Impact of Territorial Features on the Improvement of the Irrigation Efficiency:

"What Kind of Proximity is Relevant for Improving Irrigation?"

Case Study in Beheira Governorate, Egypt

A DISSERTATION PRESENTED
BY

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ABSTRACT

This dissertation explores the possible differential influence of territorial features on the performance of irrigation improvement programs in Egypt. The study was conducted in El-Mahmoudia main canal, Beheira governorate which is one of the command areas in Nile Delta where Integrated Irrigation Improvement and Management Project (IIIMP) was applied in accordance with the principles of Integrated Water Resources Management (IWRM). Three branch canals on El-Mahmoudia main canal were purposively selected to represent the current situation of improved and unimproved irrigation systems. The first is a successful improved branch canal (KafrNikla); the second is relatively less successful improved branch canal (Besentway), and; the third one is unimproved sub-branch canal from El-Mahmoudia canal (Ganabet Bastara& El Ziana).

A simple random sample of 220 water users (25%) was drawn from the total estimated number of water users on the selected branch canals (160 from improved branch canals and 60 for unimproved ones). *Mesqas*' locations on branch canals, and water users' land locations on *mesqas* (upstream/ midstream/ downstream) were taken into account to represent the current situation of irrigation systems in these areas. Data were collected through personal interviews by using a semi-structured questionnaire designed and pretested to achieve the study objectives.

Findings indicate that in improved areas, there are statistically significant and positive correlations between specific proximity dimensions (cognitive, and social) and each of IIIMP and BCWUAs' performances. Meanwhile, results point to a significant positive relationship between organizational proximity and IIIMP performance.

Among the different proximity dimensions, there are significant positive relationships between: cognitive and social; cognitive and organizational, and; social and organizational proximities.

Comparing the studied branch canals (Nikla and Besentway) within two different territories, there is a significant positive correlation between social proximity and *mesqas'* geographical location of the successful branch canal (Nikla). However, there are significant and negative relationships between Besentway's *mesqas* geographical locations and each of: cognitive proximity, social proximity, and IIIMPs' performance.

These findings lead to an empirical evidence that cognitive, social, and organizational proximities have a strong role in supporting the implementation of IWRM.

Key words: Territorial features, IWRM, Irrigation system, Proximity, Egypt

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For any errors or inadequacies that may remain in this work, of course, the responsibility is entirely my own.

WEIGHTS AND MEASURES

1 kilogram (kg)	=	2.204 pounds (lb)
1 000 kg	=	1 metric tonne (t)
1 kilometer (km)	=	0.62 miles (mi)
1 metre (m)	=	1.09 yards (yd)
1 square metre (m^2)	=	10.76 square feet (ft^2)
1 acre (ac)	=	0.405 ha
1 hectare (ha)	=	2.47 ac
1 feddan	=	0.42 ha
1 ha	=	2.38 feddan
1 feddan	=	24 Kirat
1 Kirat	=	175 square meter (m^2)
1 cubic meter	=	1000 liters

ABBREVIATIONS AND ACRONYMS

AHD: Aswan High Dam

BCM: Billion Cubic Meter

BCWBs: Branch Canal Water Boards

BCWUA: Branch Canal Water Users Association

CAPMS: Central Agency for Public Mobilization and Statistics

CHE: Conference on the Human Environment

EEAA: Ministry of Egyptian Environmental Affairs Agency

EWUP: Egyptian Water Use and Management Project

FAO: Food and Agriculture Organization

GIS: Geographic Information System

GWP: Global Water Partnership

GWPO: Global Water Partnership Organization

HDR: Human Development Report

IAS: Irrigation Advisory Service

ICWE: International Conference on Water and the Environment

IFAD: International Fund for Agricultural Development

IHP: International Hydrological Programme

IIIMP: Integrated Irrigation Improvement and Management Project

IIP: Irrigation Improvement Projects

IMT: Irrigation Management Transfer

IWMDs: Integrated Water Management Districts

IWRM: Integrated Water Resources Management

KfW: German Development Bank (Kreditaustalt fur Wiederaufbau)

MALR: Ministry of Agriculture and Land Reclamation

MDGs: Millennium Development Goals

MOHP: Ministry of Health and Population

MOHU: Ministry of Housing, Utilities and Urban Development

MWRI: Ministry of Water Resources and Irrigation

NDC: Netherlands Development Cooperation

NMP: National Master Plan

NSAS: Nubian Sandstone Aquifer System

NWC: National Water Council

NWRP: National Water Resources Plan

O&M: Operation and Maintenance

PVC: Polyvinylchloride

RIIP: Regional Irrigation Improvement Project

RMC: Regional Management Committee

SDGs: Sustainable Development Goals

SIDA: Swedish International Development Agency

SIS: State Information Services

SPSS: Statistical Package for the Social Science software

UN: United Nation

UNCED: United Nations Conference on Environment and Development

UNDP: United Nations Development Program

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNWC: United Nations Water Conference

USAID: United States Agency for International Development

VWT: Virtual Water Trade

WB: World bank

WEI: Water Exploitation Index

WUA: Water Users Association

WUs: Water Users

WWC: World Water Council

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CHAPTER 1

Introduction

The protection of water resources is one of the major reasons of conflicts, and sometimes war among countries over time. Recently, these conflicts have worsened in consequence of the misuse of water resources (Darwish, 2003), especially among countries like Egypt that share the same water source (Nile River) with other ten riparian countries, and suffering from water scarcity. Water scarcity could be assessed by the Water Exploitation Index (WEI) which illustrates to which extent the total water demand puts pressure on the available water resource in a given territory and points out the territories that have high water demand compared to their resources (European Commission, 2016).

In fact, the largest demand for the world's water is agriculture, where more than two-thirds of world water is used for irrigation. In this context, solutions for water scarcity is debatable, some scholars adopt the concept of Virtual Water Trade (VWT), which signify that using water for local food production is not necessary and the easier and economically smart alternative for water scarce countries is to import "Virtual Water" incorporated in food from water rich countries (FAO, 2003). The international food production system and the global trading system in food staples have enabled regions such as the Middle East to meet their water deficits by importing virtual water (Allan, 1995).

However, other scholars such as Horlemann and Neubert (2007) criticized VWT concept and raised the attention on possible consequences which would be highly negative for both exporting and importing countries. On the one hand, the importing countries will suffer from blackmail, rise of unemployment, internal migration, and insufficient irrigation management. On the other hand, exporting countries will suffer from over exploitation of water resources, environmental pollution, and water scarcity(Figure 1). This could lead to the concept "territorial transfer of sustainability" according to which a country achieves sustainable development at the expenses of another country (Adhikary and Chowdhury, 2010 in Gawel and Bernsen, 2011).

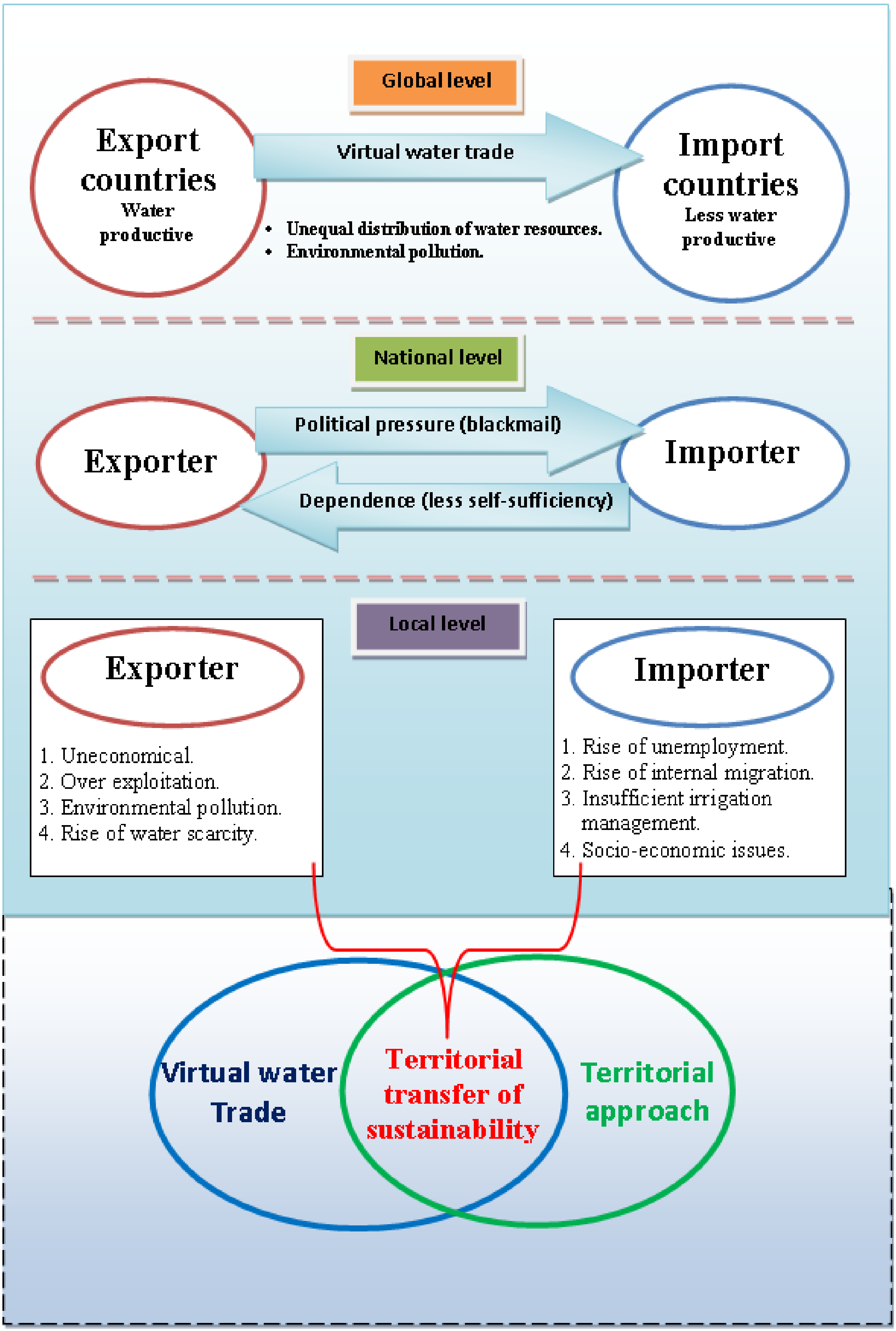

Figure 1. Possible consequences of Virtual Water Trade on the global, national and local level (Sources: Author's elaboration)

Alternatively, Irrigation Management Transfer (IMT),is the relocation of responsibilities and authority for irrigation management from government agencies to water users (Vermillion and Sagardoy, 1999, p. 104). Faggi (1995) as cited in Zinzani (2014a) supported shifting the management control from state departments to the local communities of Water Users (WUs), which necessitate the need for a structural adjustment of the water sector and related policies, and a deep understanding of new territories that are strictly connected with water, and its belonging issues (Zinzani, 2014b). the new spatial dimension is re-launching the role of the proximity[1] of actors in the construction of territory and its resources (Pecqueur, 2013). In addition, the interaction between local actors in these territories could be interpreted by the different dimensions of proximity (Balland, Boschma and Frenken, 2014), that proposed by Boschma in 2005, which are: cognitive, social, organizational, institutional, and geographical proximities, which in turn, could reduce uncertainty, enhance coordination and interactive learning (Boschma, 2005).

Water user collectives, although internally differentiated, require a collective identity connected to its water sources and socio-technical infrastructure system, shared normative system and a physical, natural and human-bounded territorial water control space (Boelens et al. 2016). Based on this, implementation of Integrated Water Resource Management (IWRM), could be considered a prescription for poor water governance and management (Bliek, 2014). IWRM aims to develop and implement well-organized and sustainable solutions to water and development problems. In addition, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing water resources to ensure the equilibrium between social and economic needs, and that ensures the protection of ecosystems for future generations (Upadhyay, 2012).

In Egypt, the government in collaboration with other governmental and non-governmental actors and donor agencies has launched IWRM approach through the establishment of Irrigation Improvement and Management Project (IIIMP) in 2004 on specific command areas, to meet the challenges of limited water resources, growing demand, degrading water quality, which is caused by diverse source of pollution (industrial and agricultural waste, sewage, house residues, etc.), inefficient water use,

[1]**Proximity** nearness in space, time, or relationship

inadequate finance, ineffective stakeholders' participation, and insufficient laws enforcement (Abdelgawad, Allam and Elgamal, 2010). IWRM is sought to be a promising system that enable farmers to become the managers, and the government to be the service and support provider. IWRM (through PIM) is expected to: endorse WUs in cost of irrigation water delivery and to feel a responsibility toward their irrigation system; manage the operation and maintenance (O&M) practices according to their irrigation requirements, and; collectively as an organized group allocate irrigation water effectively (IFAD, 2001).

IWRM can however be considered as a 'Nirvana concept' (Molle, 2008) when applied to unsuitable territorial contexts, in the sense that its full application can be too abstract when addressing implementation challenges, which in turn makes it less operational and practical specially in developing countries. Additionally, its difficulty to recognize conflict and enabling proper prioritization that are most important for local people (CFS, 2015).

1.1 Problem statement

In Egypt, under the unimproved[2] irrigation arrangements, there is a tendency to favor the farmers whom lands are located at the head of the irrigation channels (branch canal[3]) on the expenses of in tail farmers. This situation lead, in most cases, to serious conflicts among WUs, social anxiety, and further marginalization of farmers located at downstream of water channels that affects their production and abilities to cope with water scarcity.

Government's inability to meet WUs' needs, misuse of the resources, multifarious technical system, and the absence of an exclusive and transparent cost-recovery mechanism are major drivers of inefficient irrigation system (FAO, 2005). All these obstacles forced the government of Egypt to find mechanisms in collaborations with international organizations (e.g. World Bank, and USAID, etc.) to reduce the burden on WUs. The adoption of IWRM could be a promising solution as it is more bottom up approach and incorporate social and environmental aspects.

[2]**Unimproved areas** are still under the traditional irrigation system, where WUs use their personal irrigation pumps to lift water from canals to irrigate their lands. Absence of water scheduling among WUs is usually observed.

[3]**Branch canal** represents the micro level of the irrigation system in Egypt which could be considered as a base to identify the territorial boundaries in the irrigation system.

However, introducing innovations in local communities could be affected by knowledge sharing, trust, culture, boundaries, etc

Accordingly, the following questions have been provoked:

(1) What is the current situation of the irrigation process under improved[4] and unimproved irrigation systems?
(2) To what extent the irrigation improvement system is efficient?
(3) To what extent the irrigation improvement system is effective?
(4) What are the different kinds of proximity that have impact on the performance of irrigation improvement system?

1.2 Objectives of the study

The overall objective of the study is to explores the possible differential influence of territorial features on the performance of irrigation improvement programs in Egypt. In order to achieve this, the following specific objectives have been defined:

(1) To compare the current situation of WUs' demographic characteristics in improved and unimproved areas.
(2) To test significance of difference between improved and unimproved areas.
(3) To investigate the relationships between the studied independent variables and BCWUA performance.
(4) To investigate the relationships between the studied independent variables and IIIMP performance.
(5) To investigate the relationships among different kinds of proximity.
(6) To investigate the impact of different kinds of proximity on the performance of BCWUA.
(7) To explore the relationships of different kinds of proximity on IIIMP performance.
(8) To examine the relationships between the studied independent variables and different kinds of proximity.

[4]**Improved areas** are the areas in which Irrigation Improvement Projects (IIP) have been applied to replace the traditional irrigation system (using personal irrigation pumps) aiming to improve system design and performance and enhancing farmers' skills to control and manage their irrigation system more efficiently during its operation (Augier, Baudequin, and Cemagref, 1996).

(9) To investigate the relationships between geographical location and different kinds of proximity.

(10) To examine the relationship between *mesqas'*[5] geographical location and BCWUAs' performance.

(11) To examine the relationship between *mesqas'* geographical location and IIIMP's performance.

1.3 Limitations of the study

(1) Due to the limitations of facilities to cover all branch canals located on El-Mahmoudia main canal; only three districts were selected namely: El-Mahmoudia, Abu Homs and Damanhur.

(2) Due to overlapping tasks among diverse authorized agencies concerning irrigation water (department of water steering and department of water engineering), it took long time to obtain official permission for data collection.

(3) This study is based on WUs' perceptions regarding IIIMP and BCWUAs' performances, for this reason the study did not address the dimension of institutional proximity

(4) Regarding sampling:

(3.1) Land owners are not usually the cultivators of their lands, where some of them rent their lands to other WUs who are sometimes changed every season. Consequently, it took time in collaboration with a key person to determine the actual number of WUs and to meet them.

(3.2) Some *mesqas* located on the downstream of Nikla branch canal were still under the traditional irrigation system, as a result they were excluded and that affected the intended sample number.

[5]**Mesqas**or tertiary canals, which distribute water to the *marwas* (private properties and subject to the farmer's authority) or directly to the basins and furrow on private farms. These *mesqas* are normally about half a meter below the field level. Thus, farmers must lift the water from the branch canals to their *mesqas* according to the rotation system (Nawar, 2007, p. 18)

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

1. Nile River Basin, General Description

The Nile River Basin is one of the most unique world's rivers, it is 6,853 km long from its farthest sources at the headwaters of the Kagera River in Burundi and Rwanda to its Delta in Egypt. The total area of the Nile basin represents 10.3 percent of the area of the continent and flows through eleven countries, namely: Tanzania, Uganda, Rwanda, Burundi, Kenya, Ethiopia, Eritrea, South Sudan, Sudan, Democratic Republic of the Congo, and Egypt (FAO, 1997), as shown, in Figure (2). Approximately 300 million people within the riparian countries benefit from the Nile Basin, out of them 140 million people live outside the boundaries of the Nile Basin and use other water resources that include groundwater sources (Oloo, 2007, p.96) or rainfalls, in the case of most humid upstream areas.

Figure 2. Countries in the Nile River basin (Source: Odyssey, 2017)

Egypt is densely inhabited country, where the total population in July 2017 is estimated by 97,041,072 makes it the third most populous country in Africa, behind Nigeria and Ethiopia. The length of the Nile River in Egypt is about 1530 km. About

95% of the population is concentrated in a narrow strip of fertile land along the Nile River, which represents only about 5% of Egypt's land area (CIA, 2017).

2. A brief history on Nile River agreements

Nile Basin Initiative (NBI) is an intergovernmental partnership that launched in 1999, and comprising 10 Nile riparian countries, and Eritrea that participates as an observer (NBI, 2017). NBI aimed to strengthen the cooperation within the basin through building trust, and implementing actual development project. The NBI was sought to be a transitional institution until the Nile Cooperative Framework Agreement (CFA) was signed in 2010. However, this time only six countries have signed the agreement, namely: Uganda, Ethiopia, Kenya, Rwanda, Tanzania, and Burundi (FAO AQUASTAT, 2016), in 2012, South Sudan signed the CFA to become the seventh country to join the agreement (Shay, 2017).

In fact, CFA (Entebbe Agreement) has been strongly rejected by Egypt and Sudan due to the wording of some of its articles that seems to be unfair for both countries and cancelling their historical rights in the Nile River's quota from their perspectives. Consequently, Egypt and Sudan remain adhering to the first two agreements. The first one was in 1929, the Anglo-Egyptian Treaty, which granted Egypt an annual water allocation of 48 BCMs, and 4 BCMs for Sudan. Besides, Egypt has veto power over construction projects on the Nile River and any of its tributaries. The second was in 1959, in which Egypt and Sudan signed a bilateral agreement that increased water allocations to Egypt to reach 55.5 BCMs and 18.5 BCMs for Sudan (MWRI, 2005; Kimenyi and Mbaku, 2015; FAO, 2016).

Now it is clear that both downstream and upstream countries have contradictory needs and all have their justifications. On the one hand, the upstream countries refuse what they called "Egypt's acquired rights" in the Nile water, and strongly denounce both 1929 and 1959 agreements as it is not reasonable to adhere to agreements where they are not included. These reasons drive some of the upstream countries to sign agreements *for their own benefit; although, the central point of having a treaty on the Nile watercourse is to balance upper and lower riparian interests*". In addition, to build various dams on both the Blue and White Niles (e.g.

the Grand Renaissance Dam in Ethiopia) for agricultural and hydroelectric power generation projects.

On the other hand, Egypt's limited water resources where it depends mostly on Nile River (as discussed in next section), forces it to overuse subterranean water, which could salinate and deplete underground reservoirs in many places. Unfortunately, Egypt also use contaminated agricultural drainage water to compensate the shortage, which is even more polluted by untreated sewage and industrial waste flowing into it (Al-Naggar, 2014).

Unilateral, uncoordinated development by riparian countries in a transboundary basin may foreclose opportunities for optimized development from a regional perspectives and may even have detrimental consequences for the hydrology and ecosystem health of the basin. Thus, cooperative action is necessary to optimize benefits regionally and mitigate the shared risk including those associated with climate change and variability (WB, 2017). Additionally, further comparative studies is critically needed that aims to make comparison across the different riparian countries.

3. Types of agriculture lands in Egypt

The total cultivated land area in Egypt is about 3.6 million ha which represent 3 percent of the total land area. Egypt is seeking to increase its irrigated areas, thus, its irrigation development plan involve the enhancement of water use efficiency (vertical expansion) through developing its irrigation systems. Additionally, increasing the cultivated area (horizontal expansion), which in turn, leads to classifying the irrigated areas into: 1) **Old lands,** which covers 2.25 million ha in the Nile Valley and Delta, and desert lands that were reclaimed several years ago, cultivated mostly using water from the Nile and irrigated by traditional surface irrigation systems, and distinguished by alluvial soil; 2) **New lands** (old new lands and new-new lands) covers 1.05 million ha, these lands were reclaimed since the construction of the Aswan High Dam (AHD); they are irrigated using Sprinkler and drip irrigation regimes. Although, New lands are less fertile, innovative and developed water management and cropping patterns will improve its productivity (IFAD, no date; Karajeh *et al*, 2011); 3) **Rainfed**[6] **areas** cover about 84,000 ha in Egyptian North coast, where North Sinai and Marsa Matrouh are located.; and 4) **Oases** where groundwater is used for irrigation (FAO, 2016).

The problem of irrigation in the old lands is particularly focused on the misuse and/or abuse of water. Deficiencies in the local management of irrigation water could be attributed to defects in the organization of irrigation process leading to unequal distribution of irrigation water among WUs. This in turn, may lead to disputes among WUs; affecting the social relations among irrigators. Additionally, Nawar, Abdel-Kader and El-Bendary (2001, p.3) mentioned that as the pressure on water resources increased the growing water balance deficit became more alarming. Thus, many empirical studies revealed the urgent need to rationalize the use of water resources to overcome such constrains and the potential consequent social problems.

4. Egypt's water resources

Water resources in Egypt are varied, including conventional and non-conventional water resources.

[6]The term **Rainfed** agriculture is used to describe farming practices that rely on rainfall for water.

4.1 Conventional water resources

Conventional water resources in Egypt are limited mainly to the Nile River and the groundwater in the Nile Delta, the deserts and Sinai Peninsula. Limited rainfall and flash floods are also viable sources of water (Abdel-Gawadh et al., 2002).

4.1.1 Nile River

As mentioned above, the Nile River is the most important source of water in Egypt as it represents 76.7 percent of the country's available water resources (Salim, 2012). The water amount (55.5 BCM/year) is guaranteed by the multi-year regulatory capacity provided by the AHD (MWRI, 2002; MWRI, 2014). AHD is the major regulatory facility on the river. Its operation started in 1968 ensuring Egypt's control over its share of water and guiding its full utilization. Downstream AHD, the Nile water is diverted from the main stream into an intensive network of canals through several types of control structures. These canals provide water mainly for agricultural use (Abdel-Aziz, 2003).

4.1.2 Rainfall

Rainfall in Egypt is very scarce except in a narrow band along the Northern coastal areas. Rainfall occurs in winter in the form of scattered showers along the Mediterranean shoreline (Attia, 2009). The average annual amount of effectively utilized rainfall water is estimated to be 1.3 BCM/year (MWRI, 2014).

4.1.3 Groundwater

Exists in Western Desert and Sinai in aquifers that are mostly deep and non-renewable (e.g., Nubian Sandstones Aquifers). The total groundwater volume has been estimated at about 40,000 BCM. However, abstraction is estimated to be 2.0 BCM/year. The great depths (up to 1500 m in some areas) of these aquifers and the drop in water quality are of major difficulties in utilizing this indispensable water resource (Abu-Zeid, 1995; MWRI, 2014). Main aquifer systems in Egypt (Figure 3) are: Nile aquifer system, Nubian Sandstone Aquifer System (NSAS)[7], the fissured carbonate aquifer, the coastal aquifer, the Moghra aquifer, and the Hard rock aquifer system (Arabi, 2012).

[7]**NSAS** is the largest groundwater aquifer underneath the eastern part of the African Sahara, and is shared between Egypt, Chad, Libya, and Sudan (IAEA, 2011).

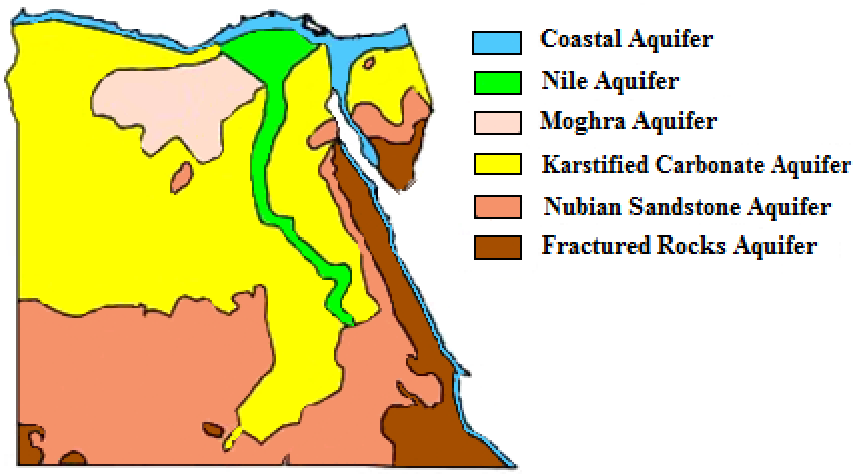

Figure 3. Aquifer systems in Egypt

4.2 Non-conventional water resources

Non-conventional water resources include renewable groundwater aquifer in the Nile basin and Delta, agricultural drainage water, treated wastewater, and desalinated sea water. These water sources cannot be considered independent resources and their uses are exclusively a recycling process of the previously Nile fresh water. Thus, rigorous safety standard should be applied for its usage (El-Gohary, 2002).

4.2.1 Shallow groundwater

The Nile aquifer cannot be considered a separate source of water, it is renewable only by seepage losses from the Nile, irrigation canals, and drains, and percolation losses from irrigated lands. The total available storage of the Nile aquifer is estimated at 500 BCM but the maximum renewable amount (the aquifer safe yield) is around 7.5 BCM. The existing rate of groundwater abstraction in the Valley and Delta regions is about 4.8 BCM/year, which is still below the potential safe yield of the aquifer (El-Gohary, 2002; Alnaggar, 2003, p. 59).

4.2.2 Treated sewage water

It can be used in irrigation as it is or by mixing it with fresh water. in Egypt the treated sewage water is about 0.3 BCM in 2013 (MWRI, 2014). Nevertheless, Misheloff (2010) revealed that some risks may result from using inadequately treated sewage water, which are as follows: a) health risks resulting from human exposure to pathogens; b) contamination of soils and plants because of harmful chemicals; and c) groundwater pollution from infiltration of contaminated water.

4.2.3 The agricultural drainage water reuse

It is the excess of crop evapo-transpiration in addition to canal tail losses. The drainage flow is carried by the drainage system to be disposed out of the irrigation system. The philosophy of drainage reuse is to lift out a portion of this drainage water to be mixed with canal water. Hence, the canal will be able to irrigate more land (Abdel-Azim and Allam, 2005, p. 105). El-Sayed (2011) mentioned that drainage water reuse is needed as the water resources in Egypt are limited, the gap between fresh water supply and demand is 6 BCM/year and expected to reach 10 BCM by year 2017.

4.2.4 Desalinated seawater

Desalination of seawater is being practiced in Egypt along the Mediterranean coast, the Red sea coast, and in North and South Sinai as small-scale desalination plants due to high cost (Abdel Ghaffar, 2006). In Egypt desalinated seawater comprises only 0.08 percent of the total water resources (Salim, 2012).

5. Water use in Egypt

In Egypt, of all sectors agricultural consumes extremely large quantity of water, exceeding 84 percent of the total water demand compared with other sectors such as drinking water consumes 12 percent, and industry consumes 4 percent (Wolters*et al.*, 2016). However, Egypt is facing severe water scarcity due to over population and climate change; the per capita share of water in 2006 was 850 m^3/year and dropped to 700 m^3/year in 2011 and it is expected to reach 500 m^3/year by 2030, which is considered to be below the water poverty level. This could necessitate a reduction in water quantity consumed in agriculture; thus, improving water efficiencies over a range of scale is urgently needed (Karajeh *et al*, 2011). Water is also extremely important for energy production, navigation, tourism and recreation, fisheries and the preservation of valuable nature areas.

6. The institutional setting of irrigation system in Egypt

This section presents the physical structure of the irrigation canals network, main organizations in the water sector, and the legislation framework ruling all aspects of the irrigation behavior at the local and higher administrative levels.

6.1 Egypt's Irrigation Network in Nile Delta

WUs obtain their water demand through a complex network (Figure 4), which consists of a principal canal (*Rayah*), main canals (primary), branch canals (secondary), *Mesqa* (tertiary canals), and finally, reach WUs' fields through *Merwa* (quaternary field ditches). Principal canal, main canals, and branch canals are governed by General Directorate for Water Distribution, which allocates the water to the Irrigation Directories. Then, Irrigation Directories distributes it to the Irrigation Districts (Mohsen *et al*, 2012).

The irrigation water is diverted from the Nile river by barrages; then, through the primary irrigation system (principal canal, and main canal) under a continuous flow of water. The discharge are regulated by head-control structures, generally equipped with lifting gates. After that, the irrigation water flows to the secondary systems (branch canals controlled by lifting gates), which are operated with rotation system (two or three turn) under administration of district engineers. From branch canals, irrigation water is distributed over the tertiary canals (*mesqas*), then, a farmer is free to distribute it over his fields by his own methods (individual irrigation pump or collective pump) (Oosterbaan, 1999). Branch canals may have sub-branches (*Gannabia*). Main and branch canals are public property under MWRI's Irrigation Sector and its Irrigation District Units. While *mesqas* are fully owned, managed, and maintained by a group of farmers (Molle*et al*, 2015; FAO, 2004).

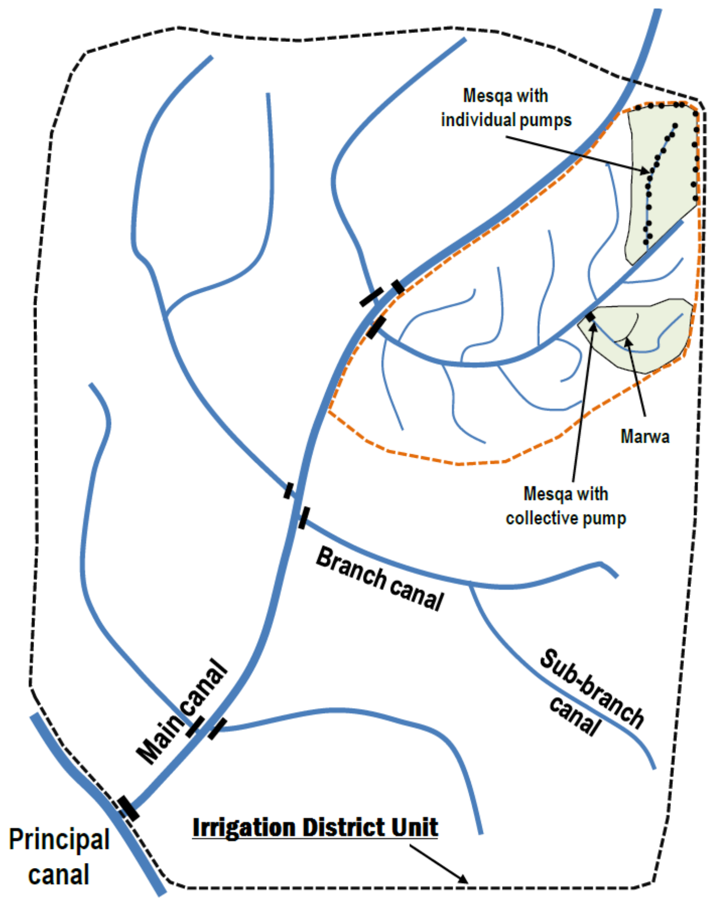

Figure 4. Egypt's Irrigation Network in Nile Delta (Source: Molle, and Rap, 2013)

6.2 Water management, policies and legislations related to water use in agriculture

The Ministry of Water Resources and Irrigation (MWRI) is the main governmental body governing the issue of water management and usage in Egypt. There are other public authorities involved in water issues and collaborate with MWRI. Some of these public authorities' responsibilities will be discussed in the next section and others will be noted in Table (1) that addresses Egypt's main water laws.

6.2.1 Ministry of Water Resources and Irrigation (MWRI)

The water resources sector management in Egypt is centralized and is set to be managed by MWRI, which is responsible for: formulating water policy; using technologies in managing different water resources to maximize its revenue and increase its efficiency; developing irrigation methods for effective use of the available water resources; controlling irrigation water distribution; protect water from pollution; and cooperating with the Nile basin countries to establish joint projects to make use of the lost water (CEDARE, 2014).

6.2.2 Ministry of Agriculture and Land Reclamation (MALR)

The MALR cooperate with the MWRI to improve water management, reduce effects of pollution (e.g. regulating the effects of fertilizer and pesticide use, etc.), and maintain adequate water quantity (USAID, 2010). In addition to employing maximum crop per drop concept (CEDARE, 2014).

6.2.3 Egyptian Environmental Affairs Agency (EEAA)

EEAA cooperates with MWRI and MALR and other ministries to protect Nile river and water ways by enforcing laws and other environmental rules, including monitoring to ensure that the existing establishments comply with the available technical methods, and international environmental standards (EEAA, 2017).

6.2.4 National Water Council (NWC)

Works on integrating policies and activities at national and local level, through inter-ministerial coordination. NWC is assist by a technical secretariat and Water & Environment units within the different Ministries and organizations. At governorate level, a Regional Management Committee (RMC) includes all stakeholders and is chaired by the local MWRI responsible (MWRI, 2005).

Table 1. Description of the main Egypt's water laws and their implementing agencies

Law/Year	Deals with	Description	Implementing agency
Law no. 12/1984	Irrigation and drainage	Regulates the use of water, include full recovery of subsurface drainage cost by farmers	MWRI
Law no. 93/1962	Drainage of liquid waste	Regulates the discharge of waste water into sewer systems and specifies standards for waste disposal to sewers and for use in irrigation.	MOHU
Law no. 48/1982	Protection of the Nile River and Waterways	Classifies types of waterways and regulates the discharge of waste water into these waterways.	MWRI & MOHP
Law no. 4/1992	Laws for the Environment	Provides rules for protection of the environment, regulates air pollution; sets standards for industry.	EEAA
Law no. 213/1994	Legalizes WUAs	Legalizes WUAs at *mesqas* level and provides for recovery of capital cost for IIP.	MWRI

Source: (Fahmy, et al. 2000)

7. Overview on Integrated Water Resource Management (IWRM)

In 1962 after publishing **Silent Spring** book, the need for sustainable development idea attracted global attention (Claassen, 2013), passing by the **United Nation (UN) Conference on the Human Environment (CHE)** held in Stockholm, Sweden in 1972 declared principles, which incorporate the idea of sustainable development (Biodiversity A-Z, 2014).

In 1977, The United Nations Water Conference (UNWC) in **Mar del Plata**, Argentina, assured the importance of developing a real coordination among all bodies responsible for the investigation, development and management of water resources. Nevertheless, negative environmental impact of high water demand was still not considered (UNWC, 1977).

In 1987, **World Commission on Environment and Development (Brundtland Commission)** submitted a report entitled "Our Common Future", which is significant milestone which popularized the definition of sustainable development *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Biodiversity A-Z, 2014).

The sustainability emerged was not enough to deal with the global water crisis; thus, a supportive approach to water resource management is necessary considered. As a result IWRM approach was evolved (Ferreira, and Leitão, 2006, p.147).

The **International Conference on Water and the Environment(ICWE)** also known as Dublin conference held in Dublin, Ireland (26-31 January 1992). The Dublin statement and a report were the conference outcomes. The conference declared four main principles (Dublin guiding principles) that should be taken into consideration to achieve integrated water resources development and management. Dublin guiding principles are (ICWE, 1992):

1st principle: fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

2nd principle: water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

3rd principle: women play a central part in the provision, management and safeguarding of water.

4th principle: water has an economic value in all its competing uses and should be recognized as an economic good.

These principles and many other ICWE's outputs were integrated in the freshwater section (Chapter 18 of Agenda 21[8]) of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil (3-14 June 1992).

UNCED (also known as Earth Summit, Rio de Janeiro Earth Summit , Rio Summit, and Rio Conference) expressed the need for sustainable development and addressed the need for water sector integration. The paper proposed by Koudstaal, Rijsberman & Savanije (Water and sustainable development) in ICWE presents almost all of IWRM characteristics, which are: 1) water resources should be an integral part of socio-economic development at national level; 2) integrated management approach should be adopted by water authorities; 3) water authorities should engage dynamically in socioeconomic development process through efficient water use; 4) management of water as a scarce resources (demand management); 5) accept charging for the utilization and management of water resources; and 6) adopting institutional approaches that allow charging for the utilization and management of water resources (UNCED, 1992); (Koudstaal, Rijsberman, and Savanije, 1992); and (Snellen, and Schrevel, 2004).

The paper proposed by Falkenmark and Lundqvist (Coping with Multi-cause Environmental Challenges - a Water Perspective on Development) in Dublin conference focused on the importance of land resources management for the quantity and quality of water resources which was not considered in Koudstaal, Rijsberman, and Savanije paper (Snellen, and Schrevel, 2004).

Based on many international conferences (e.g. Mar del Plat 1977, Duplin 1992, and Earth Summit 1992), the **World Water Council (WWC)** and the **Global Water Partnership (GWP[9])** were formed. GWP was established to operationalize and promote the Dublin Principles in the form of IWRM (Mwanza, 2006, p. 92).

[8]**Chapter 18 of Agenda 21** is on protection of the quality and supply of freshwater resources: Application of integrated approaches to the development, management and use of water resources.

[9]**GWP** is created by World Bank, the United Nations Development Program (UNDP), and the Swedish International Development Agency (SIDA) in 1996 (GWP, 2010). GWP became an intergovernmental organization under international law known as the Global Water Partnership Organization (GWPO) in 2002.

GWP's immediate objective was to ensure that IWRM is applied in a growing number of countries and regions, as a means to foster equitable and efficient management and sustainable use of water." GWP (2010), stated that, "*IWRM takes into account all sources and users of freshwater within a well defined physical area, such as a watershed or a river basin*" .

In 2000, IWRM was first officially defined by GWP in Technical Advisory Committee (TAC), Background Papers No. 4. IWRM was defined as:

"IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2000).

IWRM is also defined by Cap-Net UNDP[10] as:

"A systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives" (Cap-Net, 2005, p. 6).

USAID (2011, p. 26) defines IWRM as:

"A participatory planning and implementation process, based on sound science th at brings stakeholders together to determine how to meet society's longterm needs for water and coastal resources while maintaining essential ecological services a nd economic benefits."

It is worth noting that, IWRM call for a different way of water resource management as it is: more "bottom up"; cross-sectoral, and interdisciplinary; and incorporate the management of other related activities (e.g. land use) that affect water resources (Heathcote, 2002)

In 2014 the UNESCO's International Hydrological Programme (IHP) proposal in the post-2015 development agenda[11] recommends that the focus on water issues should be broadened and extend beyond the Millennium Development Goals

[10]**Cap-Net UNDP** is an international network for capacity development in sustainable water management.

[11]**Post-2015 development agenda** follows one of the main outcomes of *Rio+20 Conference,* which was the agreement to start a process of defining SDGs, which will be built on the MDGs.

Rio+20 Conference: The United Nations Conference on Sustainable Development (UNCSD) held in Rio De Janeiro, Brazil (20-22 June 2012) also known as Rio+20, Rio 2012 or Earth Summit 2012. Rio+20 Conference was follow-up to UNCED "Earth Summit 1992/2002". In Rio+20 Conference reaffirmed their commitment to Agenda 21 (global sustainable development agenda beyond 2015). A document called "The Future We Want" was the Rio+20's outcome.

(MDGs), which focus on access to water and sanitation to comprise other crucial issues such as water issues such as water-use efficiency, water quality and wastewater management, water-related disasters, in addition to, IWRM-based approach to water resources management. Thus, the UNESCO proposed five water-related Sustainable Development Goals (SDGs). Target three focused specifically on IWRM approach. This target advocates using the "public registration of water rights" as a measurable indicator to measure the integration of the IWRM concept in water policies.

> ***"Target 3: By 2030, increase by 50% the number of countries that have adopted and implemented policies and programmes for the public registration of water rights based on the IWRM approach"*** (UNESCO, 2014, p.5).

The SDGs, officially known as Transforming our world: the 2030 Agenda for Sustainable Development, is a set of 17 "Global Goals" with 169 targets among them (UN, 2015). All links between the sixth SDG's aspects (access to water, access to sanitation, water quality, water scarcity and water related ecosystems) and the other SDGs have to a certain extent, relevance for IWRM. Thus, IWRM is of crucial importance for the successful implementation of all other SDGs (UNESCO, 2016).

IWRM approach focuses on three basic pillars and explicitly aims at avoiding a fragmented approach of water resources management by considering the following aspects (UN, 2009, p.3):

(1) Enabling environment of suitable policies, strategies and legislation for sustainable water resources development and management

(2) Putting in place the institutional framework through which to put into practice the policies, strategies and legislation

(3) Setting up the management instruments required by these institutions to do their job.

8. Informal forms of stakeholders' participation in irrigation water

In Egypt, there are different informal (traditional) forms of stakeholders' participation in irrigation water use, which differ slightly among areas. There are "*Munawaba and Motarafa*" system and the "*Saqia ring*[12]" for collective water pumping. The "*Munawaba and Motarafa*" traditional system is an organizational unit at the "*mesqa*" service area with an off-take from a canal. The leader known as the

[12]The ***Saqia ring*** is animal or diesel powered water lifting system (at *mesqa* level). Water is allocated among WUs according to a turn system using individual water pumps. *Saqia* leader is responsible for money collection from WUs, conflict resolution, and O&M of both *saqia* and *mesqa*.

"*Rais El Munawaba*", and this leader has considerable responsibilities and authority for managing the irrigation water. He is respectable, usually old, with high socioeconomic status and must own land on the same *mesqa*. This organization allocates the water on a time basis to all water users on the *mesqa* fairly and rationally, settles irrigation water disputes and maintains the *mesqa* micro system on a regular basis (Nawar, Abdel-Kader, and El-Bendary, (2001, p.3); Alnaggar, (2003); and Abdel-Aziz, (2003, p.10)).

Serious conflicts and social anxiety have been resulted from the traditional system due to: inequitable water allocation, government's inability to meet WUs' needs, misuse of the resources, multifarious technical system, and the absence of an exclusive and transparent cost-recovery mechanism (FAO, 2005). All these difficulties are strong reasons that drive water authorities to launch various developments that aim to maximize the total amount of water available through improving irrigation efficiencies and the reuse of drainage water (MWRI, 2005).

9. Irrigation Improvement Projects (IIPs)

Based on the above, Irrigation Management Transfer[13] (IMT) process took place through Regional Irrigation Improvement Project (RIIP), which following the key recommendations that was set out by Egyptian Water Use and Management Project (EWUP) during the period between 1985-1988 (Gouda, 2016, p. 62).

EWUP developed a package of solutions including: a) on-farm irrigation system improvement using precision land leveling, irrigation scheduling, and improved crop production/management practices; b) water delivery improvements including continuous flow availability (versus rotational deliveries) and *mesqa* improvements; c) formation of Water Users Associations (WUAs); and d) establishment of Irrigation Advisory Service (IAS[14]) (APRP, 1998).

Irrigation Improvement Projects (IIP) was launched in 1988 based on EWUP, which considered a milestone project that involved MWRI's institutional reform and policy changes. The IIP aimed at achieving the main goals of the National Master Plan approved by the Cabinet in 1984 (IPTRID, 2005; IPTRID, 2007).

[13]**IMT** is the relocation of responsibilities and authority for irrigation management from government agencies to NGOs (e.g. Water Users Associations) (Vermillion and Sagardoy, 1999).

[14]**IAS** provide educational and technical transfer assistance to WUAs in relation to water delivery, water use and the process of WUA organization (Havidt, 1997)

The IIP package includes; a) the *physical changes* included changing the operation of secondary system (main, and branch canal) from rotational to continuous flow (still not reached), rebuilding of existing tertiary canals (*mesqas*) by conversion of low level *mesqas* to raised canals (J-section) or underground pipe lines (PVC[15]), and replacing individual pumps at multiple points along the *mesqa* by one collective lifting point (pumping stations) at a single point (Upstream of the improved *mesqa*), b) the *organizational changes* that included establishment of WUAs[16], and IAS (Kotb and Boissevain, 2012). The total area covered by IIP in 2017 is estimated to be 2.5 million feddan.

IIP focused on improving the efficiency and equitable distribution of water at the *mesqa* level. However, the main and branch canals as well had to function efficiently to deliver water to the *mesqa* outlets. As a result, the focal point of Integrated Irrigation Improvement and Management Project (IIIMP) is to improve the main and branch canals structure through the establishment of Branch Canal Water Board (BCWB) and Branch Canal Water Users Associations (BCWUAs) to improve the hydraulic capacity of the system and deliver more water to the *mesqas* canals (WB, 2016, P.5; Abdelgawad, Allam and Elgamal, 2010).

10. Integrated Irrigation Improvement and Management Project (IIIMP)

In Egypt, planning and implementation of IIIMP is one of the main project that makes IWRM approach tangible on the ground. Thus, water resources authorities (e.g. MWRI, MALR, MOLD, MOHUC) realized the extent of the challenge when they began to transfer the approach from an abstract idea to reality (FAO, 2005).

In line with that, based on the partnership between World Bank and MWRI (irrigation and drainage sector), and collaboration with the German Development Bank (Kreditaustalt fur Wiederaufbau, KfW), the Netherlands Development

[15]**PVC** Polyvinylchloride is a piped *mesqa* which replaces a previous ditch and saves on conveyance losses.

[16]**WUAs** are organizations responsible for the operation of the pump station, scheduling irrigations among water users, collection of pumping charges, hiring pump operators, maintain the *mesqa* and pumps and handling conflicts among the users (Havidt, 1997, p. 215). Law no. 213/1994 (an amendment to Law no. 12) legalized the establishment of WUAs at *mesqa* level (Freisem and Scheumann, 2001).

Cooperation (NDC), and other donors through their technical assistance and investments, IIIMP was build (WB, 2016).

In 2004, IIIMP program aimed to modernize Egypt's vital irrigation and drainage systems and their supporting institutions (CES, 2012). Consequently, (Figure 5) IIIMP has launched its improvement in about 500,000 feddan in five command areas, (WB, 2004; Misr Consult, 2005) namely:

1. Mahmoudia Command Area-280,000 feddan (Behera Governorate),
2. Meet Yazid Command Area-197,000 feddan (Kafr El Sheikh and Gharbia Governorates),
3. Bahr Tanah Command Area-84,000 feddan (Dakahleya Governorate),
4. Serry Command Area- 120,000 feddan (Minia Governorate), and
5. Tomas and Afia Command Area-17,000 feddan (Qena Governorate).

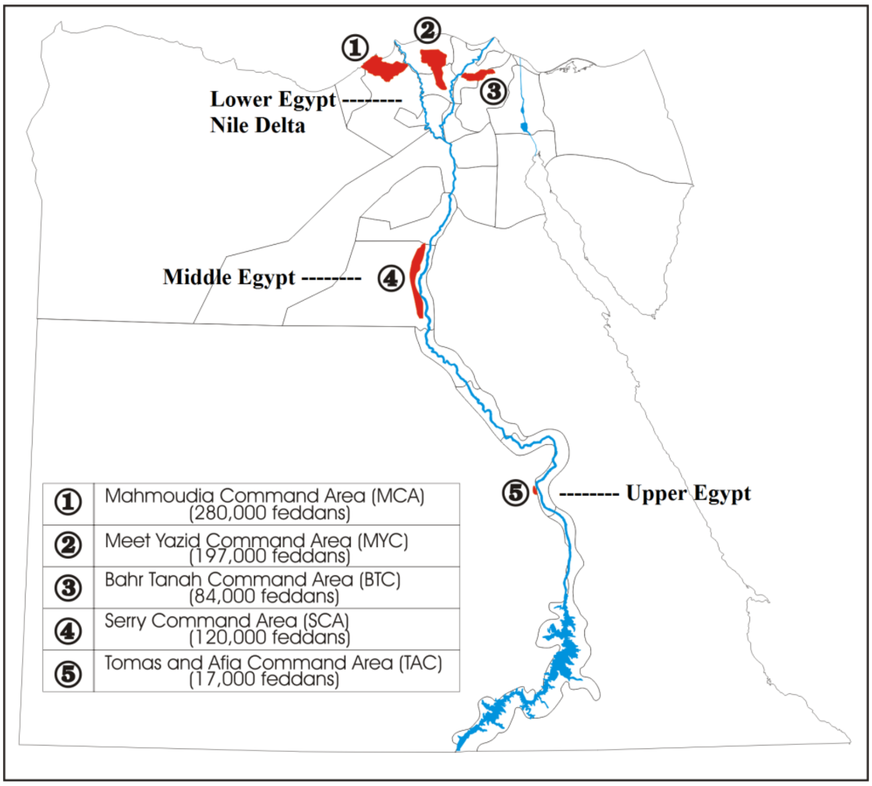

Figure 5. General Location Map for the IIIMP Five Command Areas (Source: Misr Consult, 2005)

IIIMP has taken the lead in launching institutional and water management reform process based on IWRM principles that are identified in the National Water Resources Plan (NWRP) 2017. This includes: a) user participation, b) subsidiarity of water resources management. c) considering water as a scarce commodity, d) recognition of women's role in water management, e) integration of ministerial services and f) adoption of an enabling legal framework, for which an amendment to Law 12/1984 has been prepared (Euroconsult Mott MacDonald, 2008).

10.1 IIIMP components

IIIMP compromises five components, and each component could have other sub-components. WB (2005) and Khafagy (2006), identified these components in details and they could be summarized as follows:

10.1.1 Improved and Integrated Water Management

It includes implementation of irrigation and drainage rehabilitation, improvement and modernization works and programs at all levels of the selected command areas.

10.1.2 Improved On-Farm Water Management

Providing WUs with relevant on-farm water control and rational irrigation practices though promoting and strengthening IAS.

10.1.3 Institutional Development and Capacity Building

Empowering WUs through organizations' establishment (WUAs, BCWUA, and BCWBs) that enabled the gradual transfer of responsibilities, which in turn, drive WUs to be actors within the water management and decision making process at district and command area levels. In addition to, establishment and mainstreaming of Integrated Water Management Districts (IWMDs).

10.1.4 Project Management, Coordination, and Integration

Integrated cooperative management among MWRI and other concerned agencies, and enhancing cross-sectoral coordination to overcome duplication and contradiction among them. integration of the various functions and contributions, both within the MWRI and between the MWRI and other involved and concerned ministries. In addition, authorize proper regulatory and policy framework that enable interconnectedness at and between central and local levels, finally, setting up monitoring and evaluation programs.

10.1.5 Environmental Mainstreaming.

Carrying out environmental management programs (e.g. public awareness, solid waste management, etc.) that lead to a positive impact the IIIMP.

10.2 Key stakeholders involved in IIIMP at the branch canal level

10.2.1 Branch Canal Water Users Association (BCWUA)

BCWUA is basically considered a regulatory process that involves all WUs, farmers, residents, and others in a specific area of the irrigation canal (branch canal belt area); these users collaborate in managing the association for the benefit of all WUs. Additionally, BCWUA only exist on improved *mesqa*s and act as a liaison to clarify WUs' different interests to MWRI and any other institutions. In order to achieve this goal successfully, MWRI is assigning essential tasks to BCWUA with regard to water management and it also supervises the formation of the BCWUA, taking into account the comprehensive representation of all WUs inside branch canal belt area. The four pilot BCWUAs are in Salhia, Dakalhia, Beheira, and Qena governorates.

Accordingly, BCWUA performs the following tasks in accordance with the Ministerial Decree No. 23 of 2001:

(1) Water resources management inside branch canal belt area.
(2) To represent all WUs (on the same branch canal) to different parties.
(3) To enhance the sustainability of the association.
(4) To ascertain the following of the internal system based on participation and equality among members of the association.

- *The representative committee:*
    - It is considered the supreme authority of the association, where it has the right to elect and also to drop the membership of anyone of the association's board of directors.
    - It is responsible for the approval of the association's general policy and its internal regulations.

- *Formation of BCWUA*, (Figure 6)*:*
    - All residents and farmers on the same branch canal are members in the association.
    - All members have the right to elect their representatives in the association committee (representative committee and management association council).
    - The representative committees are elected through the basic units (agricultural units, housing units, and special units for other water uses).

- The association's president and its board of directors are nominated and elected by the representative committee.

BCWUAs' tasks:

(1) Development and implementation of a system that enables effective communication and information exchange among all members of the association.

(2) Cooperation with MWRI and other parties to improve water services.

(3) Development of the association's annual plans, and the supervision of its implementation.

(4) Writing reports.

(5) Organization of periodic meetings with the representative committee.

(6) Conflict resolution on irrigation water inside branch canal belt area.

(7) The commitment of the association's internal regulations and laws.

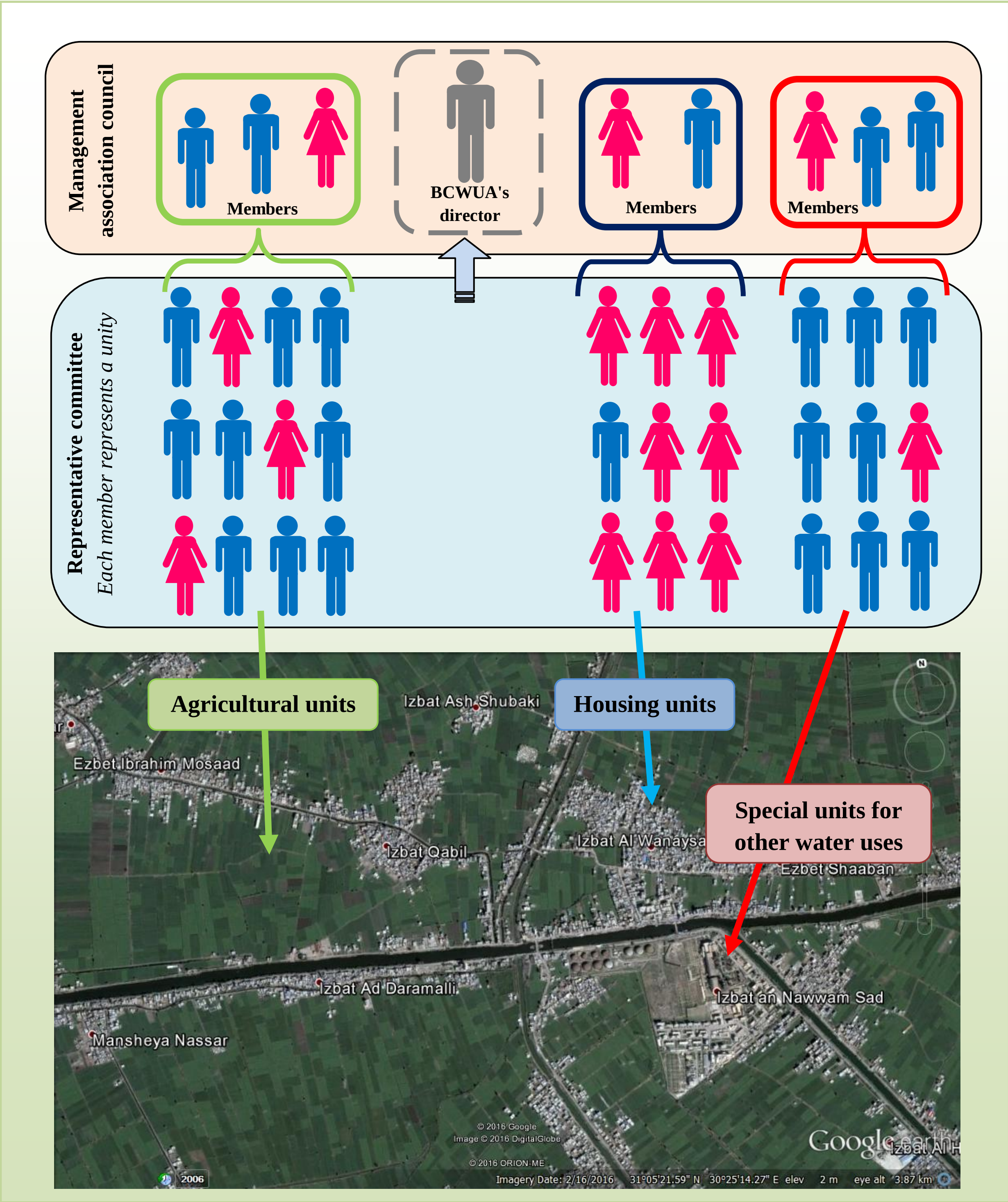

Figure 6. Election and formation of BCWUA (Source: Author's elaboration)

11. Proximity

Introducing innovations to local community is not an easy matter, where the performance of territorial innovation systems depends on the relations between diverse knowledge sources and proximity. This means that if there is no enough proximity, there is no innovation even in a large territory with diversified knowledge but lack the communication (Meeus and Oerlemans, 2005, p. 175).

This could explain why one territory, more than another, is endogenously able to learn and grow through innovation, which in turn, lead to territorial development (Capello, 2011, p. 116). This could lead to think about how geographical proximity has a great impact on innovation performance. However, Boschma (2005) stated that "*geographical proximity per se is neither a necessary nor a sufficient condition for learning to take place: at most, it facilitates interactive learning, most likely by strengthening the other dimensions of proximity*". In view of that, this section handling the different proximity dimensions (Geographical, cognitive, organizational, social, and institutional) based on the analytical distinction proposed by Boschma in 2005.

11.1 Cognitive proximity

The concept of cognitive proximity has been developed by Noteboom in the period of 1999 – 2000, and it is defined by Wuyts et al. (2005) as "*the similarities in the way actors perceive, interpret, understand, and evaluate the world*". Meanwhile, some researchers consider the cognitive proximity a part of the organizational proximity, as the latter based on the notion that sharing routines, cultures, values, and norms facilitates the interaction of actors over geographical distances (cited in Knoben, 2008).

Although cognitive proximity facilitates communication and a prerequisite to connect (Boschma and Frenken, 2012, p. 73); Boschma (2005) mentioned three reasons for why too much cognitive proximity could be detrimental. The first is that similarities could prohibit novelty; the second, cognitive proximity could lead to "lock-in", and; the third, it increases the risk on involuntary spillover. Meanwhile, Nooteboom (2009, p. 4) highlighted the importance of an optimal "cognitive distance" as it yields both a problem and opportunity. The problem lies in that the people are heterogeneous and interpret the world differently, the more difficult to collaborate with each other. The opportunity is that larger distance yields a greater potential for more radical novelty.

Capello and Lenzi (2013, p. 162) in their study found that the flow of basic knowledge are influenced to a limited extent by geographical proximity, and much more by similar backgrounds, cognitive maps and what is called "common basic knowledge" shared by two regions. As a result, they emphasized that the potential acquisition of basic knowledge from other regions could be weighed by the degree of cognitive proximity between pairs of regions. This means that the potential acquisition of knowledge depends mainly on the readiness of the other party (individual, organization, firm, region, etc.) in terms of absorptive capacity that enable him to perceive something new (idea, object, etc.).

Hautala (2011) in her findings highlighted that one of the most important results is what is called "cognitive friction". Cognitive friction is expressed by the similarities in knowledge base content but maintain distance by structure (i.e. cognitive friction is achieved when a group of people have cognitive proximity by the content but maintain cognitive distance by the structure of their knowledge bases). She stated that "*solutions to successful knowledge creation are not about how cognitively proximate or distant people are at a certain moment in time, but how they strive for cognitive friction*".

11.2 Organizational proximity

Organizational proximity refers to the extent to which relations are shared within an organization or between organizations (Kudic, 2014, p.35). To avoid overlap that could happen between cognitive proximity and organizational one, Boschma (no date) define organizational proximity as the "*extent to which relations are shared in an organizational arrangement, either within organization, or between organizations*". It focuses on the rate of autonomy involved and the degree of control that can be exerted in organizational arrangements. Boschma (2005) also referred to organizational proximity as the similarity in which actors are connected by sharing the same reference space and knowledge. In addition, it could be expressed by the extent to which relations are shared in organizational arrangements either within or between organizations. Yet, organizational proximity suffers from a relatively high level of conceptual ambiguity (Knoben and Oerlemans, 2006).

Organizational proximity creates trust between collaborators, and reduces the uncertainties in the collaborative exchange (Caniels, Kronenberg, and Werker, 2014). However, too much organizational proximity results in closeness of organization towards external sources of knowledge, which could lead to the failure of learning and organizational process. Too little organizational proximity could lead to a lack of control and increases the opportunistic behaviours (Carbonara, 2014).

11.3 Social proximity

Following Granovetter's initial concept of embeddedness, social proximity refers to the socially embedded relations between agents at the micro-level that involve trust based on friendship, kinship and experience. As social proximity involves trust that are based on friendship, kinship and experience; the past cooperation experiences could decrease the social distance between two partners, which positively impacts their future cooperation (Broekel and Boschma, 2012; Drejer and Ostergaard, 2014; Obrecht, 2011, p. 130).

However, too much social proximity could hinder the performance of innovation as a matter of an overload of loyalty and commitment in social relationships; in addition to the risk of an underestimated opportunism. Meanwhile, too little social proximity could hinder the interactive learning and innovation due to a lack of trust and commitment (Boschma, 2005).

Social proximity is often affected by geographical proximity like institutional proximity where both are geographically bounded. Nevertheless, social proximity is unlike institutional proximity which based on general trust that is evolved from common rules, norms, and values that have been developed and established over a long term, such as laws, regulations, and cultural habits (Fu, 2015, p. 71).

11.4 Geographical proximity

Proximity basically expressed by to what extent individuals are nearby each other in terms of the absolute distance between them or by the time taken to meet each other. This could be called "geographical proximity", where face to face meetings could be planned and organized or happened by chance, which in turn, play a crucial role in the diffusion of innovation, Particularly, the unplanned meetings (Winden et al. 2014, p. 10).

Boschma (2005b) points out that geographical proximity is neither necessary nor sufficient for learning, knowledge exchange, and innovation to take place. Yet, it may facilitate interactive learning in the presence of other proximities that enable effective knowledge transfer (Boschma, 2005b). Additionally, in a study on how the cognitive and geographical proximities influence firms' innovation performance, it is found that both proximity dimensions have no indication for the interrelated effects (in either a substitutive or a complementary sense) on firms' innovation performance (Broekel and Boschma, 2017).

Other scholars' in their study found that geographical proximity seems to matter between organizations with different institutional background more than those with similar ones; consequently, it is indirectly more important by overcoming institutional differences (Ponds, Van Oort, and Frenken, 2007). In Boschma, Balland, and Van (2014, p. 258) study, they found a positive and significant impact of geographical proximity on network dynamics. They confirm the findings of other empirical network studies that support the importance of geographical proximity, specially, to share tacit knowledge. However, they contradict the "death of distance thesis".

In sum, Proximity is of a dynamic nature that could lead to the formation of knowledge network, which ultimately, leads to increasing the proximity level (Balland, Boschma, and Frenken, 2014).

12. Statistical hypothesis

In order to achieve the study objectives, the following statistical hypothesis was stated:

(a) There is no difference in the distribution of responses to WUs' awareness with the authorized stakeholders in irrigation system in improved and unimproved areas.

(b) There is no difference in the distribution of responses to efforts in providing up to date and comprehensive information in improved and unimproved areas.

(c) There is no difference in the distribution of responses to WUs' perspective on the effectiveness of authorized stakeholders in improved and unimproved areas.

(d) There is no difference in the distribution of responses to WUs' perspective on the quantity and quality of irrigation water and agricultural soil condition in improved and unimproved areas.

(e) There is no difference in the distribution of responses to WUs' awareness with BCWUAs' role in improved areas.

(f) There is no difference in the distribution of responses to agencies that WUs can complain to when facing problems in irrigation in improved and unimproved areas.

(g) There is no difference in the distribution of responses to WUs' perspectives on BCWUAs' transparency in Nikla and Besentway branch canals.

(h) There is no difference in the distribution of responses to tasks required from BCWUAs' Board of Director in Nikla and Besentway branch canals.

(i) There is no difference in the distribution of responses to mutual trust and connectedness between WUs in irrigation management process in improved and unimproved areas.

(j) There is no difference in the distribution of responses to values of simple Pearson correlation coefficient among the studied independent variables in improved areas.

(k) There is no difference in the distribution of responses to IIIMPs' Performance levels in improved areas.

(l) There is no difference in the distribution of responses to BCWUAs' Performance levels in improved areas.

(m) There is no difference in the distribution of responses to values of simple Pearson correlation coefficient among the studied dependent and independent variables in improved areas.

(n) There is no difference in the distribution of responses to values of simple Pearson correlation coefficient among the studied explanatory variables and dependent variables in improved areas.

(o) There is no difference in the distribution of responses to values of simple Pearson correlation coefficient among the studied explanatory variables and independent variables in improved areas.

(p) There is no difference in the distribution of responses to values of simple Pearson correlation coefficient among the studied explanatory variables in improved areas.

(q) There is no difference in the distribution of responses to values of simple Pearson correlation coefficient between *mesqas'* geographical locations and different kinds of proximity in improved areas.

CHAPTER 3

Methodology

This part describes the description of the studied area; sampling; data collection tools; operational definitions of the studied variables and their measurements and the applied statistical tools of analysis.

1. Description of the studied area

Beheira Governorate (Figure 7) is located on the North-West of the Arab Republic of Egypt. Beheira got the priority for improving its irrigation system as it is considered the largest governorate as to area of agricultural lands which are estimated at 1623.59 thousand feddans (including the Nubaria new reclaimed lands[17]) with the highest irrigation water consumption rate, and the largest workforce in agriculture among all the governorates of Egypt. It is famous for its diversified agricultural production, particularly onions, barley, beets, wheat, potatoes and fava beans. Beheira Governorate comes first as to fruits and vegetables production, and export of citrus, potatoes, tomatoes, artichoke, watermelon, string beans and pepper. Thus, Beheira Governorate is chosen for conducting the study as it is one of the leading governorates applying IWRM approach through IIIMP.

[17]**New reclaimed lands** are sandy clay soil and most of the inhabitants are graduates and new comers using modern irrigation techniques.

Figure 7. Beheira Governorate location (Source: Google Earth, 2017)

1.1 Administrative division

Beheira Governorate comprises sixteen districts, each of which comprises a number of main villages, affiliated villages, and kafr and hamlets[18] (Table 2).

Table 2. Beheira Governorate administrative division

Districts and Cities	Cities	Main villages	Affiliated villages	Kafr and hamlets "ezabs"
1. **Damanhur**	1	7	57	824
2. **Abo El- Matamer**	1	6	17	597
3. **Abu Homs**	1	7	31	849
4. **Aldlnegat**	1	5	37	771
5. **El-Mahmudiya**	1	6	19	282
6. **Aitai el barood**	1	8	64	391
7. **HawshIssa**	1	4	13	355
8. **Rasheed**	1	3	16	86
9. **Shbrakhitt**	1	5	46	190
10. **Kafr El-Dawar**	1	9	43	795
11. **Kom Hamada**	1	9	62	476
12. **Wadi El Natrun**	1	3	4	36
13. **Rahmaniyah**	1	3	26	95
14. **Edco**	1	3	2	74
15. **Badr**	1	6	25	84
16. **West Nubaria**	-	-	6	-
Total	15	84	468	5905

Source: (Human Development report, 2005, p.17)

[18]**Kafr and hamlets "ezabs"** are small settlements, generally smaller than a village.

1.2 Population

The total area of Beheira Governorate is 9123 km2, which is equivalent to 9% of the total area of Egypt (HDR, 2005). Three-quarters of population live in rural areas. the population increased by 788100 during the period from 2002 till 2011, by about 17.6% during that period (Table 3).

Table 3. Estimates of midyear population of Behera Governorate

Year	Population
2002	4469924
2003	4557648
2004	4647280
2005	4732127
2006	4819797
2007	4802272
2008	4911894
2009	5035067
2010	5155442
2011	5258024

Source: (CAPMAS, 2012 p. 26)

1.3 Economic activity

Agriculture is the main occupation due to the availability of agricultural and arable land. The governorate also contributes to the industrial activity in spinning and weaving industry, Keliem and carpets, cotton ginning, chemicals and dying. In addition, the governorate has four industrial zones in Natron Valley, al-Bousili desert, New Nubaria and Edco (SIS Beheira Governorate) (Table 4).

Table 4. Estimates of employed persons (15 years old and over) by sex and economic activities in Beheira 2011

Economic activity	Males No.	Females No.
Agriculture, Hunting, Forestry and cutting of wood trees	6711	5352
Mining and quarrying	2	0
Manufactures	947	221
Electric, as, steam, air condition supply	266	2
Water support, drain, recycling	63	0
Constructions	1044	2
Whole and retail sale vehicles, and motorcycles repairing	1265	127
Transportation and storage	907	7
Food, residence services	198	0
Information, telecommunications	46	11
Insurance and Financial intermediation	83	24
Real estate, Renting	0	0
Specialized technical, scientific activities	145	20
Administrative activities and support services	57	7
Public Administrative, defense, social solidarity	1066	173
Education	541	542
Health and social work	133	249
Amusement and creation and arts activities	37	9
Other services activities	325	2
Services of home service for private householders	35	11
International and regional agencies and organizations	0	0
Activities not classified	2	0
Total	13873	6759

Source: (CAPMAS, 2012, p. 85)

1.4 El-Mahmoudia command area

The Mahmoudia canal is located in Beheira governorate west of the delta. It applied IIIMP program in 2004. As shown in Figure (8), the canal serve three districts, namely: Abou Homos, Al Mahmoudia and Kafr Al Dwar. The supply of water is received primarily from the Rosetta branch through the El-Atf pump station that feeds the Mahmoudia canal. The El-Atf pumping station is located at the most downstream reach of the Rosetta branch. The Mahmoudia canal is also the main source for Alexandria drinking water treatment plants and its natural sink is Lake Maryut. El-Mahmoudia command area obtains some of its water through east El-Khandak canal, as a supplementary source of water where official drainage water reuse takes place.

El- Mahmoudia canal is 77 km length, its total command area is about 305 000 feddans. 6000 feddans have already been improved under the USAID/IIP and improvement of a further 103000 feddans is ongoing under the WB/KfW-funded IIP; IIIMP targets the remaining 196000 feddans. Six branch canals are fed from El-

Mahmoudia canal, in addition to El-Atf pump station there is one reuse pumping station (Edku pump station) plus three pumping stations to divert drinking water to Alexandria city.

Most of the El-Mahmoudia command area is covered with tile drainage. A modified drainage system has been installed (123 feddans) on a pilot scale in the Balaqter area; other areas are under construction in El-Fadil and El-Hossan command areas for a total area of around 5 000 feddans. IIP is implemented in full (continuous flow is applied) in a small area of Mahmoudia: Besintway branch canal (8 000 feddans) and Balaqter canals (5 500 feddans) (FAO, 2005).

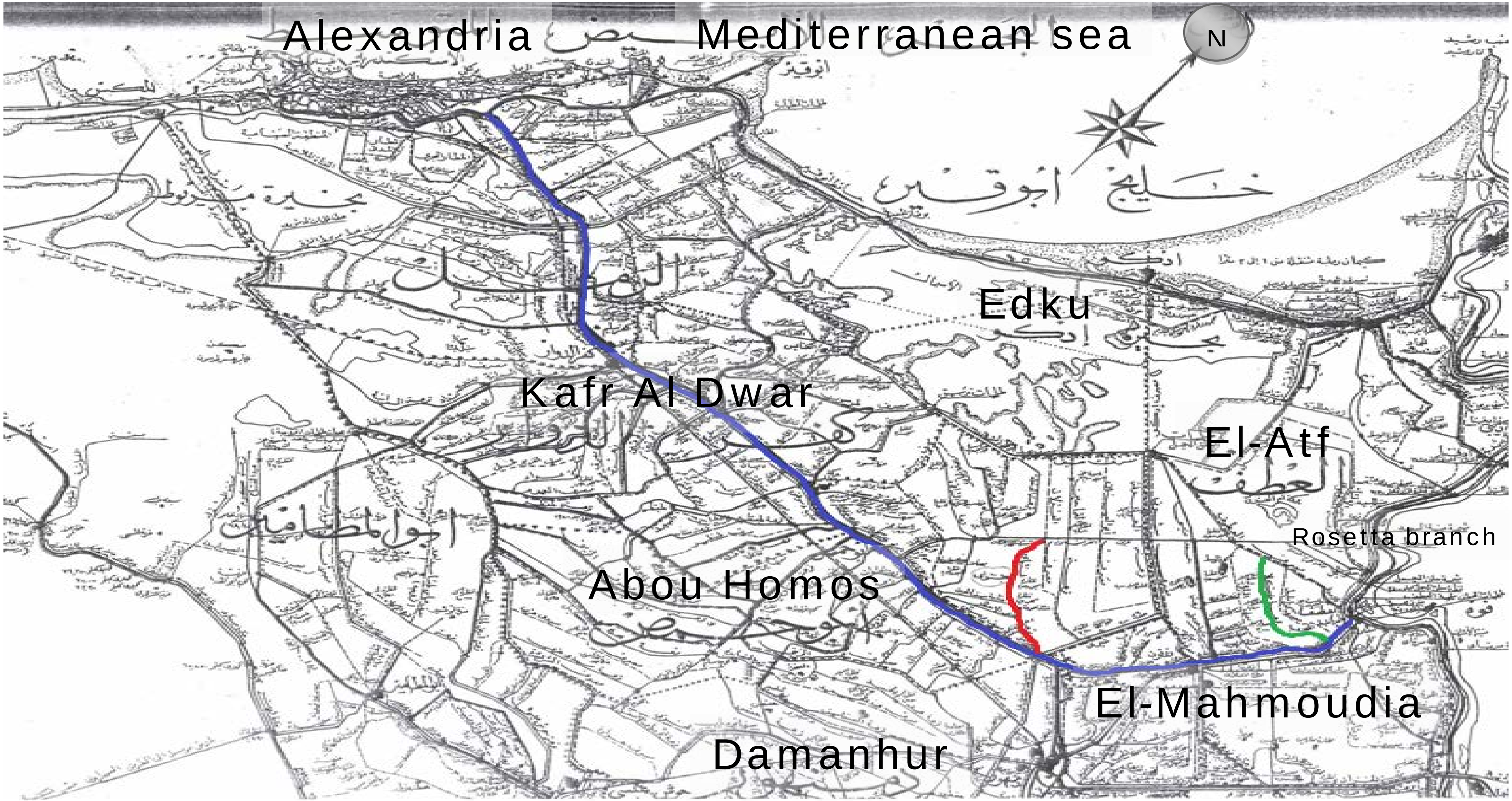

Figure 8. Canals and Drains of El-Mahmoudia command area (Sources: IAS)

1.5 Description of the studied branch canals

Nikla branch canal is geographically located between 31°10'1.28" N and 30°31'39.02" E. It is a branched canal on the right side of El-Mahmoudia main canal. Its irrigation water intake is at a distance of 2.18 km from Rosetta branch, and its length is about 8.400 km. Nikla branch canal comprising 51 improved *mesqas* that serves about 3460 feddan. Nikla's major cultivated crops are wheat, alfa alfa, vegetables, rice, cotton, corn, and beets.

Besentway branch canal is geographically located between 31° 5'17.91" N and 30°25'12.17" E. It is a branched canal on the right side of El-Mahmoudia main canal. Its irrigation water intake is at a distance of 16.6 km from Rosetta branch, and its length is about 9 km. Besentway branch canal comprising 102 improved *mesqas* that serves about 4698 feddan. Besentway branch canal have two sub-branch canals namely; El-Ahkar and Saif El-Deen.

Generally, as a prerequisite for IIIMP establishment, each branch canals was divided into three sections (Table 5). Then, each section was divided geographically into a number of unites (Figure 9) based on the existence of a natural borders (e.g. drainage canals, *mesqas*, roads, etc.). The main purpose of the division is to facilitate the nomination and election of branch canals' representative committee members (see page 25) from which BCWUA's board of directors were chosen.

Table 5. Main characteristics of Nikla and Besentway branch canals

Items of comparison	**Branch canal name**	
	Nikla	**Besentway**
Distance from Rosetta branch/km	2.18	16.6
Length/km	8.400	9
Number of improved *mesqas*	51	102
Total served area/feddan	3460	4698
1st section/feddan	1430	1144
2nd section/feddan	1000	1476
3rd section/feddan	1030	2078
Number of unites	31	36
Total number of BCWUA's board of directors	11	12
Number of "males" in BCWUA's board	9	10
Number of "females" in BCWUA's board	2	2

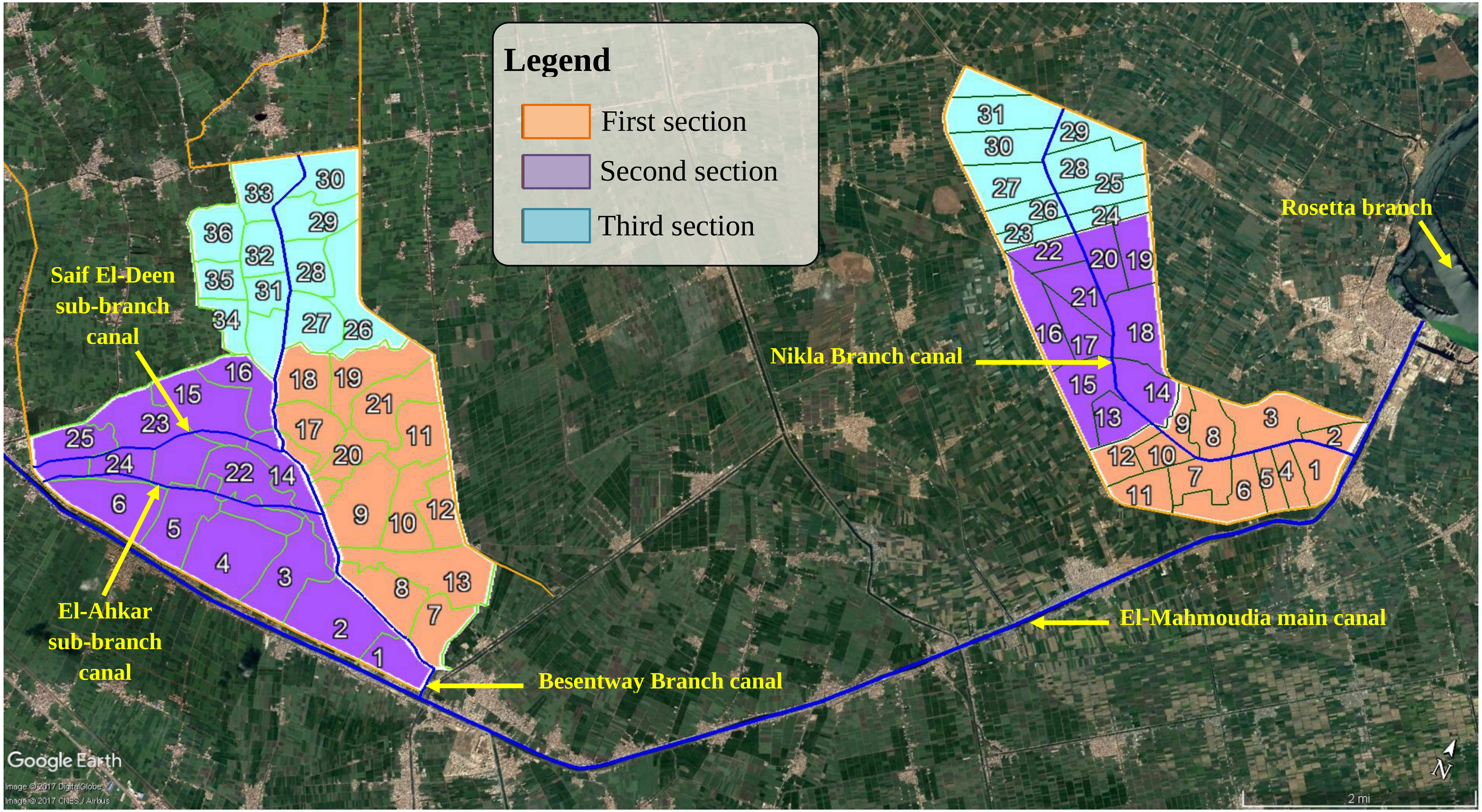

Figure 9. Nikla and Besentway branch canals (Source: Google Earth-Author's elaboration, 2018)

2. Sampling

WUs with landholding on El-Mahmoudia main canal were chosen, where IIIMP was applied on the majority of its branch canals (Figure 9). Due to the limitations of facilities to cover all districts located on El-Mahmoudia main canal; only three districts were selected namely: El-Mahmoudia, Abu Homs and Damanhur.

Three branch canals on El-Mahmoudia main canal were purposively selected to represent the current situation of improved and unimproved irrigation systems. The first, is Kafr Nikla (El-Mahmoudia district), as it is considered a successful branch canal to the extent that its board of director and secretariat participated in many seminars outside their boundaries to discuss their successful irrigation management outcomes with their peers; the second, is Besentway (Abu Homs district) that is considered less successful compared with Kafr Nikla branch canal. On the other hand, as shown in Figure (10) the third unimproved sub-branch canals from El-Mahmoudia main canal (Damanhur district) was chosen to represent the current situation of traditional irrigation system, namely: Ganabet Bastara & El Ziana.

A simple random sample of 220 water users (25%) was drawn from the total estimated number of water users on the selected branch canals (160 from improved branch canals and 60 for unimproved ones). *Mesqas*' locations on branch canals, and water users' land locations on *mesqas* (upstream/ midstream/ downstream) were taken into account to represent the current situation of irrigation systems in these areas.

3. Data collection tools

Data were collected through individual personal interviews with each of WUs from the mid of June to the mid of August 2016 by using a semi-structured questionnaire (see Annex1) on the selected branch canals. The questionnaire was designed and pre-tested for achieving the study objectives.

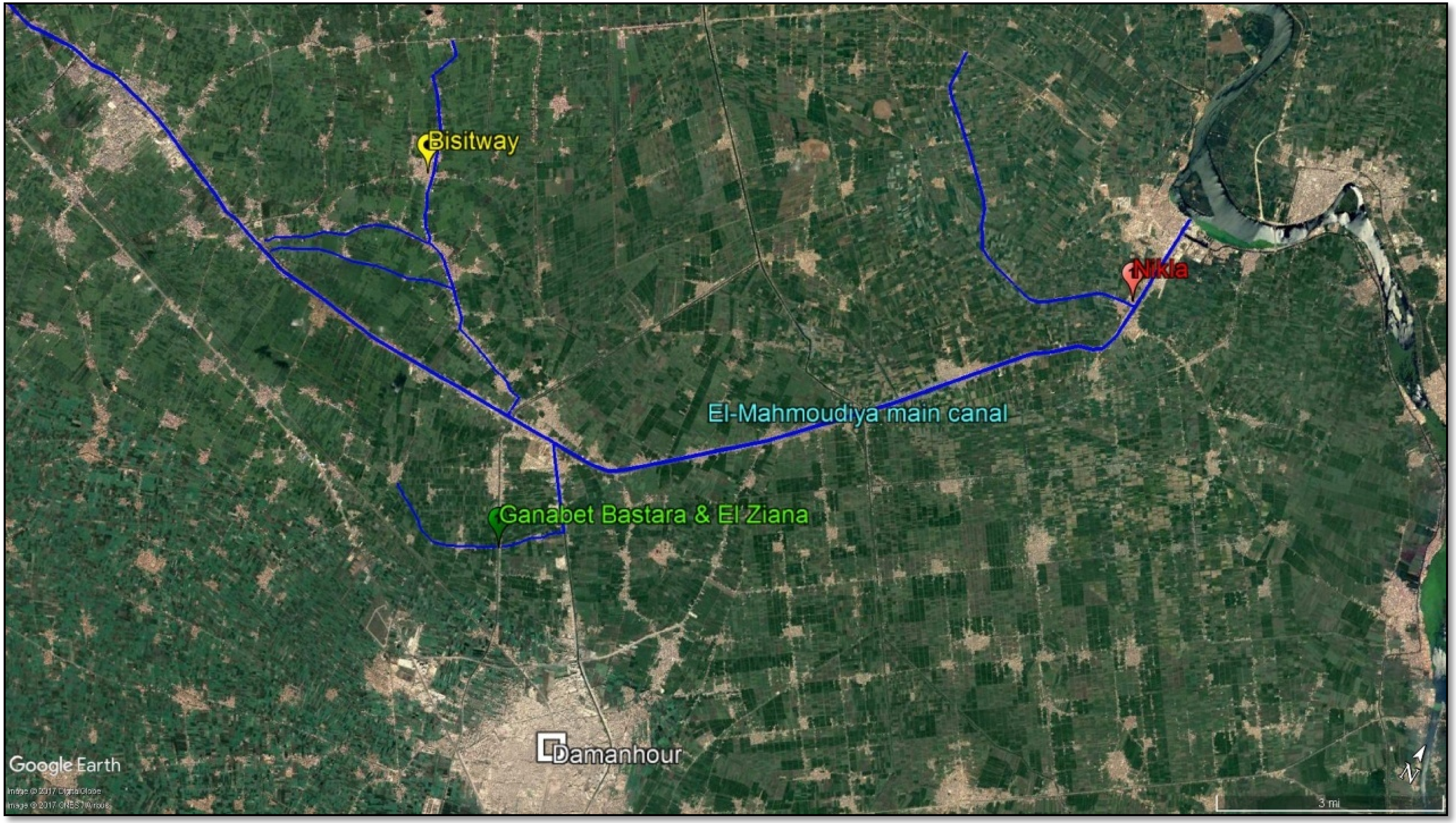

Figure 10. Studied improved and unimproved branch canals located on El Mahmoudia main canal (source: Google Earth- Author's elaboration, 2016)

4. Operational definitions and measurement of variables

4.1 Independent variables

- **WUs' age:** it is measured in years at the time of survey and categorized into five categories as follows: (20-30), (31-41), (42-51), (52-61), and (62 and above).
- **WUs' educational status:** measured by number of years of formal education the a WU has completed. illiterate WUs were given zero, can read and write (4), completed primary stage (6), completed preparatory school (9), completed secondary school (12), intermediate education (two years institutions) were given (14), and university graduates (16). Then, education is categorized in to five levels, which are: illiterate; can read and write; from primary to preparatory school; intermediate education, and; university
- **WUs' main occupation:** if WUs' main occupation is agriculture, code (1) is given, (2) for employee in the government, (3) pumping station operator, (4) handiwork, (5) village mayor, and (6) BCWUA secretariat.
- **Number of family members:** measured by the number of members in the family, then categorized into: small (2-10), medium (11-19), and large (20-30).
- **Family unit:** were coded as follows: (1) for nuclear family is expressed by a couple of adults and their children; (2) for compound family is expressed by polygynous family consisting of a man, his wives and their children; (3) for extended family is expressed by a family which extends beyond the nuclear family to include other relatives; and (4) for mixed between compound and extended family unit.
- **House holding:** expressed by whether WUs own, rent, or have mixed holding house.
- **Living expenses:** indicated by the annual expenses of a family in the following items: food, clothes, education, "electricity, water, and house rentals", transportation, health care, complementary occasions, recreational activities, and miscellaneous. Then, living expenses is categorized into three categories: low, medium, and high.
- **Land holding size**: it is measured by the size of the total land holding taking into account the type of its land tenure system (owned, rented, and/or shared). Then, land holding is categorized into five categories: less than one feddan, from one to

three feddans, above three to five feddans, above five to ten feddans, and above ten feddans.

- **Number of agricultural plots inside branch canal belt area:** is measured by how many agricultural plots the WUs have.
- **Land Tenure system**[19]**:** will be expressed by whether the WUs' plots owned, rented, or mixed holding[20].
- **Kind of crops WUs usually cultivate:** crops were coded as follows: (1) for wheat, (2) alfaalfa, (3) cotton, (4) rice, (5) corn, (6) fruits, and (7) vegetables.
- **Animal holding:** measured by the number of each species separately, taking into account its type of ownership (owned or shared).
- **Agricultural and transport tools holding:** measured by the number of each Agricultural and transport tool separately, taking into account its type of ownership (owned or shared).

4.2 Dependent variables

4.2.1 Performance of IIIMP: measured by the efficiency and effectiveness[21] of IIIMP from WUs' perspectives. A set of questions were designed to measure the degree of IIIMP performance in improved areas (Nikla and Besentway branch canals). This index includes 24 questions that focus on topics such as: WUs' knowledge about authorized stakeholders involved in the irrigation process, participation of stakeholders including WUs in decision making process, stakeholders' efforts in information sharing, women role expression in the irrigation system, changes occurred in WUs' irrigational behavior, WUs' accessibility to authorized stakeholders, stakeholders' cooperation, irrigation water quantity and quality, soil condition, etc. One score was assigned for each positive indicator and zero for the negative ones.

4.2.2 Performance of BCWUAs: measured by the efficiency and effectiveness of BCWUA from WUs' perspectives. A set of questions were designed to measure the degree of BCWUA performance in improved areas (Nikla and Besentway branch canals). This index includes 17 questions that focus on BCWUAs' performance encompass: WUs' awareness with the BCWUAs' role, solving irrigation problems,

[19]**Land Tenure system** is the legal regime in which land is owned by an individual, rented, or mixed holding.
[20]**Mixed land holding**two or more persons sharing the ownership of the same land.
[21]"**efficiency**" describe the relationship between inputs and outputs, whereas "**effectiveness**" describe the relationship between outputs and the intended results of the organizations (Hauswirth, 2006).

time period taken to solve problems, BCWUAs' transparency, tasks required from BCWUAs are executed, etc. One score was assigned for each positive indicator and zero for the negative ones.

Finally, an adjusted index was obtained by calculating the total score for each of IIIMP performance, and BCWUA performance. Then, the total scores were divided by 100 for the purposes of statistical analysis.

4.3 General questions applicable for improved and unimproved areas

Generally, a set of questions were developed to compare the situation regarding WUs' irrigational behavior, different socioeconomic aspects, and main obstacles facing WUs in their communities (e.g. environmental pollution, health problems, etc.). Besides, WUs in improved areas were asked about the changes happened "before and after" IIIMP establishment. On the other hand, in unimproved areas, WUs were asked about the changes occurred "five years ago and at the present" in their branch canals. Certainly, WUs were asked specific questions that were only applicable to their branch canal status whether it was improved or unimproved.

4.4 Explanatory variables

4.4.1 Cognitive proximity is measured by asking WUs questions that indicate what they have in mind (knowledge similarity) toward IIIMP and BCWUA. To measure the degree of cognitive proximity an index consists of 11 questions (e.g., kinds and usefulness of seminars held by IIIMP, rational irrigation practices adopted, the extent of cooperation among various stakeholders, etc.) was developed. One degree was assigned for "yes" response and zero for "no".

4.4.2 Social proximity is indicated by asking WUs questions that reflects their socially embedded relations among WUs that involves trust and knowledge sharing. To measure the degree of social proximity an index consists of 5 questions (e.g., trust among WUs, exchange new agricultural information, WUs' action when facing common problems, people care about others welfare) was developed. One degree was assigned for "yes" response and zero for "no".

4.4.3 Organizational proximity is expressed by asking WUs questions that reflect their similarity in sharing the same reference knowledge within the same BCWUA.

To measure the degree of organizational proximity an index consists of 7 major questions was developed (e.g., cooperation with MWRI and other parties to improve irrigation water services, organizing periodic meeting with reprehensive committee, conflict resolution inside branch canal belt area, etc.). One degree was assigned for "yes" response and zero for "no".

4.4.4 Geographical proximity: is measured by the distance in (kilometer) between *mesqas* located on improved branch canal.

4.4.5 Geographical location: is measured by the distance in (kilometer) from the principal canal (Rosetta branch) to each *mesqas* located on improved branch canal.

To measure proximity dimensions, any similar questions used in measuring IIIMP and/or BCWUA performance where excluded. Finally, an adjusted index was obtained by calculating the total score for each of cognitive, social, and organizational proximities. Then, the total scores were divided by 100 for the purposes of statistical analysis.

5. Statistical tools of analysis

To achieve the study objectives, data processing and analysis is performed using Statistical Package for the Social Science (SPSS) software (Version 21), which was used for obtaining percentages, frequency tables, median, Chi-square test for testing significance of differences, Pearson correlation coefficient, and Spearman correlation coefficient.

CHAPTER 4

Result and discussion

This chapter presents the findings of the study in accordance with the study objectives.

1. Demographic characteristics of the sample

The following are the demographic characteristics of the WUs' sample, as shown in Table (6).

- In improved areas, more than one quarter (26.3%) of WUs fall in the age category (42-51) compared with 28.3% in unimproved areas.
- In improved areas, 29.4% of WUs were "illiterate"; nonetheless, in unimproved areas 28.3% of WUs were "intermediate education".
- The majority of WUs (85.6%) in improved areas and 78.3% of WUs in unimproved areas has "agriculture" as main occupation.
- Out of WUs who had other occupation, 53.7% and 81.3% were "employed in the government" in improved and unimproved areas, respectively.
- More than three quarters of WUs (78.8%) in improved areas and 83.3% in unimproved areas had "small-size" families (2-10 persons).
- More than half of WUs (58.8%) in improved areas and 71.7% of WUs in unimproved areas were "nuclear" families.
- The majority of WUs (88.1%) and (91.7%) in improved and unimproved areas, respectively, "own" their houses.
- More than half of WUs (57.6%) in improved areas fall in "low" and "medium" living expenses categories, compared with 81.6% of WUs in unimproved areas.
- In improved areas, 58.1% of WUs had "from one to three feddans (24-72 kirats)", compared with 60% in unimproved area.
- Nearly three fourths of WUs (74.4%) in improved areas cultivate "two plots", compared with 76.6% of WUs in unimproved areas.
- Out of WUs who cultivated "two plots", 78.2% and 67.4% were "land owners", in improved and unimproved areas, respectively.

- In improved areas, the overwhelming majority of WUs (91.3%) cultivated “rice”. However, the second most cultivated crop was “wheat” with the percentage of 75%. In unimproved areas, the overwhelming majority of WUs (96.6%), and (91.6%) cultivated “rice” and “wheat”, respectively.
- Concerning animal holding, in improved areas, “owned” domestic animal breeding were as follows: 67.5% of WUs had “cows”, 61.3% had “birds” 60.6% had “donkeys”, and 53.1% had “buffalos”. Alternatively, in unimproved areas, 88.3% of WUs had “birds”, 63.3% had “cows”, 58.3% had “donkeys”, and had 55% “buffalos”.
- In improved areas, out of WUs who “owned” domestic animals, 96.5% had “one up to four buffalos”, 95% had “one donkey”, 90.7% had “one up to four cows”, and 64.3% had “one up to twenty birds”.
- In unimproved areas, out of WUs who “owned” domestic animals, 97.4% who had “one up to four cows”, 97.1% who had “one donkey”, 97% who had “one up to four buffalos”, and 79.2% who had “one up to twenty birds”.
- Normally, all WUs (100%) in unimproved areas had “irrigation pumps” compared with 2.5% in improved areas.

Table 6. Demographic characteristics of WUs in improved and unimproved areas

Demographic characteristics	Improved N=160		Unimproved N=60	
	Freq	**%**	**Freq.**	**%**
WUs' age category				
20-30	15	9.2	6	10
31-41	38	23.8	16	26.7
42-51	42	26.3	17	28.3
52-61	39	24.4	9	15
62 & above	26	16.3	12	20
WUs' education				
Illiterate	47	29.4	14	23.3
Can read and write	27	16.9	5	8.4
From primary to preparatory school	29	18.1	13	21.7
Intermediate education	29	18.1	17	28.3
University	28	17.5	11	18.3
WUs' main occupation				
Agriculture	137	85.6	47	78.3
Other occupation	23	14.4	13	21.7
WUs' other occupation	**N=41**		**N=16**	
Employee in the government	22	53.7	13	81.3
Pumping station operator	1	2.4	-	-
Handiwork	16	39	3	18.7
Village mayor	1	2.4	0	0
BCWUA secretariat	1	2.4	-	-
Number of family members	**N=160**		**N=60**	
Small (2-10)	126	78.8	50	83.3
Medium (11-19)	27	16.9	9	15
Large (20-30)	7	4.4	1	1.7
Family unit				
Nuclear	94	58.8	43	71.7
Compound	2	1.2	3	5
Extended	64	40	14	23.3
House holding				
Owned	141	88.1	55	91.7
Shared	14	8.8	3	5
Rented	5	3.1	2	3.3
Living expenses (L.E./annually)				
Low (5180-28400)	46	28.8	24	40
Medium (28600-46800)	46	28.8	25	41.7
High (47120-184200)	68	42.4	11	18.3
Landholding size				
Less than one feddan (<24 Kirat)	34	21.3	9	15
From one to three feddans (24-72 Kirat)	93	58.1	36	60
Above three to five feddans (73-120 Kirat)	22	13.8	10	16.7
Above five to ten feddans (121-240 Kirat)	11	6.9	3	5
Above ten feddans (>240 Kirat)	0	0	2	3.3

Cont. Table 6. Demographic characteristics of WUs in improved and unimproved areas

Demographic characteristics	Improved N=160		Unimproved N=60	
	Freq	%	Freq	%
Land Tenure system of agriculture plots inside branch canal belt area				
One plot				
Owned	133	83.1	42	70
Mixed	11	6.9	1	1.7
Rent	16	10	17	28.3
Two plots	**N=119**		**N=46**	
Owned	93	78.2	31	67.4
Mixed	12	10.1	0	0
Rent	14	11.8	15	32.6
Three plots	**N=67**		**N=25**	
Owned	53	79.1	15	60
Mixed	5	7.5	0	0
Rent	9	13.4	10	40
Four plots	**N=36**		**N=7**	
Owned	28	77.8	5	71.4
Mixed	2	5.6	0	0
Rent	6	16.7	2	28.6
Five plots	**N=13**		**N=4**	
Owned	9	69.2	3	75
Mixed	1	7.7	0	0
Rent	3	23.1	1	25
Kind of crops usually cultivated	**N=160**		**N=60**	
Wheat	120	75	55	91.6
Alfa alfa	113	70.6	51	85
Cotton	75	46.8	39	65
Rice	146	91.3	58	96.6
Corn	118	73.7	40	66.6
Fruits	35	21.8	1	1.6
Vegetables	35	21.8	4	6.6
Animal holding				
Cows (owned)	**N=108**		**N=38**	
Less than or equal to four (≤4)	98	90.7	37	97.4
From five to eight (5-8)	6	5.6	0	0
Above eight (>8)	4	3.7	1	2.6
Cows (shared)	**N=36**		**N=6**	
Less than or equal to four (≤4)	34	94.4	6	100
From five to eight (5-8)	2	5.6	0	0
Buffalos (owned)	**N=85**		**N=33**	
Less than or equal to four (≤4)	82	96.5	32	97
Above four (>4)	3	3.5	1	3
Buffalos (shared)	**N=17**		**N=3**	
Less than or equal to four (≤4)	17	100	3	100
Goats/sheep (owned)	**N=26**		**N=14**	
Less than or equal to five (≤5)	21	80.8	12	85.7
Above five (>5)	5	19.2	2	14.3
Goats/sheep (shared)	**N=7**		**N=0**	
Less than or equal to five (≤5)	7	100	0	0

Cont. Table 6. Demographic characteristics of WUs in improved and unimproved areas

Demographic characteristics	Improved N=160		Unimproved N=60	
	Freq.	**%**	**Freq.**	**%**
Animal holding				
Donkey (owned)	**N=97**		**N=35**	
One donkey	92	95	34	97.1
Two donkeys	5	5	1	2.9
Birds (owned)	**N=98**		**N=53**	
Less than or equal twenty birds (≤20)	63	64.3	42	79.2
From twenty one to forty birds (21-40)	16	16.3	8	15.1
Above forty birds (>40)	19	19.4	3	5.7
Agricultural and transport tools holding	**N=160**		**N=60**	
Irrigation pumps (owned)	4	2.5	50	83.3
Irrigation pump (shared)	0	0	10	16.6
Tractor (owned)	2	1.3	3	5
Tractor (shared)	7	4.4	0	0
Motorcycle (owned)	35	22	9	15
Car (owned)	12	7.5	8	13.3
Trailer (owned)	6	4	1	1.6
Cart (owned)	15	9.3	0	0

2. Performance of irrigation process under improved and unimproved irrigation system

2.1 Efficiency of IIIMP

2.1.1 Authorized stakeholders involvement in the irrigation system

Strikingly, when WUs in improved areas were asked who are the authorized stakeholders in IIIMP system, barely, 46.3% of WUs answered this question (Table 7). Consequently, more than half (53.7%) of WUs in improved areas could not identify who are the stakeholders involved in IIIMP system. This could indicate at least that these stakeholders are not stuck in WUs' mind. In contrast, all WUs (100%) in unimproved areas mentioned at least one of these authorized stakeholders in irrigation system. The chi^2 test for this distribution was statistically insignificant.

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Table 7. WUs' awareness with IIIMP/authorized stakeholders in improved and unimproved areas

Questions	Improved N=160		Unimproved N=60	
	Freq.	%	Freq.	%
Do you know who are the IIIMP/authorized stakeholders in the irrigation system	**N=160**		**N=60**	
Yes	74	46.3	60	100
No	86	53.7	0	0
Who are the IIIMP/authorized stakeholder in the irrigation system	**N=74**		**N=60**	
MWRI	10	13.5	1	1.7
MALR	6	8.1	0	0
BCWUAs	7	9.5	-	-
Irrigation engineering	39	52.7	52	86.7
MWRI & MALR	8	10.8	3	5
MWRI & BCWUAs	3	4.1	-	-
Agriculture local unit	1	1.3	4	6.6

(-) not applicable

In improved areas (Nikla and Besentway branch canals), Table (8) is revealing the drop in the WUs' responses in the previous results, as it explains that the majority of WUs (85.3%) in Nikla branch canal mentioned at least one of the authorized stakeholders involved in IIIMP, compared with only (14.6%) in Besentway branch canal. The chi^2 test for this distribution was statistically insignificant.

Table 8. WUs' awareness with the authorized stakeholders in Nikla and Besentway branch canals

Questions	Nikla N=71		Besentway N=89	
	Freq.	%	Freq.	%
Who are the IIIMP/authorized stakeholder in the irrigation system	**N=61**		**N=13**	
MWRI	7	11.5	3	23.1
MALR	4	6.6	2	15.4
BCWUAs	6	9.8	1	7.6
Irrigation engineering	36	59	3	23.1
MWRI & MALR	5	8.2	3	23.1
MWRI & BCWUAs	3	4.9	0	0
Agriculture local unite	0	0	1	7.7

2.1.2 Authorized stakeholders' efforts in providing up to date and comprehensive information

Concerning awareness seminars in irrigation, although more than half of WUs (53.8%) in improved areas stated that they "never heard" that there were awareness seminars held in irrigation in their surrounding area, a good percentage 46.2% mentioned that there were seminars held. Comparatively, in unimproved areas, the over whelming majority of WUs (90%) "never heard about" any awareness seminars regarding irrigation. The chi^2 test for this distribution was statistically significant ($p < .000$).

In improved areas, among WUs who mentioned that stakeholders made awareness seminars in irrigation, approximately one third of these WUs (32.4%) mentioned that the main topic of these seminars were about “IIIMP benefits”. Nevertheless, among those who could remember the seminars' topics, 66.1% mentioned that these seminars were “highly useful” as it increased their awareness toward “irrigation water conservation” and “efficient irrigation water allocation” methods. As a result, 54.8% changed their irrigation practices after attending these seminars. In conclusion, as it was expected more seminars were held in improved areas compared with unimproved areas as a prerequisite for the establishment of IIIMP.

The majority of WUs (86.2%) in improved areas and the overwhelming majority (93.3%) of WUs in unimproved areas mentioned that women role in the irrigation process was never expressed. Among the very few number of WUs in improved areas who agreed that women role in the irrigation process was expressed, more than half (54.5%) mentioned that “women right to be in the BCWUAS' representative committee” was underlined (Table 9).

Observably, based on the communication effort done in improved areas, results revealed a significant impact on changing WUs' knowledge and practices in irrigation process. However, more effort should be done in expressing the necessity of women participation in irrigation process as they are considered a key principle in IWRM approach.

Table 9. Efforts in providing up to date and comprehensive information in improved and unimproved areas

Questions		Improved		Unimproved	
		Freq.	%	Freq.	%
IIIMP/authorized stakeholders in the irrigation system held awareness seminars in irrigation in your surrounding area[1]		**N=160**		**N=60**	
Yes		74	46.2	6	10
Never heard about		86	53.8	54	90
What was the topics of these seminars?		**N=74**		**N=6**	
Cannot remember		12	16.2	1	16.7
IIIMP benefits		24	32.4	-	-
Improving irrigation water quality		10	13.5	0	0
Equity of water resources distribution		5	6.8	2	33.3
Increase water resource productivity		9	12.2	0	0
Women role in irrigation process		1	1.4	0	0
Improving irrigation water quality, quantity and distribution		13	17.6	3	50
To what extent these seminars were useful?		**N=62**		**N=5**	
Highly useful		41	66.1	2	40
Moderate		15	24.2	1	20
Not useful		6	9.7	2	40
Why these seminars were useful/moderate/un-useful?		**N=62**		**N=5**	
Highly useful	- Increasing awareness toward efficient irrigation water allocation	17	27.4	1	20
	- Increasing awareness toward irrigation water conservation	24	38.7	1	20
Moderate & not useful	- What they discussed are not applied in real life	21	33.9	3	60
Have you changed your irrigation behavior after attending these seminars		**N=62**		**N=5**	
Yes		34	54.8	1	20
To some extent yes		7	11.3	1	20
No		21	33.9	3	60
IIIMP/authorized stakeholders in the irrigation system express women role in the irrigation process		**N=160**		**N=60**	
Yes		22	13.8	4	6.7
No		138	86.2	56	93.3
What are women role in the irrigation process		**N=22**		**N=4**	
Women's right to be member in BCWUAs		7	31.8	0	0
Women's right to be in the BCWUAS' representative committee		12	54.5	4	100
Women's right to be in BCWUAs' board of director		3	13.6	0	0

1. X^2=24.779[a] df.=1 Sig. 0.000

2.2 Effectiveness of IIIMP

2.2.1 WUs' perspective on the effectiveness of authorized stakeholders in irrigation system in improved and unimproved areas

Normally, in improved areas, 64.4% of WUs changed their irrigation practice, compared with very few number (13.3%) in unimproved areas who were still under traditional irrigation system (Table 10). Among WUs who changed their irrigation practices in improved areas, more than half (56.3%) mentioned directly that the reason for changing their irrigation practices was due to the establishment of IIP in their area. The chi^2 test for this distribution was statistically significant ($p < .000$).

In improved areas, over one half of WUs (57.5%) have easy access to different stakeholders in case of necessity. Disappointedly, 61.7% of WUs in unimproved areas could not communicate easily with authorized stakeholders. The chi^2 test for this distribution was statistically significant ($p < .005$).

Unexpectedly, 53.1% of WUs in improved areas and the overwhelming majority of WUs (91.7%) in unimproved areas mentioned that they are not provided with as much as necessary information regarding irrigation water. The chi^2 test for this distribution was statistically significant ($p < .000$).

As well, the involvement of WUs in irrigation water decision-making process to some extent was neglected by the authorized stakeholders, where more than two third of WUs (68.1%) in improved areas and (91.7%) in unimproved areas mentioned that they have never been involved. The chi^2 test for this distribution was statistically significant ($p < .000$). Moreover, 61.9% of WUs in improved areas and 88.3% in unimproved areas said that they were not informed with the updated decision regarding irrigation water. The chi^2 test for this distribution was statistically significant ($p < .000$).

With respect to WUs' perspectives in improved areas about the authorized stakeholders in irrigation process: 65.6% of WUs stated that stakeholders “never” meet with each other to discuss important issues regarding irrigation; 68.1% mentioned that stakeholders “never” cooperate with each other to solve irrigation problems; 66.8% stated that stakeholders “never” cooperate with BCWUAs to solve branch canal problems, and; more than half of WUs (52.6%) agreed upon that stakeholders respect BCWUAs' decisions.

In improved areas, more than two third of WUs (70%) confirmed that stakeholders “do not” solve irrigation problems in their areas, compared with, the majority of WUs (95%) in unimproved areas. The chi^2 test for this distribution was statistically significant ($p < .000$).

However, in improved areas, 67.5% of WUs agreed upon the importance of stakeholders in their community, they mentioned the following reasons, which are: 35% stated that stakeholders reduced conflict on irrigation water; 25.6% stated that they control water and electricity, and; only 6.9% stated they improve water quantity and quality. On the other hand, 91.7% of WUs in unimproved areas confirmed that stakeholders are neither important nor capable to accomplish their tasks. The chi^2 test for this distribution was statistically significant ($p < .000$). Thus, the importance of stakeholders' role from WUs' perspectives is according to stakeholders' power in controlling water and electricity other than solving technical and administrative problems.

Table 10. WUs' perspective on the effectiveness of authorized stakeholders in improved and unimproved areas

Questions	Improved N=160		Unimproved N=60	
	Freq.	%	Freq.	%
In the last five years, have you changed your irrigation practices[1]				
Yes	103	64.4	8	13.3
No	57	35.6	52	86.7
Reasons for changing your irrigation practice[2]	**N=103**		**N=8**	
We have Irrigation Improvement Project (IIP)	58	56.3	-	-
Irrigate at night	6	5.8	7	87.5
Reduce irrigation water consumption	39	37.9	1	12.5
Is it easy to contact with authorized stakeholders in case of necessity[3]				
Yes	75	46.9	23	38.3
Sometimes	17	10.6	0	0
No	68	42.5	37	61.7
Authorized stakeholders provide information regarding irrigation water [4]				
Yes	57	35.6	5	8.3
Sometimes	18	11.3	0	0
No	85	53.1	55	91.7
Farmers are involved with diverse departments in the irrigation water decision-making process [5]				
Yes	51	31.9	5	8.3
No	109	68.1	55	91.7
Authorized stakeholders inform you with updated decisions regarding irrigation water [6]				
Always	32	20	1	1.7
Sometimes	29	18.1	6	10
Never	99	61.9	53	88.3
Is it easy for authorized stakeholders to meet at any time to discuss important issues regarding irrigation			-	
Yes	55	34.4	-	-
No	105	65.6	-	-
Do you think departments cooperate with each other to solve irrigation problems			-	
Yes	51	31.9	-	-
No	109	68.1	-	-
Does the departments cooperate with BCWUAs			-	
Yes	53	33.1	-	-
No	107	66.8	-	-
Does the departments respects BCWUAs' decisions?			-	
Yes	42	26.3	-	-
Sometimes	42	26.3	-	-
No	76	47.5	-	-
Authorizes stakeholders in the irrigation system do their best to solve irrigation problems? [7]	**N= 160**		**N= 60**	
Yes	48	30	3	5
No	112	70	57	95

(-) not applicable

1. X^2=45.477[a] df.=1 Sig. 0.000 **2. X^2=48.113[a] df.=2 Sig. 0.000**

3. X^2=10.448[a] df.=2 Sig. 0.005 **4. X^2=28.469[a] df.=2 Sig. 0.000**

5. X^2=12.745[a] df.=1 Sig. 0.000 **6. X^2=16.010[a] df.=2 Sig. 0.000**

7. X^2=15.315[a] df.=1 Sig. 0.000

Cont. Table 10. WUs' perspective on the effectiveness of authorized stakeholders in the irrigation system in improved and unimproved areas

		Improved N=160		Unimproved N=60	
		Freq.	%	Freq.	%
Authorized stakeholders in the irrigation system in your community are important? [8]		**N= 160**		**N= 60**	
Yes		108	67.5	5	8.3
No		52	32.5	55	91.7
Why authorized stakeholders in the irrigation system are important/not important in your community? [9]					
Important	- They control water and electricity	41	25.6	0	0
	- They reduced conflicts on irrigation water	56	35	5	8.3
	- They improved quantity and quality of irrigation water	11	6.9	0	0
Not important	- They do not do their tasks	52	32.5	55	91.7

8. X^2=61.149[a] df.=1 Sig. 0.000 9. X^2=62.099[a] df.=3 Sig. 0.000

2.2.2 Quantity and quality of irrigation water and agricultural soil condition in improved and unimproved areas

As shown in (Table 11, 12) in improved areas, 66.9% of WUs, and almost all WUs (98.3%) in unimproved areas mentioned that quantity of irrigation water available was sufficient in the past. The chi^2 test for this distribution was statistically significant ($p < .000$). However, 40.6% and 61.3% of WUs in improved areas approved that water quantity and quality became worse after IIIMP installation, respectively. On the other hand, currently 86.7%, and 96.7% of WUs in unimproved areas agreed that water quantity and quality became worse, respectively. The chi^2 test for this distribution was statistically significant ($p < .000$). Normally, as irrigation water is already insufficient as WUs stated, 71.9% and 68.3% of WUs mentioned there is no waste of in irrigation water during allocation in improved and unimproved areas, respectively. The chi^2 test for this distribution was statistically in significant.

As expected, the O&M cost in improved areas is more reasonable, were 65% agreed on that by “yes” and “sometimes”. Conversely, almost half of WUs (48.3%) who are still under traditional irrigation system (individual pumps) consented that the cost is high. The chi^2 test for this distribution was statistically significant ($p < .000$).

In improved areas, more than three fourths of WUs (77.5%) agreed that branch canal is periodically cleaned, compared with, 71.7% of WUs in unimproved areas who assured that the branch canal was “rarely” cleaned and they used to clean them by themselves. The chi^2 test for this distribution was statistically significant ($p < .000$).

In improved areas, more than two third (66.9%) mentioned that irrigation pollution increased (Figure 11) compared with, almost all WUs (98.3%) in unimproved areas. The chi^2 test for this distribution was statistically significant ($p < .000$). Additionally, in improved areas, 48.1% of WUs mentioned that the soil condition "changed for the better" compared with 81.7% of WUs in unimproved areas who mentioned that it "became worse". The chi^2 test for this distribution was statistically significant ($p < .000$).

Figure 11. WUs in Besentway branch canal cleaning canal gates from house residues (This photo was captured during data collection)

During data collection, it was observed that there were branch canals totally blocked by house residues, sewage, dead animals, and factories waste, were 93.8% and 98.3% of WUs in improved and unimproved areas, respectively, agreed unanimously on these main reasons of water pollution as shown in Figures (11). By asking a number of farmers about this issue, they mentioned that they were suffering from this problem since many years and it became worse due to the dramatic increase in the number of illegal housing units on both sides of branch canals that does not provide services that afford healthy and safe environment.

Figure 12. House residues in *mesqas* and *merwas*
(These photos were captured during data collection

Table 11. WUs' perspective on the quantity and quality of irrigation water and agricultural soil condition in improved and unimproved areas

Questions	Improved N=160		Unimproved N=60	
	Freq.	**%**	**Freq.**	**%**
Before IIIMP/five years ago the quantity of irrigation water available was sufficient [1]				
Yes	107	66.9	59	98.3
Sometimes	40	25	0	0
No	13	8.1	1	7.1
Quantity of irrigation water available now: [2]				
Changed for better	65	40.6	0	0
As bad as before	30	18.8	8	13.3
Became worse	65	40.6	52	86.7
Quality of irrigation water now: [3]				
Changed for better	38	23.8	0	0
As bad as before	24	15	2	3.3
Became worse	98	61.3	58	96.7
Is there a waste of irrigation water during its allocation?				
Yes	30	18.8	11	18.3
Sometimes	15	9.4	8	13.3
No	115	71.9	41	68.3
O&M costs for irrigation is reasonable ? [4]				
Yes	60	37.5	1	1.7
To some extent	44	27.5	30	50
No	56	35	29	48.3
The branch canal is cleaned: [5]				
Always	77	48.1	3	5
Sometimes	47	29.4	14	23.3
Rarely	36	22.5	43	71.7
Main irrigation problems in respondents' region?				
There is no irrigation water problem in this region	25	15.6	2	3.3
Insufficient irrigation schedule	14	8.8	0	0
Inaccuracy in the collective pump station installation	46	28.8	0	0
Throwing house residues in canals	42	26.3	33	55
Branch canal is not cleaned	12	7.5	1	1.7
Throwing sewage in the canal	8	5	9	15
The branch canal gate is usually closed	13	8.1	0	0
Chemicals from electric station	0	0	15	25
Irrigation water pollution [6]				
Increased than before	107	66.9	59	98.3
No change	19	11.9	0	0
Decreased than before	34	21.3	1	1.7
Is there a fine in the case of polluting water?[7]				
Yes	65	40.6	2	3.3
No	95	59.4	58	96.7

1. X^2**=23.583**[a] **df.=2 Sig. 0.000** **2.** X^2**=42.510**[a] **df.=2 Sig. 0.000**
3. X^2**=26.995**[a] **df.=2 Sig. 0.000** **4.** X^2**=28.783**[a] **df.=2 Sig. 0.000**
5. X^2**=52.267**[a] **df.=2 Sig. 0.000** **6.** X^2**=23.367**[a] **df.=2 Sig. 0.000**
7. X^2**=28.652**[a] **df.=1 Sig. 0.000**

Cont. Table 11. WUs' perspective on the quantity and quality of irrigation water and agricultural soil condition in improved and unimproved areas

Questions	Improved N=160		Unimproved N=60	
	Freq.	%	Freq.	%
What are the main sources of irrigation pollution [8]				
There is no source of pollution in this region	10	6.2	1	1.7
Throwing house residues and sewage in branch canal	102	63.8	39	65
Throwing house residues and dead animals in branch canal	25	15.6	5	8.3
Throwing house residues, sewage and factories waste	23	14.4	15	25
The soil condition: [9]				
Change for the better	77	48.1	4	6.6
No change	29	18.1	7	11.7
Became worse	54	33.8	49	81.7

8. X^2=6.397^a df.=3 Sig. 0.094 9. X^2=42.883^a df.=2 Sig. 0.000

Cross-tabs (Table 12) were used to explain why a contradiction happened in the results concerning irrigation water quantity and soil condition in improved areas after establishment of IIIMP. The results shows that Besentway branch canal was the reason for increasing the percentage of WUs who mentioned that quantity of water "became worse", were 55% confirmed that. Similarly, 44.9% said that the soil condition "became worse". The chi^2 test for this distribution was statistically significant ($p < .000$). Generally, one of the major indicator for the good quality of soil condition is the availability of sufficient amount of fresh water, in turn, Besentway branch canal was responsible for most of the drop occurred in the results when comparing the irrigation system situation in improved and unimproved areas.

Table 12. WUs' perspective on the quantity and quality of irrigation water and agricultural soil condition in Nikla and Besentway branch canals

Questions	Nikla N=71		Besentway N=89	
	Freq.	%	Freq.	%
Quantity of irrigation water available now: [1]				
Changed for better	41	57.8	24	27
As bad as before	14	19.7	16	18
Became worse	16	22.5	49	55
The soil condition: [2]				
Change for the better	44	62	33	37.1
No change	13	18.3	16	18
Became worse	14	19.7	40	44.9

1. X^2=19.556^a df.=2 Sig. 0.000 2. X^2=12.534^a df.=2 Sig. 0.002

In conclusion, the amount of fund available for engineers payment in IIIMP have been stopped, which in turn, prompting engineers to return to their offices and discontinue providing their recommendations to WUs regarding IIIMP. Additionally during data collection it was observed by the team that some of the engineers were not totally aware with the IIIMP. As a result, this lead to many failures and overlapping tasks among various departments. On the other hand, WUs were promised by applying IIIMP in their areas will guarantee a continuous flow of irrigation water. Unfortunately, this is not achieved in reality except in few areas and for a short period of time, thus, WUs betrayed their trust to some extent in IIIMP.

3. Performance of organization under improved and unimproved irrigation system

3.1 Efficiency of BCWUAs

3.1.1 WUs awareness with the BCWUAs' role in improved areas

In improved areas, over three fourths of WUs (76.8%) are aware with the presence and role of BCWUAs. These WUs were asked about each role of BCWUAs separately, and their responses were listed in descending order as follows: 52.8% for “cooperation with the departments and all stakeholders to improve irrigation water services”, 52% for “conflict resolution on irrigation water”, 50.4% for “facilitating communication and information sharing among all members of the association”, 47.9% for “commitment to internal laws of the association”, 41.4% for “organizing meetings with representative committees”, 38.2% for “writing reports”, and 32.5% for “development of annual plans and overseeing its implementation” (Table 13).

Table 13. WUs' awareness with BCWUAs' role in improved areas

Statement	Improved N=123	
	Freq.	%
WUs awareness with the BCWUAs' role		
- Communication is facilitated and information is shared among all members of the association	62	50.4
- Cooperation with MWRI and other parties to improve water services	65	52.8
- Development of annual plans and overseeing its implementation	40	32.5
- Report writing	47	38.2
- Organizing meetings with representative committees	51	41.4
- Conflict resolution on irrigation water inside branch canal belt area	64	52
- Commitment to internal laws of the association	59	47.9

In improved areas, it is relatively obvious (Table 14) that a significant number of WUs (40.4%) in Besentway branch canals were not aware with the presence of BCWUAs. During data collection in Besentway branch canal it was perceived that BCWUA's Board of Directors has been already formed, but they were not well known by all Besentway's WUs. The chi^2 test for this distribution was statistically significant ($p < .005$).

Table 14. WUs' awareness with BCWUAs' role in Nikla and Besentway branch canals

Statement	Nikla N=71		Besentway N=53	
	Freq.	%	Freq.	%
- Communication is facilitated and information is shared among all members of the association [1]	27	38	35	66
- Cooperation with MWRI and other parties to improve water services [2]	31	43.6	34	64.2
- Development of annual plans and overseeing its implementation [3]	17	23.9	23	43.4
- Report writing [4]	23	32.3	24	45.3
- Organizing meetings with representative committees	27	38	24	45.3
- Conflict resolution on irrigation water inside branch canal belt area [5]	30	42.2	35	66
- Commitment to internal laws of the association [6]	27	38	31	58.5

1. X^2=9.102^a df.=1 Sig. 0.003 2. X^2=4.777^a df.=1 Sig. 0.029
3. X^2=5.020^a df.=1 Sig. 0.025 4. X^2=1.973^a df.=1 Sig. 0.160
5. X^2=7.319^a df.=1 Sig. 0.007 6. X^2=5.746^a df.=1 Sig. 0.017

3.2 Effectiveness of BCWUAs

3.2.1 Agencies that WUs can complain to when facing problems in irrigation in improved and unimproved areas

More than half of WUs (55.6%) in improved areas, and (58.6%) in unimproved areas mentioned that they return to “irrigation engineers” when they face any problem in irrigation. However, these agencies are not always fair when solving WUs' irrigation problems, where one half of WUs (50%) in improved areas and two third (66.7%) in unimproved areas stated that their irrigation problems are “sometimes” fairly solved. The chi^2 test for this distribution was statistically significant ($p < .000$). Concerning time period taken to solve irrigation problems, 44.9% of WUs in improved areas assured that their problems are solved in a “reasonable” time period. Conversely, 77.8% of WUs in unimproved areas mentioned that their problems takes “long” time period to be solved (Table 15). The chi^2 test for this distribution was statistically significant ($p < .000$).

Table 15. Agencies that WUs can complain to when facing problems in irrigation in improved and unimproved areas

Questions	Improved N=160		Unimproved N=60	
	Freq.	%	Freq.	%
To whom you complain when you have irrigation problem				
No one	22	13.8	6	10
The village mayor	4	2.5	2	3.3
WUA	13	8.1	-	-
The irrigation engineers	89	55.6	35	58.3
BCWUA	14	8.8	-	-
Relatives with authority	3	1.8	0	0
Police station	1	0.6	1	1.7
Local unit	14	8.8	16	26.7
These agencies are fair in their resolutions? [1]	**N=138**		**N=54**	
Always	58	42	3	5.6
Sometimes	69	50	36	66.7
Never	11	8	15	27.8
Time period taken by these agencies to solve problems [2]				
Long time period	44	31.9	42	77.8
Reasonable time period	62	44.9	12	22.2
Short time period	32	23.2	0	0

1. X^2=29.467[a] df.=2 Sig. 0.000 2. X^2=35.964[a] df.=2 Sig. 0.000

Moreover, cross-tabs (Table 16) showed that in Nikla branch canal 70.7% of WUs stated that their problems are solved in “reasonable” and “short” time period. However, one third (33.8%) of WUs in Besentway consented that it takes “long” time period to be solved.

Table 16. Agencies that WUs can complain to when facing problems in irrigation in Nikla and Besentway branch canals

Questions	Nikla N= 71		Besentway N= 89	
	Freq.	%	Freq.	%
These agencies are fair in their resolutions?[1]	**N= 58**		**N= 80**	
Always	34	58.7	24	30
Sometimes	22	37.9	47	58.8
Never	2	3.4	9	11.2
Time period taken by these agencies to solve problems:				
Long time period	17	29.3	27	33.8
Reasonable time period	22	37.9	40	50
Short time period	19	32.8	13	16.2

1. X^2=12.035[a] df.=2 Sig. 0.002

3.2.2 WUs' perspectives on BCWUAs' transparency in improved areas

Concerning BCWUAs' transparency, in Nikla branch canal 42.3% of WUs stated that they have chosen their Board of Director by “reputation”, although BCWUAs' Board of Directors supposed to be chosen by election under the supervision of IIIMP. On the other hand, 39.3% of WUs in Besentway branch canal could not even recognize the concept of BCWUA. The chi^2 test for this distribution was statistically significant ($p < .000$). Among WUs who recognized how BCWUA was chosen, approximately three quarters (74%) confirmed that this was a “good” method because it achieves transparency and credibility (Table 17).

Table 17. WUs' perspectives on BCWUAs' transparency in Nikla and Besentway branch canals

Questions		Nikla N=71		Besentway N=89	
		Freq.	%	Freq.	%
The way by which BCWUAs' Board of Directors were chosen?[1]					
Election		20	28.2	16	18
Reputation		30	42.3	30	33.7
Don’t know how they were chosen		20	28.2	8	9
Never heard about BCWUAs		1	1.4	35	39.3
WUs opinion on the way by which BCWUAs' Board of Directors were chosen		**N= 50**		**N= 46**	
Good		33	66	38	82.6
Not good		17	34	8	17.4
Why this way of selecting BCWUAs' Board of Directors is good/not good?[2]					
Positive:	- Transparency and credibility	34	68	41	89.1
Negative:	- They do not represent us as WUs	16	32	5	10.9

1. X^2=36.131[a] df.=3 Sig. 0.000 2. X^2=6.259[a] df.=1 Sig. 0.012

3.2.3 Tasks required from BCWUAs' board of director

As shown in (Table 18), 47.9% of WUs in Nikla branch canal stated that the conflicts on irrigation water decreased, compared with one third (33.7%) in Besentway. Additionally, one half of WUs (50%) in Nikla said that it took “long” time for their problems to be solved by BCWUA. In comparison, in Besentway over one half of WUs (58.5%) mentioned that their problems were solved in a “reasonable” time period. The chi^2 test for this distribution was statistically significant ($p < .005$).

Although 51.4% of WUs in Nikla agreed that BCWUA Board of Director “never” encouraged the spirit of cooperation among WUs, a significant percentage (35.7%) mentioned that they “always” keen to raise the spirit of cooperation. In comparison, in Besentway 45.3% of WUs said that their Board of Director “always” encouraged them to cooperate together. The chi^2 test for this distribution was statistically significant ($p < .005$). WUs in both Nikla and Besentway, stated that their opinions have never been taken by BCWUA in any decision with the percentages 57.2% and 51%, respectively. The chi^2 test for this distribution was statistically insignificant.

Moreover, over one half of WUs (55.7%) in Nikla and the majority (83%) in Besentway confirmed that their decisions were “always” and “sometimes” respected by BCWUA Board of Director. The chi^2 test for this distribution was statistically significant ($p < .005$). Concerning the overall tasks required from BCWUAs' Board of Directors, 47.2% of WUs in Nikla mentioned that “nothing” of the required tasks were done, conversely 54.8% of WUs in Besntway mentioned that “some” of these tasks were accomplished. The chi^2 test for this distribution was statistically significant ($p < .005$). Besides, more than half of WUs (57.1%) and 72.2% in Nikla and Besentway, respectively, perceived BCWUAs' Board of Directors as collaborating partners. The chi^2 test for this distribution was statistically insignificant.

Table 18. Tasks required from BCWUAs' Board of Director in Nikla and Besentway branch canals

Statement	Nikla N=71		Besentway N=89	
	Freq.	**%**	**Freq.**	**%**
Conflicts on irrigation water among WUs				
Decreased than before	34	47.9	30	33.7
No change	14	19.7	20	22.5
Increased than before	23	32.4	39	43.8
Time period taken by BCWUA to solve irrigation problems[1]	**N=70**		**N= 53**	
Long time period	35	50	15	28.3
Reasonable time period	23	32.9	31	58.5
Short time period	12	17.1	7	13.2
BCWUAs' board of director encourage the spirit of cooperation among WUs? [2]	**N=70**		**N= 53**	
Always	25	35.7	24	45.3
Sometimes	9	12.9	13	24.5
Never	36	51.4	16	30.2
Have you ever been consulted in any decision taken by BCWUAs?	**N=70**		**N= 53**	
Always	15	21.4	12	22.6
Sometimes	15	21.4	14	26.4
Never	40	57.2	27	51
BCWUAs respect WUs' decisions [3]	**N=70**		**N= 53**	
Always	30	42.9	25	47.2
Sometimes	9	12.8	19	35.8
Never	31	44.3	9	17
Tasks required from BCWUAs' board of director[4]	**N=70**		**N= 53**	
All of it done	19	27.1	12	22.6
Some of it done	18	25.7	29	54.8
Nothing of it done	33	47.2	12	22.6
How BCWUAs' board of director regard each other?	**N=70**		**N= 53**	
As partners	40	57.1	39	72.2
They have some conflicts	6	8.6	6	11.1
Don't know	24	34.3	9	16.7

1. X^2**=8.310**[a] **df.=2 Sig. 0.016** **2.** X^2**=6.209**[a] **df.=2 Sig. 0.045**
3. X^2**=14.045**[a] **df.=2 Sig. 0.001** **4.** X^2**=11.832**[a] **df.=2 Sig. 0.003**

4. Mutual trust and connectedness between WUs in the irrigation management process

With respect to mutual trust among WUs, in improved areas, over two thirds of WUs (69.4%) and 48.3% in unimproved areas "agreed" that they trust each other. The chi^2 test for this distribution was statistically significant ($p < .005$). Consequently, the majority of WUs (90.6%) in improved areas, and 76.7% in unimproved areas cooperate together to solve their problems. The chi^2 test for this distribution was statistically insignificant. Similarly, WUs used to share new agricultural information with their neighbors, were almost all WUs in improved and unimproved areas 98.1% and 98.3%, respectively, agreed upon this statement. The chi^2 test for this distribution was statistically insignificant.

Expectedly, more than two thirds of WUs (69.4%) in improved areas, and the majority (81.7%) in unimproved areas confirmed that no one is excluded when taking decision regarding irrigation. The chi^2 test for this distribution was statistically insignificant. However, among those who agreed that there are some WUs are excluded, 79.6% said that trouble makers are excluded. Although, a significant number of WUs assured that no one is excluded in decision making, 65.6% and 96.7% in improved and unimproved areas, respectively, convinced that it is quite normal to keep women out from decision making process. The chi^2 test for this distribution was statistically significant ($p < .000$). This could be due to that the mental model and tradition of rural community believe that women role is limited to household tasks, and one of the main objectives of IIIMP is to change this perception.

Approximately two thirds of WUs (65%) in improved areas, and the majority of WUs (88.3%) in unimproved areas, do not have any connection with formal/informal institutions. Based on the previous result, it is obvious that over one third of WUs (35%) in improved areas confirmed that they have connections with people in formal and/or informal institutions, 48.2% of them assured that they "sometimes" gain benefits from this connection. Logically, it is accepted result, where WUs in improved areas are supposed to have more access to connections in formal and/or informal institutions due to the existence of IIIMP and BCWUA (Table 19).

Table 19. Mutual trust and connectedness between WUs in irrigation management process in improved and unimproved areas

Questions	Improved N=160		Unimproved N=60	
	Freq.	%	Freq.	%
Do you think that people her generally trust one another in matters of irrigation process [1]				
Yes	137	85.6	60	100
No	23	14.4	0	0
Do you think that people here care about others' welfare [2]				
Agree	111	69.4	29	48.3
Neutral	35	21.9	26	43.3
Disagree	14	8.7	5	8.4
From your perspective, how WUs in your community act when facing a common problem?				
Nothing done	5	3.1	0	0
We act separately	10	6.3	14	23.3
We solve the problem together	145	90.6	46	76.7
Do you share new agricultural information with your neighbors?				
Yes	157	98.1	59	98.3
No	3	1.9	1	1.7
Do your neighbors share new agricultural information with you?				
Yes	143	89.4	55	91.7
No	17	10.6	5	8.3
Is there any of WUs can be excluded when taking decision regarding irrigation?				
Yes	49	30.6	11	18.3
No	111	69.4	49	81.7
Why there are WUs excluded from participating in decision making process?	**N=49**		**N=11**	
Widow women who rent their lands to others, are not asked for their opinion	3	6.1	0	0
WUs who are usually source of problems	39	79.6	11	100
Only leaders take decisions regarding irrigation	7	14.3	0	0
Rural people of both sexes (males and females) are represented in decision making at all levels? [3]	**N=160**		**N=60**	
Yes	55	34.4	2	3.3
No	105	65.6	58	96.7
Do you have connection with any formal and/or informal institution?	**N=160**		**N=60**	
No	104	65	53	88.3
WUAs	8	5	0	0
MWRI	6	3.8	3	5
Parliament	9	5.6	1	1.7
BCWUAs	3	1.9	0	0
Ministry of agriculture	9	5.6	2	3.3
MWRI and Ministry of agriculture	16	10	1	1.7
Ministry of electricity and energy	5	3.1	0	0
How do they belong to you?	**N=56**		**N=7**	
My relatives	13	23.2	2	28.6
My friends	32	57.2	4	57.1
Both	11	19.6	1	14.3
Do you gain benefits from this connection?				
Always	23	41.1	1	14.3
Sometimes	27	48.2	2	28.6
Never	6	10.7	4	57.1

1. X^2=9.632^a df.=1 Sig. 0.002 2. X^2=10.291^a df.=2 Sig. 0.006
3. X^2=21.904^a df.=1 Sig. 0.000

Cont. table 19. Mutual trust and connectedness between WUs in irrigation management process in improved and unimproved areas

Questions Freq.	Improved N=160		Unimproved N=60	
	Freq.	**%**	**Freq.**	**%**
Do you think that religious people have influence on the irrigation water management process?	**N=160**		**N=60**	
Yes	35	21.9	8	13.3
No	125	78.1	52	86.7
So, what is the role of these religious people?	**N=35**		**N=8**	
Conflict resolution on irrigation water	2	5.7	2	25
Increase farmers' consciousness regarding water usage	33	94.3	6	75

5. Relationships between studied independent variables

These relationships were tested based on the following stated statistical hypotheses: there are no significant relationships between the independent variables (Table 20).The following statistically significant and positive correlations, were found:

- Between WUs' age (r = 0.355) and number of household members, at 0.01 level. This could be due to that relatively older WUs tend to have more children as they are considered as a source of income whether by working in their own land or as a casual labor in other fields.
- Between WUs' education (r = 0.164) and land holding size, at 0.05 level. Logically, relatively educated WUs tend to adopt more agricultural innovations that eventually increase their income and enable them to enlarge their land size.
- Between WUs' living expenses (r = 0.348) and number of household members, at 0.01level.
- Between WUs' living expenses (r = 0.188) and land holding size, at 0.05 level.
- Between WUs' landholding size (r = 0.235) and number of household members, at 0.01level. which could indicate that WUs who have relatively large agricultural areas tend to have more number of children and in some cases get married again.

The following statistically significant and negative correlations, were found:

- Between WUs' age (r = - 0.447) and education, at 0.01 level. Generally, in rural areas, level of education is considerably low specially among elderly people.

- WUs' education (r = - 0.267) and number of household members, at 0.01 level. This interdependence implies that more educated people are better in adopting family planning concept.

Thereby, based on the above the statistical hypothesis could be rejected. However, there are no relationships between: age and living expenses, age and landholding size, and education and living expenses. Thus, the statistical hypothesis could not be rejected.

Table 20. Values of simple Pearson correlation coefficient among the studied independent variables in improved areas

	Age	Education	No. of household members	Living expenses	Land holding size
-Age	-	-.447**	.355**	.079	.066
-Education	-.447**	-	-.267**	-.053	.164*
-No. of Household members	.355**	-.267**	-	.348**	.235**
-Living expenses	.079	-.053	.348**	-	.188*
-Land holding size	.066	.164*	.235**	.188*	-

**** Significant at 0.01 level** *** Significant at 0.05 level**

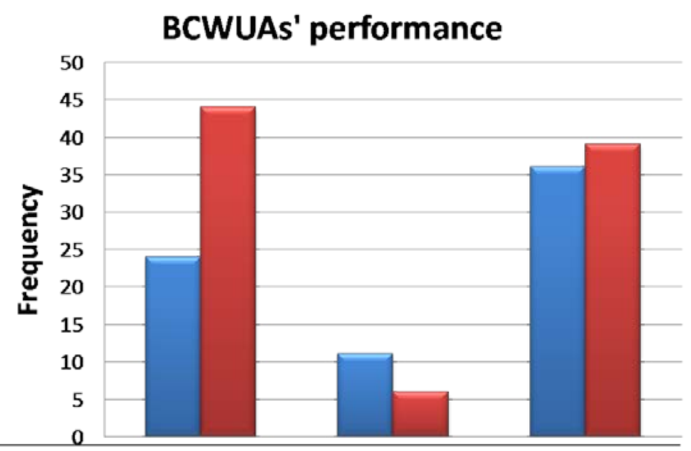
6. IIIMP and BCWUAs' Performance levels in improved areas

WUs' adjusted score were classified into three levels according to their responses: low, medium, and high. BCWUA performance actual range was (0-0.17), with a median of 0.06. IIIMP performance actual range was (0.01-0.22), with a median of 0.08.

In general, WUs in improved areas had conflicting perspectives regarding the BCWUAs' performances (Figure 13). The study revealed that one half (50.7%) of WUs in Nikla branch canal reported high level of BCWUA performance, on the contrary, 49.4% of WUs in Besentway reported low level of BCWUA performance. There is an agreement among WUs in Nikla and Besentway branch canals regarding IIIMP performance, where 43.7% and 49.4%, respectively, reported low level of IIIMP performance (Figure 14).

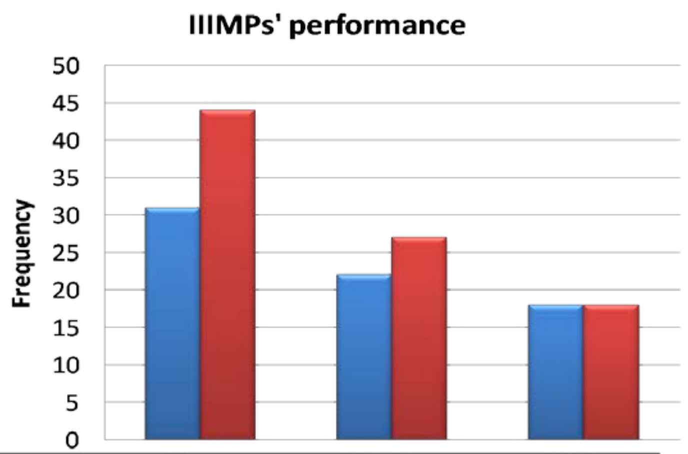
In sum, some *mesqas* located on the downstream in Nikla branch canal was still unimproved. This could possibly explain the WUs' perspectives (already on improved *mesqas*) toward IIIMP performance, where they feel that authorized stakeholders could be reluctant in overcoming the obstacles that could hinder the completion of the improved project. In Besentway, its geographical location (i.e.

distance from main canal compared with Nikla, agglomeration of building on both sides of the branch canal, etc.) could be a major cause for its frequent problems and this in turn contributed to the success and failure of BCWUA in Nikla and Besentway branch canals, respectively.



	Low		Medium		High	
	Freq.	%	Freq.	%	Freq.	%
Nikla (N=71)	24	33.8	11	15.5	36	50.7
Besentway (N=89)	44	49.4	6	6.7	39	43.8

Figure 13. BCWUAs' performance in Nikla and Besentway branch canals



	Low		Medium		High	
	Freq.	%	Freq.	%	Freq.	%
Nikla (N=71)	31	43.7	22	31	18	25.4
Besentway (N=89)	44	49.4	27	30.3	18	20.2

Figure 14. IIIMP's performance in Nikla and Besentway branch canals

7. Relationships between the studied independent variables and BCWUA and IIIMP performance

These relationships were tested based on the following stated statistical hypotheses: there are no significant relationships between the independent variables and the performance of both BCWUA and IIIMP. Statistically significant and positive correlation, at 0.01 level, was found between WUs' age and IIIMP performance (r = 0.223). Thereby, the statistical hypothesis could be rejected. This statistically significant and positive correlation could be due to that the past experience of the relatively older WUs enable them to judge the project more objectively. However, there are no significant relationships between independent variables (education, number of household members, living expenses, and land holding size) and the performance of both BCWUA and IIIMP. Thus, the statistical hypotheses could not be rejected (Table 21).

Table 21. Values of simple Pearson correlation coefficient among the studied dependent and independent variables in improved areas

Independent variables	Dependent variables	
	BCWUA performance	IIIMP performance
Age	.125	.223**
Education	.090	.110
Number of household members	-.076	-.060
Living expenses	.018	.012
Land holding size	.150	.114

**** Significant at 0.01 level**

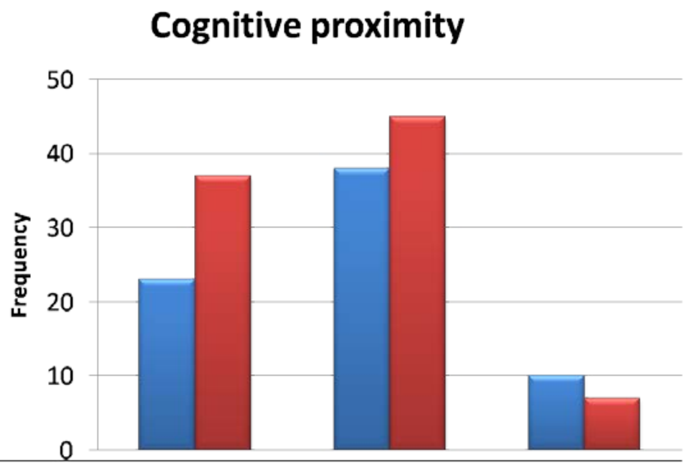
8. Dimensions of proximity in improved areas

Each proximity dimension score (cognitive, social, organizational) was categorized into three levels: low, medium, and high. Meanwhile, geographical proximity was categorized into three levels: short distance, average, and long distance. Cognitive proximity actual range is (0.01-0.11), with a median of 0.05. Social proximity actual range is (0.02-0.05), with a median of 0.05. Organizational proximity actual range is (0-0.07), with a median of 0.01. Geographical proximity actual range for Nikla branch canal is (≤0.13-4.64), with a mean of (2.25) and geographical proximity actual range for Besentway branch canal is (≤0.47-4.01), with a mean of (5.44).

In improved areas, WUs' in both Nikla and Besentway branch canals (Figure 15) showed "medium" level of cognitive proximity, 53.5% and 50.6%, respectively.

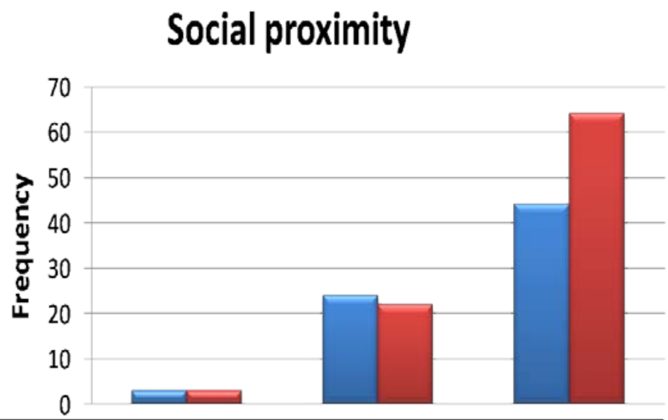
Alternatively, result revealed a "high" level of social proximity (Figure 16) with the percentages of 62% and 71.9% in both Nikla and Besentway, respectively. Concerning organizational proximity WUs' perspectives was contradictory in both Nikla and Besentway branch canal (Figure 17), where one half (50.7%) of WUs in Nikla show "high" level of organizational proximity, while 49.4% of WUs in Besentway show "low" level of organizational proximity. Regarding geographical proximity (Figure 18), in Nikla branch canal, more than half of WUs' *mesqas* (54.9%) are located at "average" distances from each other. Comparatively, in Besentway, 50.6% of WUs' *mesqas* are located at "long" distances from each other.

Sequentially, in improved areas (Figure 19), more than two third of WUs (67.5%) show "high" level of social proximity; 51.9% show "medium" level of cognitive proximity; and 47.5% show "low" level of organizational proximity.



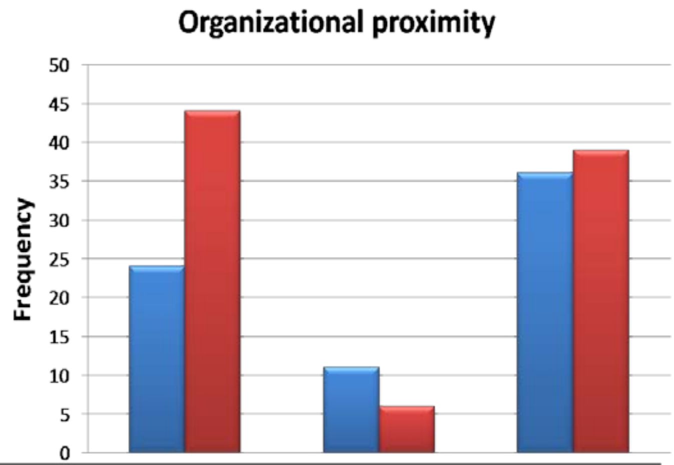
	Low		Medium		High	
	Freq.	%	Freq.	%	Freq.	%
Nikla (N=71)	23	32.4	38	53.5	10	14.1
Besentway (N=89)	37	41.6	45	50.6	7	7.9

Figure 15. Cognitive proximity in Nikla and Besentway branch canals



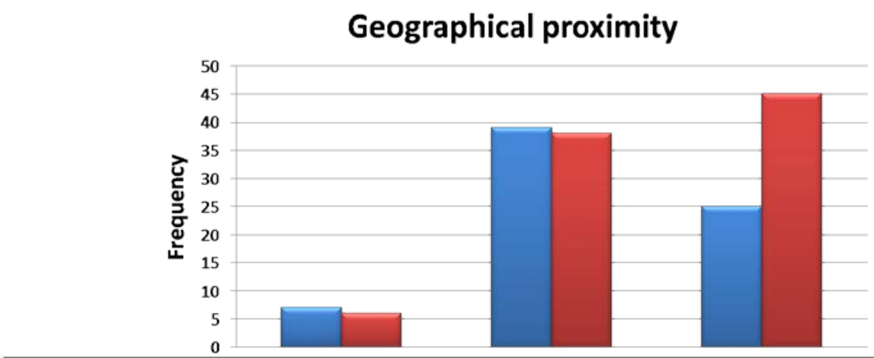
	Low		Medium		High	
	Freq.	%	Freq.	%	Freq.	%
Nikla (N=71)	3	4.2	24	33.8	44	62
Besentway (N=98)	3	3.4	22	24.7	64	71.9

Figure 16. Social proximity in Nikla and Besentway branch canals



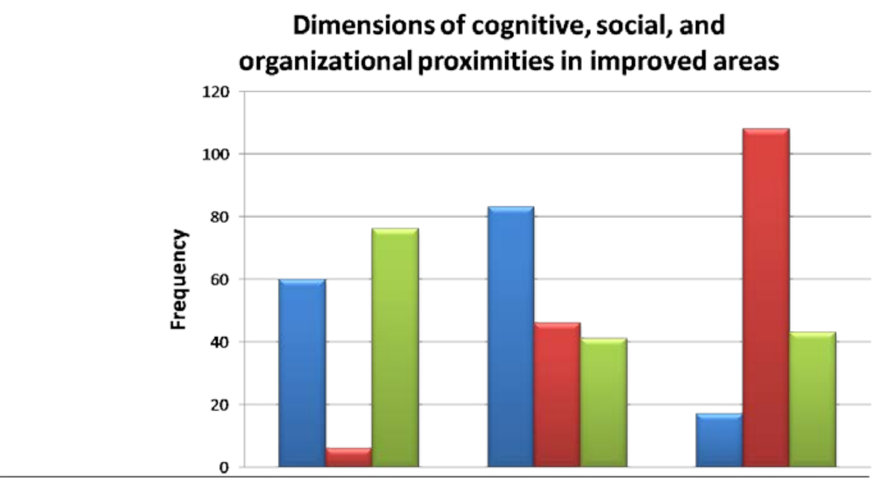
	Low		Medium		High	
	Freq.	%	Freq.	%	Freq.	%
Nikla (N=71)	24	33.8	11	15.5	36	50.7
Besentway (N=89)	44	49.4	6	6.7	39	43.8

Figure 17. Organizational proximity in Nikla and Besentway branch canals



	Short distance		Average		Long distance	
	Nikla (≤0.13) Besentway (≤0.47)		Nikla (>0.13 – 1.28) Besentway (>0.47 – 1.81)		Nikla (>1.28 – 4.64) Besentway (>1.81–4.01)	
	Freq.	%	Freq.	%	Freq.	%
Nikla (N=71)	7	9.9	39	54.9	25	35.2
Besentway (N=89)	6	6.7	38	42.7	45	50.6

Figure 18. Geographical proximity in Nikla and Besentway branch canals



N= 160	Low		Medium		High	
	Freq.	%	Freq.	%	Freq.	%
Cognitive	60	37.5	83	51.9	17	10.6
Social	6	3.8	46	28.8	108	67.5
Organizational	76	47.5	41	25.6	43	26.9

Figure 19. Dimensions of the studied proximities in improved branch canals

9. Relationships between the studied explanatory variables and independent variables in improved areas

The relationship is tested based on the stated statistical hypotheses that there is no significant relationship between independent variables and different kinds of proximity. Statistically significant and positive correlation, at 0.05 level, was found between WUs' age and cognitive proximity (r = 0.171). Thereby, the statistical hypothesis could be rejected. The result revealed that similarity of knowledge among the elder WUs is relatively higher than the similarity of knowledge among younger WUs.

Additionally, statistical significance and positive correlation, at 0.01 level, was found between land holding size and organizational proximity (r = 0.026). The statistical hypothesis could be rejected. This could mean that WUs with relatively larger land holding size are keen to share the same reference knowledge and interact effectively as they are all members in the same organization (BCWUA). However, there are no significant relationships between any other independent variables and different kinds of proximity. Thus, the statistical hypotheses could not be rejected (Table 22).

Table 22. Values of simple Pearson correlation coefficient among the studied explanatory variables and independent variables in improved areas

Independent variables	Explanatory variable		
	Cognitive proximity	Social proximity	Organizational proximity
Age	.171*	.078	.146
Education	.130	-.060	.063
Household members no.	-.082	.128	-.039
Living expenses	-.006	.100	.016
Land holding size	.155	-.042	.206**

**** Significant at 0.01 level** *** Significant at 0.05 level**

10. Relationships between the studied explanatory variables and dependent variables in improved areas

These relationships were tested based on the following stated statistical hypotheses: there are no significant relationships between different kinds of proximity and performances' of BCWUA and IIIMP.

There are statistically significant and positive correlations between cognitive proximity and BCWUA performance (r = 0.730), and between cognitive proximity and IIIMP performance (r = 0.748), at 0.01 level. the statistical hypothesis could be rejected. Cognitive proximity reflects the similarity of WUs' knowledge about the irrigation development system, which in turn affect WUs' perspectives toward BCWUAs' and IIIMPs' performance (Table 23).

There are statistically and positive correlations between social proximity and BCWUA performance (r = 0.268), and between social proximity and IIIMP performance (r = 0.233), at 0.01 level. The statistical hypothesis could be rejected. High level of social proximity among WUs indicate how much they trust, cooperate, and share more reliable information among each other, which in turn could better the performance of BCWUA, thereby improve the performance of IIIMP. Additionally, there is statistically and positive correlations between organizational proximity and IIIMP performance (r = 0.666), at 0.01 level. The statistical hypothesis could be rejected. In sum, it seems that the strong cognitive, social, and organizational proximity were in favor of the irrigation development project.

Table 23. Values of simple Pearson correlation coefficient among the studied explanatory variables and dependent variables in improved areas

Explanatory variable	Dependent variables	
	BCWUA performance	IIIMP performance
Cognitive proximity	.730**	.748**
Social proximity	.268**	.233**
Organizational proximity	-	.666**

**** Significant at 0.01 level**

11. Relationships between the studied explanatory variables in improved areas

These relationships is tested based on the stated statistical hypotheses that there is no significant relationship between different kinds of proximity and each other (Table 24). There are statistically significant and positive correlations, at 0.01 level, between: cognitive proximity and social proximity (r = 0.239); cognitive proximity and organizational proximity (r = 0.689); and social and organizational proximity (r = 0.214). Therefore, the statistical hypothesis could be rejected. Cognitive proximity reflects the similarity of WUs' knowledge about the irrigation development system, which in turn affect WUs' perspectives toward BCWUAs' and IIIMPs' performance. The interdependence among different kinds of proximity implies that any changes happen in any kind of them could result in a change of the other kinds.

Table 24. Values of simple Pearson correlation coefficient among the studied explanatory variables in improved areas

Explanatory variables	Explanatory variable		
	Cognitive proximity	Social proximity	Organizational proximity
Cognitive proximity	-		
Social proximity	.239**	-	
Organizational proximity	.689**	.214**	-

**** Significant at 0.01 level**

12. Relationships between geographical proximity and studied explanatory variables in improved areas

As shown in Table (25) Nikla's geographical proximity is positively correlated (Spearman's Rho =0.446) and is statistically significant at 0.01 level with the social proximity. In Besentway branch canal, geographical proximity is positively correlated, and statistically significant with: cognitive proximity (Spearman's Rho =0.257) at 0.05 level; organizational proximity (Spearman's Rho =0.291) at 0.01 level; and BCWUA's performance (Spearman's Rho =0.314) at 0.01 level.

In conclusion, the positively significant correlation between geographical and social proximities among WUs in Nikla branch canal could indicate that the trust among them is not affected by irrigation water insufficiency (see table 12, page 63). This probably could not be obvious in Besentway branch canal where irrigation water insufficiency after IIIMP establishment leads sometimes to conflict among WUs. Nevertheless, it is worth noting that in Besentway, the shorter the geographical distance between WUs' mesqas the greater the possibility to communicate and share the same reference of knowledge among BCWUA's members, which in turn, could be reflected on enhancing BCWUA's performance.

Table 25. Values of Spearman correlation coefficient among the studied explanatory variables in improved areas

Explanatory variables	Explanatory variable				
	Cognitive proximity	Social proximity	Organizational proximity	BCWUAs performance	IIIMPs performance
GP Nikla (N=71)	-.032	.446**	-.230	-.074	-.171
GP Besentway (N=89)	.257*	-.070	.291**	.314**	.119
GP improved (N=160)	-.037	.156*	-.043	-.025	-.057

**** Significant at 0.01 level** *** Significant at 0.05 level**

13. Relationships between *mesqas'* geographical location and explanatory variables

These relationships is tested based on the stated statistical hypotheses that there is no significant relationship between geographical location and different kinds of proximity (Table 26). There is statistically significant and positive correlations, at 0.01 level, between: Nikla's *mesqas* geographical locations and social proximity (r = 0.319). Thereby, the statistical hypothesis could be rejected. This finding shows that the mutual trust and knowledge sharing among WUs along Nikla branch canal are not affected by their geographical locations from the branch canal intake. Particularly, WUs in downstream *mesqas* were able to solve their own irrigation problems. This could be due that Nikla's location (upstream of Mahmoudia main canal) distinguish it with relatively adequate water quantity, which in turn, lead to less irrigation water problems and ease of problems solving.

In Besentway's *mesqas* the following statistically significant and negative correlations, were found:

- Between Besentway's *mesqas* geographical locations (r = -0.240) and cognitive proximity, at 0.05 level. The cognitive "distance" could be due to that WUs located on downstream of Besentway branch canal have more irrigation problems where the distance between the principal canal and Besentway branch canal is relatively long (14 km) compared with, Nikla branch canal (2 km).The statistical hypothesis could not be rejected.
- Between Besentway's *mesqas* geographical locations (r = -0.289) and social proximity, at 0.01 level. Normally, as mentioned above the long distance with inefficient irrigation management leads to more irrigation problems, conflicts, etc., which could affect WUs' trust and collaboration with each other. The statistical hypothesis could not be rejected.

Table 26. Values of simple Pearson correlation coefficient between *mesqas'* geographical locations and different kinds of proximity in improved areas

Independent variables	Explanatory variable		
	Cognitive proximity	Social proximity	Organizational proximity
Nikla's *mesqas* geographical locations	-.030	.319**	-.175
Besentway's *mesqas* geographical locations	-.240*	-.289**	-.046

**** Significant at 0.01 level** *** Significant at 0.05 level**

14. Relationships between *mesqas'* geographical location and dependent variables in improved areas

These relationships is tested based on the stated statistical hypotheses that there is no significant relationship between branch canals' *mesqas'* geographical location and IIIMP and BCWUAs' performance (Table 27). There is statistically significant and negative correlations, at 0.01 level, between: Besentway's *mesqas* geographical locations and IIIMPs' performance (r = -0.285).This finding could indicate that Besentway branch canal is not distinguished from unimproved branch canals as it did not gain the major benefit of applying IIIMP, which is the adequate allocation of irrigation water. This means that IIIMP in this branch canal is neither perceived as efficient nor effective. Thus, The statistical hypothesis could be rejected.

Table 27. Values of simple Pearson correlation coefficient between *mesqas'* geographical locations and dependent variables in improved areas

Explanatory variable	Dependent variables	
	BCWUA performance	IIIMP performance
Nikla's *mesqas* geographical locations	-.079	-.047
Besentway's *mesqas* geographical locations	-.087	-.285**

**** Significant at 0.01 level**

15. Relationships between BCWUAs' performance and dependent variables in improved areas

These relationships is tested based on the stated statistical hypotheses that there is no significant relationship between BCWUAs' performance and IIIMP's performance in Nikla and Besentways' branch canals (Table 28). There is statistically significant and positive correlations, at 0.01 level, between:

- Nikla's BCWUA performance and IIIMP's performance (r = 0.762), and;
- Besentway's BCWUA performance and IIIMP's performance (r = 0.621).

Table 28. Values of simple Pearson correlation coefficient between IIIMP and BCWUA performance in Nikla and Besentway branch canals

BCWUAs' performance	IIIMP's performance
Nikla's BCWUA performance	.762**
Besentway's BCWUA performance	.621**

**** Significant at 0.01 level**

16. Conclusion and policy implication

First, the study explores the irrigation systems in three different territories, one under the traditional irrigation system and the others under improved irrigation system, where IIIMP is applied based on IWRM approach. By testing the significance of difference (Chi-square test), results revealed that in improved areas the situation is enhanced in terms of adoption of rational irrigation practices, easiness of access to various authorized stakeholders, improvement of soil condition, cleaning of the branch canal, and reasonable O&M costs of irrigation. On the other hand, there are no remarkable improvement in terms of irrigation water quantity and quality, active participation of rural people (both sexes) in decision making process, solving irrigation water problems by authorized stakeholders, and keeping WUs' updated with decisions taken by authorized stakeholders.

In improved areas, by testing significance of difference between the two branch canals (Nikla and Besentway), significant differences were observed in terms of irrigation water quantity, soil condition, time period to solve irrigation problems, encouraging spirit of cooperation, and accomplishment of BCWUAs' board of directors tasks. Regarding BCWUAs and IIIMP performance in Nikla and Besentway branch canals, WUs in both territories agreed upon the "low" performance of IIIMP and have contradictory perspectives on BCWUAs' performance. More than half of WUs in Nikla reported "high" BCWUAs' performance and about half of WUs in Besentway take a contrary view. In Nikla branch canal, WUs' pessimistic estimation toward IIIMP performance was due to that some *mesqas* located on the downstream still unimproved. This drives WUs even in already improved *mesqas* to feel that authorized stakeholders are reluctant in overcoming the obstacles that could hinder the completion of the project. Comparatively, in Besentway, its geographical location (i.e. distance from main canal compared with Nikla) could be a major cause for its frequent irrigation problems. However, the problem of "long distance" from main canal intake is supposed to be resolved by IIIMP establishment and the maintaining of continuous flow (i.e. no WU is favored at the expense of other).

All in all, results revealed that there is a discrepancy between IIIMP overall objective agreed upon during its establishment and what have been already achieved in reality. WUs want to realize that IIIMP has substantial and tangible results as failure to achieve any of the project objectives could lead some WUs to return back to the traditional irrigation system as happened in some other territories. This could ruin the reputation of irrigation improvement programs in general, and hinder its implementation in other territories. Based on that, a systematic and objective assessment is needed to address accountability, and get benefits of lessons learned to overcome IIIMP's shortcomings.

Additionally, BCWUA is promised to be provided by many facilities (e.g., an official office, control over deciding maintenance work, etc.). These promises still have not been achieved in reality as observed during data collection. This could leads to frustration of BCWUAs' board of directors and lead farmers to ignore the existence of the associations as stated by Molle *et al* (2015).

Second, regarding proximity dimensions in improved areas (Figure 20), study findings lead to an empirical evidence of the significance of various dimensions of proximity. Whereas cognitive, and organizational proximities are strongly correlated with one another and play a key role in enhancing both performances of IIIMP and BCWUA. Similarly, social proximity shows a positive and statistically significant correlation with each of the geographical proximity and the performances of IIIMP and BCWUA, but it is weak.

In sum, the study revealed that there are inter-dependence between the studied proximity dimensions. This finding agree with the result of Menzel (2008) who found that if any change happens in one of the proximity dimension could result in a change in the other dimensions. Besides, our findings appear to be in line with Heringa *et al.* (2014) who found a positive effect of cognitive proximity on soft and hard outcomes of collaboration in water sector, as well, he found a weak effect for the social proximity on the soft outcomes, and a weak effect for the geographical proximity when controlling the other dimensions for the hard outcomes.

However, these correlations are different in their existence, significance, and strength when examined in different territories with a different network nature. Particularly, when comparing the situation in each improved branch canal (Nikla and Besentway). On the one hand, in Besentway branch canal (Figure 21), there are a positive and significant correlations among most of the studied proximity dimensions. Besides, there are a positive association between all the dimensions of proximity and the performances of both BCWUA and IIIMP except the geographical one that only shows a significant correlation with cognitive proximity, organizational proximity, and BCWUA's performance. On the other hand, only the cognitive and organizational proximities have a significantly positive relationship with BCWUA's and IIIMP's performances in Nikla branch canal (Figure 22). This confirms what is concluded by Balland, Boschma, and Frenken (2014) that the different kinds of proximity could be changed due to participation in knowledge networks that could decrease or increase the degree of proximity between the actors involved.

Further research is needed to explore the impact of the different dimensions of proximity (geographical, institutional, social, cognitive, and organizational) on the performance of irrigation improvement projects. To investigate how new networks (e.g. water users associations) could influence the degree of proximity in specific territories.

This study has a number of implications for decision makers who are involved in the design and implementation of IWRM approach.

- The study results call for empowering women role in the irrigation process as they are considered a key principle in IWRM approach, as results revealed that the mental model and tradition of rural community still believe that women role is limited to household tasks.
- A higher degree of control and supervision is crucial by the irrigation improvement sector in Ministry of Water Resources and Irrigation (MWRI) as tasks required from authorized stakeholders in solving technical and administrative problems are indistinct, and restricted to the power in controlling water and electricity.
- More awareness campaigns has to be launched to encourage rural people to gather and share eco-friendly practices, as it was observed that there were branch canals totally blocked by house residues, sewage, dead animals, and factories waste and it became worse due to the dramatic increase in the number of illegal housing units on both sides of the branch canals.
- Alternative mechanisms (e.g. incentives given to irrigation engineers) should be considered in the future to maintain the sustainability of IIIMP. As it was observed that the fund available for engineers payment in IIIMP have been stopped, which in turn, push engineers to return to their offices and discontinue providing their recommendations to BCWUAs.
- Authorities should clarify the reasons behind failure to implement the continuous flow where WUs were promised that applying IIIMP in their areas will guarantee a continuous flow of irrigation water, which unfortunately is not achieved in reality except in few branch canals and for a short period of time. Thus, WUs betrayed their trust to some extent in IIIMP.
- More training programs should be designed and incentives has to be aligned, where it is showed that some engineers were not totally aware with IIIMP, which in turn could lead to many failures and overlapping tasks among various departments.
- The transparency in the election of BCWUAs should be enhanced as it helps WUs to recognize the existence of BCWUAs and to be more aware with their role. WUs' should be enabled to participate in decision-making, as results showed that it was neglected to some extent.
- BCWUAs should be legalized by law to give them more power to ask for their rights.

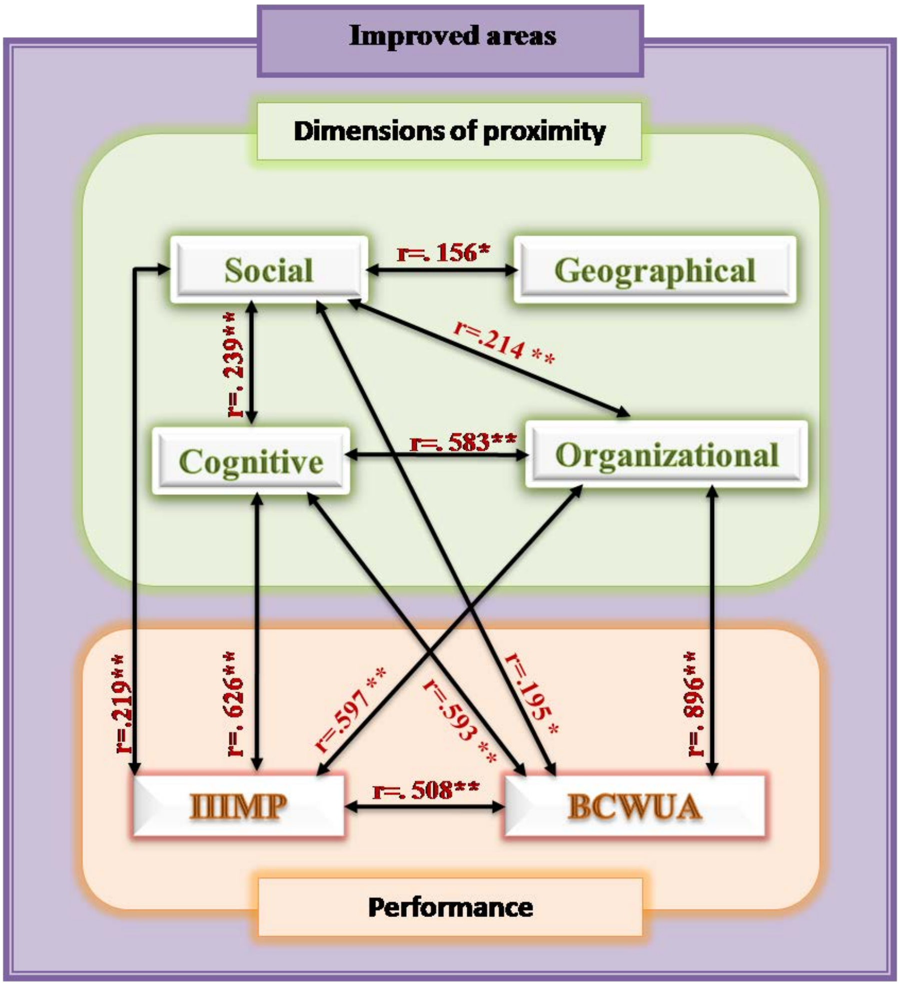


Figure 20. Relationships between studied proximity dimensions and IIIMP's and BCWUAs' performances in improved areas (Source: Author's elaboration)

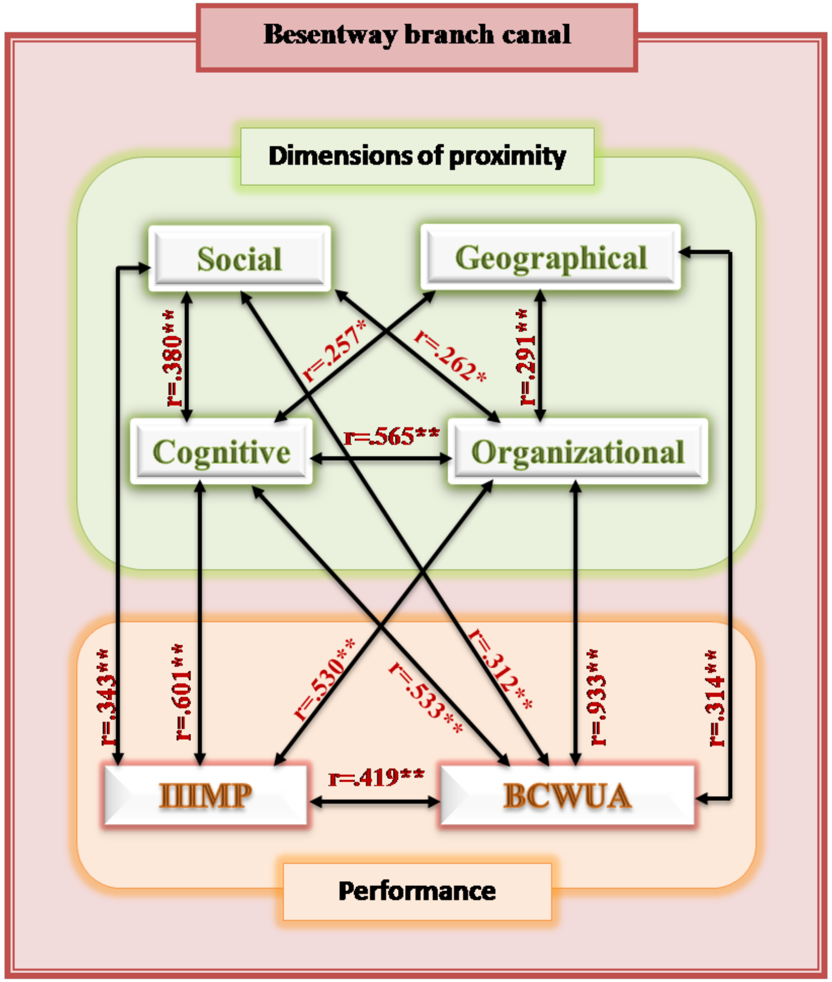


Figure 21. Relationships between studied proximity dimensions and IIIMP's and BCWUAs' performances in Besentway branch canal (Source: Author's elaboration)

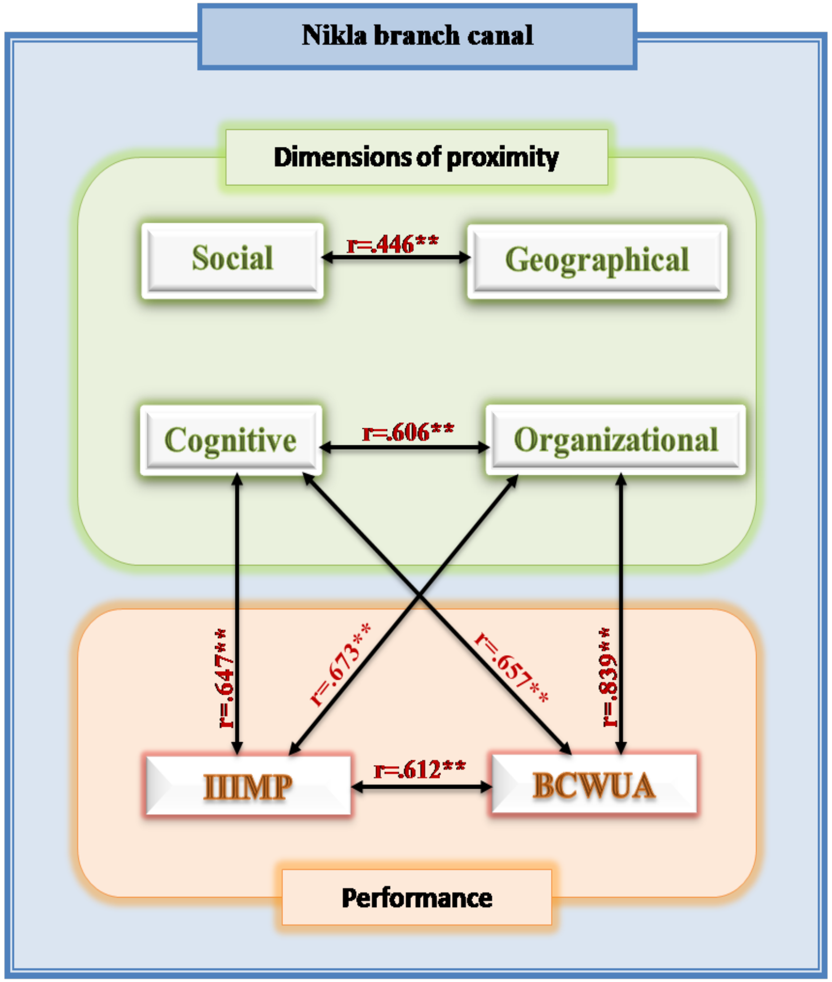


Figure 22. Relationships between studied proximity dimensions and IIIMP's and BCWUAs' performances in Nikla branch canal (Source: Author's elaboration)

Bibliography

Abdel Ghaffar, E. (2006) Non-Conventional Water Resources Management. Tenth International Water Technology Conference, IWTC10 2006, Alexandria, Egypt. Available from: https://www.researchgate.net/publication/237734806.

Abdel-Azim R., Allam M. N. (2005) Agricultural drainage water reuse in Egypt: strategic issues and mitigation measures. In: Hamdy A. (ed.), El Gamal F.(ed.), Lamaddalena N. (ed.), Bogliotti C. (ed.), Guelloubi R.(ed.). *Non-conventional water use: WASAMED project.* Bari : CIHEAM / EU DG Research, 2005. P. 105-117 (Options Méditerranéennes: Serie B. Etudes et Recherches; n. 53). Available from: http://om.ciheam.org/article.php?IDPDF=800755.

Abdel-Aziz, Y. (2003) *Decentralisation and participatory irrigation management: case study of Egypt*. Water Demand Management forum, Cairo, Egypt, 2-4 February 2003.

Abdelgawad, S., M.; Allam, M.,N., E. and Elgamal, M., H. (2010) INTEGRATED WATER RESOURCES MANAGEMENT PRACTICES IN EGYPT, A CRITICAL REVIEW AND ANALYSIS. In: *Fourteenth International Water Technology Conference IWTC*, Cairo, Egypt. pp. 749, 767.

Abdel-Gawadh, S. T.; Kandil, M. and Sadek, T. M. (2002) Water scarcity prospects in Egypt 2000-2050. Proceeding of environmental challenges in the Mediterranean 2000 -2050 Madrid, Spain (Ed. Marquina, A.). 2 – 5 October 2002. Kluwer Academic Publishers, Netherlands. pp. 187 – 203.

Abu-Zeid, M. (1995) Major policies and programs for irrigation, drainage and water resources development in Egypt. [Online] In: Abdel Hakim T. (ed.). *Egyptian Agriculture Profile*. Montpellier : CIHEAM, 1995. P. 33-49 (Options Méditerranéennes, Serie B. Etudes et Recherches; n. 9). Available from: http://om.ciheam.org/article.php?IDPDF=CI950934.

Adhikary, M., Chowdhury, S., 2010. Virtual water trade, sustainability and territorial equity across phases of globalization in India. Environmental Values 19, 33-56.

Alnaggar, D. (2003) Water resources management and policies for Egypt. Proceedings of the Symposium Organized by the Regional Centre on Urban Water Management (RCUWM-Tehran), 15-16 December 2003, Tehran, Islamic Republic of Iran, pp. 55-69. Available from: http://unesdoc.unesco.org/images/0013/001385/138521e.pdf. [Accessed: 22nd December 2015].

APRP. (1998) Egypt's irrigation improvement program: performance assessment and proposed national strategy. report no. 7. APRP, Egypt. Available from: http://www.iwrmeg.org/reports/Epiq%20report/REPORT%207%20Egypt%E2%80%99s%20Irrigation%20Improvement%20Pr ogram.pdf.

Attia, B. B. (2009) *Assessment of Vulnerability and Adaptation of Water Resources to Climate Change in Egypt.* Cairo, Egypt: Arab Water Council.

Authors. (2011) Innovation and productivity: local competitiveness and the role of space. In Cooke, P. et al.(eds.). *Handbook of Regional Innovation and growth*. Edward Elgar Publishing.

Balland, P. A., Boschma, R., and Frenken, K. (2014) Proximity and Innovation: From Statics to Dynamics. Regional Studies. [Online] 49 (6). Available from: http://dx.doi.org/10.1080/00343404.2014.883598.

Biodiversity A-Z (2014) Sustainable development. [Online] Available from: http://biodiversitya-z.org/content/sustainable-development. [Accessed: 13th April 2017].

Boschma R. A. (2005) Proximity and innovation: a critical assessment, *Regional Studies*. 39 (1). p. 61-74

Boschma, R. (nodate) Proximity and Innovation. *Regional studies*.

Boschma, R. A. (2005b) Does geographical proximity favour innovation*?. Économie et institutions.* [Online] 6-7. p. 111 – 128. Available from: https://ei.revues.org/926. DOI : 10.4000/ei.92

Boschma, R. and Frenken, K (2012) Technological relatedness and regional branching. In Bathelt, H. et al. (eds.) *Beyond Territory: Dynamic Geographies of Innovation and Knowledge Creation*. Routledge.

Boshma, R., Balland, P. A., and Van, M. (2014) The formation of economic networks: a proximity approach. In Wwallet, F. and Torre, A. (eds.). *Regional Development and Proximity Relations.* Edward Elgar Publishing. pp. 243 - 266

Broekel, T. and Boschma R. (2012) Knowledge Networks in the Dutch Aviation Industry: The Proximity Paradox. *Journal of Economic Geography* · 12 (2). p. 409 – 433. DOI: 10.1093/jeg/lbr010

Broekel, T. and Boschma R. (2017) The cognitive and geographical structure of knowledge links and how they influence firms' innovation performance. Regional studies. 6 (2). p. 3 – 26. DOI: 10.15196/RS06201

Caniels, M., Kronenberg, K. and Werker, C. (2014) Conceptualizing proximity in research collaboration. In Rutten, R. et al. (eds.). *Social dynamics of innovation networks.* Routledge.

Cap-Net. (2005) Integrated water resources management plans, training manual and operational guide. Netherlands Commission on Sustainable Development. Available from: www.un.org/esa/sustdev/csd/csd12/.

Carbonara, N. (2014) Knowledge-based externalities and geographical clusters: an agent-based simulation study. In Adamatti, D. F., Dimuro, G. P. and Coelho, H.(eds.) *Interdisciplinary Applications of Agent-Based Social Simulation and Modeling.* IGI Global.

CEDARE. (2014) Egypt Water Sector M&E Rapid Assessment Report, Monitoring & Evaluation for Water In North Africa (MEWINA) Project, Water Resources Management Program, CEDARE.

CES. (2012)INTEGRATED IRRIGATION IMPROVEMENT AND MANAGEMENT PROJECT (IIIMP), Egypt. Available from: http://cms.ces-info.com/CES/_pdf/17-0802e-cc_05-2012.pdf. [Accessed: 23th March 2016].

CIA. (2017) *The world factbook: Africa-Egypt*. [online] Available from: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/eg.html. [Accessed: 11th June 2017].

Claassen, M. (2013) Integrated Water Resource Management in South Africa. *International Journal of Water Governance*. 1. DOI: 10.7564/13-IJWG12. p. 323-338.

Drejer, I. and Østergaard, C. R. (2014) The role of geographical, cognitive and social proximity in university-industry collaboration on innovation. Presented to the 9th Regional Innovation Policy Conference, 16-17 October 2014, Stavanger, Norway.

EEAA. (2017)*Ministry of Egyptian Environmental Affairs Agency*. [Online] Available from: http://www.eeaa.gov.eg. [Accessed: 13th February 2017].

El Arabi, N. (2012) Environmental Management of Groundwater in Egypt via Artificial Recharge Extending the Practice to Soil Aquifer Treatment (SAT). *International Journal of Environment and Sustainability.* [Online] ISSN 1927-9566. 1 (3). pp.66-82. Available from: www.sciencetarget.com. [Accessed: 6th October 2015].

El-Gohary, F. (2002) Need of Alternative Water Resources in Egypt. Presented at the Workshop: 'Use of Appropriately Treated Domestic Wastewater in Irrigated Agriculture' Wageningen, The Netherlands (March 2002) WIO. Available from: http://bieb.ruaf.org/ruaf_bieb/upload/1549.pdf. [Accessed: 3th November 2015].

El-Sayed, A. (2011, November) Egyptian drainage water reuse practice and measures to alleviate risk of failure. PowerPoint presentation. Available from: http://www.arabwatercouncil.org.

Euroconsult Mott MacDonald. (2008). Integrated irrigation Improvement and Management Project, Egypt. Available from:http://www.extranet.ecbmb.nl/iddnet/download.asp?file=Docs/Projects/EC/2016_EG_253178.docx.[Accessed: 15thJune 2015].

Fahmy, S.; Elassiouty, I.; Ezzat, N.; Maher, A. and Badran, M. (2000) Analysis and review of modifications in law 12 of 1984 on irrigation and drainage. report no. 37. APRP, Egypt.

FAO. (1997) Irrigation potential in Africa: A basin approach. FAO, Rome. Available from: http://www.fao.org/docrep/W4347E/w4347e00.htm#Contents

FAO. (2005) Rapid assessment study towards integrated planning of irrigation and drainage in Egypt: In support of the Integrated Irrigation Improvement and Management Project (IIIMP), Final Report. Rome.

FAO. (2013) Irrigated agriculture. Available from: http://www.fao.org/nr/water/topics_wwf6-t2.html

FAO. (2016) AQUASTAT- *FAO's Information System on Water and Agriculture-Egypt.*[Online] Available from: http://www.fao.org/nr/water/aquastat/countries_regions/EGY/. [Accessed: 13th February 2017].

Ferreira, H. S. and Leitão, A. B. (2006) Integrating landscape and water resources planning with focus on sustainability (Chapter 11). From landscape research to landscape planning: aspects of integration, education and application. (Eds.) Tress, B.; Tress, G.; Fry, G. and Opdam, P. P. 143-159.

Freisem, C. and Scheumann, W. (2001) Institutional arrangements for land drainage in developing countries. Working Paper 28. IWMI, Colombo, Sri Lanka. Cited in http://ageconsearch.umn.edu/bitstream/92776/2/WOR28.pdf.

Fu, W. (2015) *Towards a Dynamic Regional Innovation System: Investigation into the Electronics Industry in the Pearl River Delta, China.* Springer.

Gawel, E. and Bernsen, K. (2011) What is wrong with virtual water trading? UFZ Discussion Papers Department of Economics. Helmholtz-Zentrumfür Umweltforschung GmbH – UFZ Permoserstr. 15 04318 Leipzig

Gouda, M. D. (2016) Social Capital and Local Water Management in Egypt. American University in Cairo Press. Pp.288 pages.

GWP. (2000) Integrated Water Resources Management TAC Background Papers No. 4. Sweden: GWP.

GWP. (2010) The global water partnership. global program review. Volume 4 Issue 3.

Hauswirth, A. I. (2006) Effective and efficient organizations? Government export and the UK from an organizational economics perspective. Physica-Verlag Heidelberg, Germany. 251 p.

Hautala, J. (2011) Cognitive proximity in international research groups. *JOURNAL OF KNOWLEDGE MANAGEMENT*. DOI 10.1108/13673271111151983+ (601 - 624)

Havidt,. M. (1997) Modernizing the Egyptian irrigation system: Will the new technology take root in society?. In: Sabour., M. and Vikor., K., S. (eds.). *ETHNIC ENCOUNTER AND CULTURAL CHANGE: PAPERS FROM THE THIRD NORDIC CONFERENCE ON MIDDLE EASTERN STUDIES. JOENSUU, 1995,* Bergen. Norway, Nordic Society for Middle Eastern Studies. pp. 209-232.

Horlemann, L. and Neubert, S. (2007) Virtual Water Trade: A realistic concept for resolving the water crisis. Dt. InstitutfürEntwicklungspolitik, 2007. – (Studies / Deutsches InstitutfürEntwicklungspolitik; 25) ISBN 978-3-88985-335-6

ICWE(1992) International Conference on Water and the Environment: *The Dublin Statement and Report of the Conference*. Development Issue for the 21st century, 26-31 January, Dublin, Ireland.

International Hydrological Programme (IHP), Paris, France. Available from: unesdoc.unesco.org/images/0022/002281/228120e.pd.

Karajeh, F.; Oweis, T.; Swelam, A.; El-Gindy, A.; El-Quosy, D.; Khalifa, H.; El-Kholy, M. and El-Hafez, S. (2011) Water and Agriculture in Egypt: Technical paper based on the Egypt-Australia-ICARDA Workshop on On-farm Water-use Efficiency. Available from: https://apps.icarda.org.

Khafagy., Y. (2006) Towards an Efficient Water Management for a Sustainable Development of Water Resources in Egypt. [Presentation] in: *User-Producer Conference Water Accounting for Integrated Water Resource Management*. United Nations Statistics Division, Netherlands, 22-24 May 2006. Available from: https://unstats.un.org/unsd/envaccounting/ceea/PImeetings/lodupc.htm. [Accessed: 3rd October 2015].

Knoben, J. (2008) *Firm Mobility and Organizational Networks: Innovation, Embeddedness and Economic Geography*. Edward Elgar Publishing.

Knoben, J., and Oerlemans, L. A. G. (2006) Proximity and inter-organizational collaboration: A literature review. *International Journal of Management Reviews*. 8(2). p. 71-89. DOI: 10.1111/j.1468-2370.2006.0012.x

Kotb, T., and Boissevain, W. (2012) Water saving due to irrigation improvement in the Nile Delta. Proceedings of the 5th International Scientific Conference on Water, Climate and Environment. 28 May to 2 June 2012, Ohrid, Republic of Macedonia.

Kudic, M. (2014) *Innovation Networks in the German Laser Industry: Evolutionary Change, Strategic Positioning, and Firm Innovativeness.* Springer.

Lenzi, C. (2013) Territorial patterns of innovation: Evidence from European regions In Capello, R.(ed.) *Territorial Patterns of Innovation: An Inquiry on the Knowledge Economy in European Regions*. Routledge.

Meeus, M. and Oerlemans. (2005) Innovation strategies, interactive learning and innovation networks. In Casper, S. & Waarden, F. V. (eds.). *Innovation and Institutions: A Multidisciplinary Review of the Study of Innovation Systems***.** Edward Elgar Publishing.

Misheloff, R. (2010) Integrated water resource management II: Feasibility of wastewater reuse, report no. 14. IRG, Washington. Available from: http://www.mwri.gov.eg. [Accessed: 14th October 2015].

Misr Consult. (2005) *Integrated Irrigation Improvement and Management Project Environmental Assessment (EA) Study: Final EA Study Report – Part 1, Version -01*. Misr Consult. Report No: E1106.

Mohsen, A.; Kitamura, Y. and Shimizu, K. (2012) Assessment of Irrigation Practices at Main Irrigation Network in the Nile Delta. *World Academy of Science, Engineering and Technology*. 6 (9). P. 807-814. Available from: scholar.waset.org/1999.1/12009.

Molle, F.; Rap, E. (2013) Brief Retrospective on Water User Organizations in Egypt. Working Paper. International Water Management Institute. Australian Center For International Agriculture Research.

Molle, F.; Rap, E.; Al-Agha, D.; Ismail, A.; E; El Hassan, W. and Freeg, M. (2015) Irrigation Improvement Projects in the Nile Delta: Promises, Challenges, Surprises. *Water and salt management in the Nile Delta*: International Water Management Institute, Brief Retrospective on Water User Organizations in Egypt. Report No. 4. Available from: https://www.researchgate.net/publication/295943836.

Mwanza, D., D. (2006) Water for sustainable development in Africa. The World Summit on Sustainable Development: The Johannesburg Conference. Hens, L., and Nath, B. (eds.) Springer Science & Business Media, Netherlands. P. 91-111.

MWR. (2014) Water Scarcity in Egypt: The Urgent Need for Regional Cooperation among the Nile Basin Countries. Cairo: MWRI.

MWRI. (2002) Adopted measures to face water challenges in the Egyptian water sector: From the Hague 2nd world water forum 2000 to the Kyoto 3rd world water forum 2003. Cairo: MWRI.

MWRI. (2005) Arab Republic of Egypt. Ministry of Water Resources and Irrigation. *National water resource plan for Egypt-2017: water for the future*. Cairo: MWRI Planning sector.

Nawar, H. M.; Abdel-Kader, M. A. and El-Bendary, T. A. (2001)*Operational efficiency of WUA's and its relationship with some socio-economic variables.* pp. 471-490

Nooteboom. B. (2009) *A Cognitive Theory of the Firm: Learning, Governance and Dynamic Capabilities*. Edward Elgar Publishing.

Obrecht, J. J. (2011) Environment for entrepreneurship. In Dana, L. P. (ed.). *World Encyclopedia of Entrepreneurship*. Edward Elgar Publishing.

Odyssey. (2017) *The Oil Dilemma - Only With Water: Hydropolitics and our future.* [Online] Available from: https://www.theodysseyonline.com/oil-dilemma-water. [Accessed: 11th June 2017].

Oloo, A. (2007) The Quest for Cooperation in the Nile Water Conflicts: The Case of Eritrea. African Sociological Review. [online] 11(1), pp.95-105. Available from: https://www.codesria.org/IMG/pdf/07_Oloo.pdf. [Accessed: 12th March 2016].

Oosterbaan, R. j. (1999) Impacts of the irrigation improvement project, Egypt, on drainage requirements and water savings. Technical Report. International Institute for Land Reclamation and Improvement (ILRI), Wageningen, The Netherlands.

Pecqueur, B. (2013) TERRITORIAL DEVELOPMENT. A NEW APPROACH TO DEVELOPMENT PROCESSES FOR THE ECONOMIES OF THE DEVELOPING COUNTRIES. *Interdisc. INTERthesis, Florianópolis*. 10 (2). p. 8-321. Available from: http://dx.doi.org/10.5007/1807-1384.2013v10n2p8 R. [Accessed: 15th Septemper 2017]

Ponds, R., Van Oort, F. and Frenken, K. (2007) The geographical and institutional proximity of research collaboration. *Papers in Regional Science*. [Online] 86 (3). p. 423–443. doi:10.1111/j.1435-5957.2007.00126.x

Salim, G. M. (2012) Selection of groundwater sites in Egypt, using geographic information systems, for desalination by solar energy in order to reduce greenhouse gases. *Journal of Advanced Research*. [online] 3 (1), pp.11-19. Available from: http://www.sciencedirect.com. [Accessed: 26th January 2016].

Snellen, B., W. and Schrevel, A. (2004) IWRM: for sustainable use of water 50 years of international experience with the concept of integrated water management : Background document to the FAO/Netherlands Conference on Water for Food and Ecosystems. Ministry of Agriculture, Nature and Food Quality, Netherlands. pp. 6-8.

UN. (2009) The United Nations World Water Assessment Programme: Side publications series: Dialogue Paper. report 3. *Integrated Water Resources Management (IWRM) in Action*, Paris, France. P.3.

UN. (2015) General Assembly Resolution A/RES/70/1. Transforming Our World, the 2030 Agenda for Sustainable Development. Available from: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

UNCED (1992) United Nations Conference on Environment and Development. *Sustainable Development*. Agenda 21(chapter 18), 3 to 14 June, Rio de Janerio, Brazil.

UNESCO. (2014) Water in the post-2015 development agenda and sustainable development goals: Discussion paper. UNESCO

UNESCO. (2016) Transboundary Water Cooperation and the Sustainable Development Goals. UNESCO International Hydrological Programme (IHP), France. Available from: www.unesco.org/water/ihp.

UNWC (1977) Mar Del Plata Action Plan: Policy, Planning and Management. United Nations Water Conference, Mar Del Plata, Argentina. Available from: http://internationalwaterlaw.org/bibliography/UN/UN_Mar%20del%20Plata%20Action%20Plan_1977.pdf.

USAID (2011) Mid-term evaluation report: integrated water resources management II. Implementation assessment, findings and recommendations.USAID/EGYPT Office of Sustainable Resource Management. Available from: pdf.usaid.gov/pdf_docs/pdacr891.pdf.

USAID. (2010) Mena regional water governance benchmarking project country profile – Egypt. Final report. IRG in association with International Water Management Institute, Institute of Water and Watersheds at Oregon State University, Computer Assisted Development Incorporated, Nile Consultants, and ECO Consult. Available from:https://wocatpedia.net/images/0/0c/USAID_2010_MENA_ReWaB_Country_Profile_Egypt.pdf

Vermillion, D., L. and Sagardoy, J., A. (1999) *Transfer of Irrigation Management Services*: Guidelines, Issues 58-60. Rome, Italy: FAO

WB. (2004) *EGYPT, ARAB REPUBLIC OF-EGYPT-Integrated Irrigation Improvement and Management Project.* World Bank. Report No: AB129.

WB. (2016) *IMPLEMENTATION COMPLETION AND RESULTS REPORT: EGYPT-INTEGRATED IRRIGATION IMPROVEMENT AND MANAGEMENT PROJECT.* World Bank. Report No: ICR00003931.

Winden, W. V., Braun, E., Otgaar, A. and Witte, J. J. (2014) *Urban Innovation Systems: What Makes Them Tick?.* London, Routledge.

Wolters, W.; Smit, R.; Nour El-Din, M.; Ahmed, S. E.; Froebrich, J. and Ritzema, H. (2016) Issues and Challenges in Spatial and Temporal Water Allocation in the Nile Del. *Sustainability*. 8 (4). doi:10.3390/su8040383

Annex 1

Questionnaire on:
Impact of territorial features on the improvement of the irrigation efficiency:
"What kind of proximity is relevant for improving irrigation?"
Case study in Beheira governorate, Egypt

1) Administrative
1.1) Center:...
1.2) Local unit: …..………………………………………………….....................
1.3) Village: ………..…………………………………………………………..
2) WU's geographical location on branch canal and *mesqa*
2.1) Branch canal name:………………………………………….
2.2) Branch canal location on main canal:
◯ Upstream ◯ Midstream ◯ Downstream
2.3) *mesqa* location on branch canal:
◯ Upstream ◯ Midstream ◯ Downstream
2.4) WU's land location on *mesqa*:
◯ Upstream ◯ Midstream ◯ Downstream
3) WU's demographic characteristics
3.1) Age: (…………..) years
3.2) Educational status:
◯ Illiterate ◯ Intermediate education
◯ Can read and write ◯ University
◯ From primary to preparatory school
3.3) Occupation:
3.3.1) Agriculture production is your main occupation?
◯ Yes --**{***skip***}**--*(3.4)* ◯ No
3.3.2) What is your other occupation? …………………..……………………...
3.4) Marital status:
◯ Single ◯ Married ◯ Widow
3.5) Number of family members (……………….) person
3.6) Family unit:
◯ Nuclear ◯ compound ◯ Extended
3.7) House holding
◯ Owned ◯ Mixed ◯ Rented
3.8) Living expenses/L.E.:

Items	Monthly	Annually
Food		
Clothes		
Education		
Electricity, water, and house rentals		
Transportation		
Health care		
Complimentary occasions		
Recreational activities		
Miscellaneous		
Other: …………………………………		

3.9) WU's landholding characteristics
3.9.1) Land holding size: (……………..) Kirat
3.9.2) Number of your agricultural plots inside branch canal belt: (……….) plot/s
3.9.2.1) Land Tenure system of agriculture plots: (CHECK)

Agricultural plots	Owned	Mixed holding	Rented
First plot			
Second plot			
Third plot			
Other: ……………			

3.10) What kind of crops you usually cultivate?
◯ Wheat
◯ Alfa alfa
◯ Cotton
◯ Rice
◯ Corn
◯ Fruits
◯ Vegetables

3.11) Animal holding: (IN NUMBER)

Type	Owned	Mixed holding
Cows		
Buffalo		
Goat/sheep		
Donkey		
Camel		
Birds		
Other: ………….....		

3.12) Agricultural and transport tools holding: (IN NUMBER)

Type	Owned	Mixed
Irrigation pumps		
Irrigation pump		
Tractor		
Tractor		
Motorcycle		
Car		
Trailer		
Cart		
Other: ………….....		

4) Efficiency of authorized stakeholders in the irrigation system in improved and unimproved areas

4.1) Do you know who are the authorized stakeholders in the irrigation system?
◯ Yes ◯ Never heard about --**{***skip***}**--*(4.2)*
4.1.1) In general, who are the authorized stakeholder in the irrigation system?
◯ MWRI
◯ MALR
◯ Ministry of health
◯ Other: ……………………………………………………………………
4.2) Authorized stakeholders in the irrigation system held awareness seminars in irrigation in your surrounding area?
◯ Yes ◯ Never heard about --**{***skip***}**--*(4.c)*

4.b.1) What was the topics of these seminars?
◯ Cannot remember --**{**_skip_**}**--_(4.c)_
◯ IIIMP benefits
◯ Improving irrigation water quality
◯ Equity of water resources distribution
◯ Increase water resources productivity
◯ Irrigation conflicts resolution
◯ Women role in irrigation process
◯ Environmental sustainability
◯ Health related issues
Other: …………………………………………………………………………………..
4.b.2) To what extent these seminars were useful?
◯ Highly useful ◯ Moderate ◯ Not useful
4.b.2.a) Why these seminars were useful/moderate/un-useful?
4.b.3) Have you changed your irrigation behavior after attending these seminars?
◯ Yes ◯ To some extent yes ◯ No
4.c) Authorized stakeholders in the irrigation system express women role in the irrigation process?
◯ Yes ◯ No --**{**_skip_**}**--_(5.a)_
4.c.1) What are women role in the irrigation process?
◯ Women's right to be member in BCWUAs
◯ Women's right to be in the BCWUAS' representative committee
◯ Women's right to be in BCWUAs' board of director
Other: …………………………………………………………………………………..

5) Effectiveness of authorized stakeholders in the irrigation system in improved and unimproved areas

5.a) In the last five years, have you changed your irrigation practices?
◯ Yes ◯ No --**{**_skip_**}**--_(5.b)_
5.a.1) Reasons for changing your irrigation practice?
……………………………………………………………………………………………
5.b) Is it easy to contact with authorized stakeholders in case of necessity?
◯ Yes ◯ Sometimes ◯ No
5.c) Authorized stakeholders provide information regarding irrigation water?
◯ Yes ◯ Sometimes ◯ No
5.d) Farmers are involved with diverse departments in the irrigation water decision-making process?
◯ Yes ◯ No
5.e) Authorized stakeholders inform you with updated decisions regarding irrigation water?
◯ Always ◯ Sometimes ◯ Never
5.f) Is it easy for authorized stakeholders to meet at any time to discuss important issues regarding irrigation?
◯ Yes ◯ No
5.g) Do you think departments cooperate with each other to solve irrigation problems?
◯ Yes ◯ No
5.h) Does the departments cooperate with BCWUAs?
◯ Yes ◯ No
5.i) Does the departments respects BCWUAs' decisions?
◯ Yes ◯ Sometimes ◯ No

5.j) Authorizes stakeholders in the irrigation system do their best to solve irrigation problems?

◯ Yes ◯ No

5.k) Authorized stakeholders in the irrigation system in your community are important?

◯ Yes ◯ No

5.k.1) Why authorized stakeholders in the irrigation system are important/not important in your community?

…………………………………………………………………………………………………

5.l) Before IIIMP/five years ago the quantity of irrigation water available was sufficient?

◯ Yes ◯ Sometimes ◯ No

5.m) Quantity of irrigation water available now:

◯ Changed for better ◯ As bad as before ◯ Became worse

5.n) Quality of irrigation water now:

◯ Changed for better ◯ As bad as before ◯ Became worse

5.o) Is there a waste of irrigation water during its allocation?

◯ Yes ◯ Sometimes ◯ No

5.p) Charges and fees for irrigation water allocation is reasonable?

◯ Yes ◯ To some extent ◯ No

5.q) The branch canal is cleaned?

◯ Always ◯ Sometimes ◯ Rarely

What are the main irrigation problems in your region?

…………………………………………………………………………………………………

5.r) Irrigation water pollution:

◯ Increased than before ◯ No change ◯ Decreased than before

5.s) Is there a fine in the case of polluting water?

◯ Yes ◯ No

5.t) What are the main sources of irrigation pollution?

………………………………………………………………………………………………...

5.u) The soil condition:

◯ Changed for better ◯ As bad as before ◯ Became worse

6) Efficiency of BCWUAs in improved areas

6.a) WUs awareness with the BCWUAs' role:

◯ Facilitate communication and sharing information among all members of the association
◯ Cooperation with MWRI and other parties to improve water services
◯ Development of annual plans and overseeing its implementation
◯ Report writing
◯ Organizing meetings with representative committees
◯ Conflict resolution on irrigation water inside branch canal belt area
◯ Commitment to internal laws of the association

7) Effectiveness of BCWUAs in improved areas

7.a) To whom you complain when you have irrigation problem?

◯ No one --**{***skip***}**--*(7.c)*
◯ WUA
◯ BCWUA
◯ The irrigation engineers

Other: ……………………………………………………………………………………..

7.a.1) These agencies are fair in their resolutions?

◯ Always ◯ Sometimes ◯ Never

7.b.2) Time period taken by these agencies to solve problems:
◯ Long time period
◯ Reasonable time period
◯ Short time period
7.c) How BCWUAs' board of directors were chosen?
◯ Election
◯ Reputation
Other: ………………………………………………………………………………………
7.c.1) WUs opinion on the way by which BCWUAs' board of directors were chosen
◯ Good ◯ Not good
7.c.2) Why this way of selecting BCWUAs' board of directors is good/not good?
………………………………………………………………………………………………
7.d) Conflicts on irrigation water among WUs
◯ Decreased than before ◯ No change ◯ Increased than before
7.e) Time period taken by BCWUA to solve irrigation problems
◯ Long time period
◯ Reasonable time period
◯ Short time period
7.e) BCWUAs' board of director encourage the spirit of cooperation among WUs?
◯ Always ◯ Sometimes ◯ Never
7.f) Have you ever been consulted in any decision taken by BCWUAs?
7.g) BCWUAs respect WUs' decisions?
◯ Always ◯ Sometimes ◯ Never
7.h) Tasks required from BCWUAs' board of director:
◯ All of it done
◯ Some of it done
◯ Nothing of it done
7.i) How BCWUAs' board of director regard each other?
◯ As partners
◯ They have some conflicts
Other: ……………………………………………………………………………..

8) Mutual trust and connectedness

8.a) Do you think that people her generally trust one another in matters of irrigation process?
◯ Yes ◯ No
8.b) Do you think that people here care about others' welfare?
◯ Agree
◯ Neutral
◯ Disagree
8.c) From your perspective, how WUs in your community act when facing a common problem?
◯ Nothing done
◯ We act separately
◯ We solve the problem together
8.d) Do you share new agricultural information with your neighbors?
◯ Yes ◯ No
8.e) Do your neighbors share new agricultural information with you?
◯ Yes ◯ No
8.f) Is there any of WUs can be excluded when taking decision regarding irrigation?
◯ Yes ◯ No --**{***skip***}**--*(8.g)*

8.f.1) Why there are WUs excluded from participating in decision making process?

……………………………………………………………………………………………………

8.g) Rural people of both sexes (male and female) are represented in decision making at all levels?

◯ Yes ◯ No

8.h) Do you have connection with any formal and/or informal institution?

◯ Yes ◯ No --**{***skip***}**--*(8.i)*

8.h.1) How do they belong to you?

◯ Relatives
◯ Friends
◯ Both

8.h.2) Do you gain benefits from this connection?

8.i) Do you think that religious people have influence on the irrigation water management process?

◯ Yes ◯ No --**{***skip***}**--*(8.j)*

8.i.1) What is the role of these religious people?

……………………………………………………………………………………………………

8.j) WUs' participation in decision making process regarding irrigation is important?

◯ Yes ◯ No --**{***skip***}**--*(8.l)*

8.k) Why WUS' participation in decision making process regarding irrigation is important/not important?

……………………………………………………………………………………………………

8.l) WUs respect BCWUAs' decisions?

◯ Always ◯ Sometimes ◯ Never

8.m) From your point of view, WUs' living conditions:

◯ Changed for better ◯ No change ◯ Became worse

8.n) Why do you think that WUs' living conditions has improved/worsened?

……………………………………………………………………………………………………

8.o) What are the main health problems in your community?

◯ There is no health problems in this region

……………………………………………………………………………………………………

END OF QUESTIONNAIRE

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