements in agricultural production technology. • Farmers' income has been augmented, although gains probably fall short of expectations assumed at the project design stage.
Institutional Arrangements	• Irrigation advisory service was suggested as a mechanism through which improved techniques would be introduced and diffused to farmers • The radical concept of WUAs was found: o feasible o socially acceptable o operational and replicable o needs legislation	• IIS was established in 1997 under the Irrigation Department of MWRI. • IAS was established in 1999 as a central administration in IIS that advises farmers to: o improve their irrigation practices o operate and maintain their watercourses o organize themselves in WUAs o implement a precision land leveling programme o construct on-farm irrigation systems • In 1984 was issued to regulate the operation and maintenance of *mesqas* and field drains. • In 1994, the irrigation legislation was amended (Law 231/1994) to regulate the establishment and registration of WUAs as a legal entity and to specify their responsibilities. • Currently seven thousands WUAs exist. • MWRI has facilitated alternative management models at the branch canal level, including BCWUAs.