Responses to the Irrigation Improvement Project along Abo Moustafa canal, Egypt

An analysis of water users' re-ordering of the socio-technical water network

M.Sc. Minor Thesis by Chris de Bont

November 2013

Water Resources Management Group

WAGENINGEN UNIVERSITY
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M.Sc. minor thesis Water Resources Management submitted in partial fulfillment of the degree of Master of Science in International Land and Water Management at Wageningen University, the Netherlands

This research has been initiated and supported by IWMI-CAIRO as part of the ACIAR project 'Management of water and salinity in the Nile Delta: A cross-scale integrated analysis of efficiency and equity issues'

Chris de Bont

November 2013

Supervisors:
Dr. ir. Alex Bolding
Water Resources Management Group
Wageningen University
The Netherlands
www.iwe.wur.nl/uk

Dr. ir. Edwin Rap
IWMI – Cairo
www.iwmi.cgiar.org

Abstract

This thesis analyses the re-ordering of the socio-technical water network along the Abo Moustafa canal, near Kafr el Sheikh, Egypt, after and during the implementation of the Irrigation Improvement Project (IIP). The IIP is an attempt at modernising irrigation systems in the Nile delta. Its most important features are replacing a multitude of pumps with one single lifting device per tertiary unit, replacing open tertiary canals with pipelines and setting up water user associations (WUAs).

The thesis is based on three months of field work in Egypt, especially in two tertiary units along the Abo Moustafa canal, combining methods of observation, semi-structure interviews, GPS mapping, participatory mapping and EC measurements. Analysis relies on the concepts of re-ordering and appropriation, enabling an actor-oriented approach to the interventions of the IIP.

The study shows how farmers have re-ordered their water network in an attempt to create a better 'fit' between the technology imposed by IIP and their own modes of ordering. Pumping stations have been appropriated to increase their pumping capacity; WUAs are replaced by a multitude of institutions; and farmers are using drainage water through individually operated pumps for supplementary irrigation.

The durable relations in this re-ordered network are those which fit best with the mode of ordering of independence and flexibility, and are geared towards dealing with the irregular water supply the mesqa is facing. While a system of low collective action and individually owned pumps is most tuned in to this, the social re-ordering and technical appropriation of the pumping station have partly secured the pumping station's spot in the network. However, a large part of this durability is due to the fact that it would require high investment funds to remove the IIP infrastructure. Therefore it is likely that the water network in the case study mesqas will eventually return to a system of individual pumping.

Keywords: Egypt, Irrigation Improvement Project, ordering, technology appropriation, irrigation modernisation

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List of acronyms

BC-WUA	Branch Canal Water User Association
EWUP	Egypt Water Use and Management Project
IIP	Irrigation Improvement Project
IMT	Irrigation Management Transfer
IWMI	International Water Management Institute
MPWWR	Ministry of Public Works and Water Resources
PS	Pumping station
WUA	Water User Association

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1. Introduction

Irrigation improvement projects in Egypt's Nile delta have resulted in profound changes in the area's water management in general and in farmers' irrigation practices in particular. While this fact is undisputed, more contestation exists around the question what the outcomes are of some of these projects. This thesis contributes to this discussion by studying one project in particular, the Irrigation Improvement Project (IIP), and by analysing how its implementation in one of the canals reshaped water management practices, both technically and institutionally. Furthermore, it pays special attention to the response(s) elicited from the actual water users and water managers, in particular how the former reacted and tried to adapt the new system to match their needs. In doing this, it sheds a new light on not only the implementation of IIP, but even more so on the actual irrigation practices in the IIP command area (depicted in Figure 1).

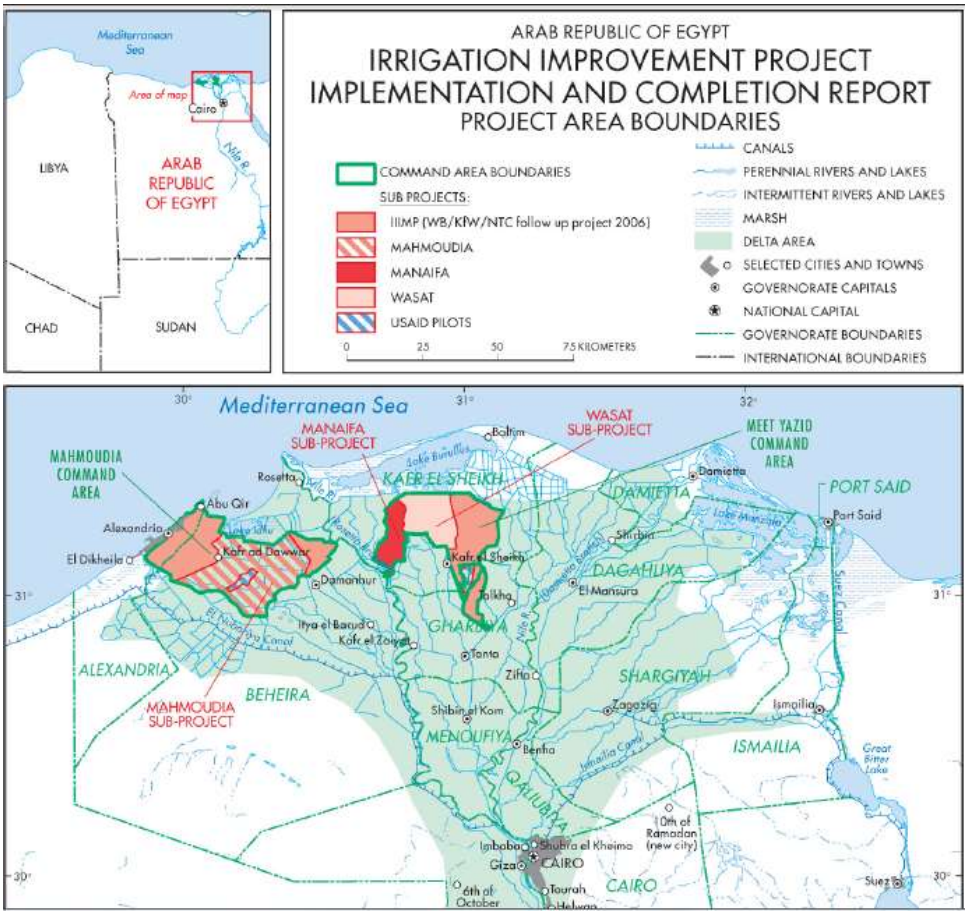


Figure 1 - IIP project area (Adapted from World Bank, 2007)

During the 1980s, Egypt's irrigation systems were facing the same problems as many others across the world: water was getting increasingly scarce, productivity was suboptimal and the State was not able/willing to pay for the improvement, operation and maintenance of the irrigation systems (Hvidt, 1995). The solution was sought in policies centred around ideas of modernisation and irrigation management transfer (IMT). The first step in developing these policies was the USAID funded Egypt Water Use and Management Project (EWUP), running from 1977 to 1984, which had the objective to introduce so-called "*modern technologies*" (p.124) in the old lands of Egypt to reduce water losses at

mesqa[1] level (Allam, 2004). EWUP resulted in a range of recommendations, which formed the foundation of the 1988 Irrigation Improvement Project. IIP aimed to "*increase agricultural production and conserve water and soil resources*" (USAID, 1990) or, about two decades later, to *"increase agricultural production and farm income by improving the irrigation infrastructure, facilitating a more equitable water distribution and improving on-farm water management*" (WMRI, 2006). These objectives do not explicitly mention management transfer or increased farmer participation and that probably indicates how we should assess these elements of the improvement package: participation and management transfer are a means to an end. In 1998, the Ministry of Public Works and Water Resources (MPWWR) already voiced its desire to "*do more with less water*" (MPWWR, 1998, p. 3-1). The overall goal is to save water so it can be used in other areas and sectors, and to do so at an affordable cost.

The water savings were supposed to materialise by means of three influential EWUP recommendations for the "modernisation" of the system: the introduction of continuous flow in the branch canals now operated under a rotation; replacing old, earthen tertiary canals which were below field level with elevated, lined canals or low pressure pipes; and shifting from individual pumping to collective pumping (Hvidt, 1996; Allam, 2004). Continuous flow was expected to stop farmers from irrigating excessively. This assumption was based on the premise that farmers over-irrigate because of a prevailing uncertainty of supply. Furthermore, it was believed possible to introduce continuous flow without increasing the total water volume allocated to each branch canal by lowering discharges (MPWWR, 1998). Piped or lined mesqas would reduce conveyance losses (saving water) and replacing many pumps with a collective one would facilitate ease of control over water abstraction by farmers.

To save costs and make sure the new systems were properly managed the IMT aspect of establishing a water user association (WUA) for each of the improved[2] mesqas became a prerequisite for project implementation. These WUAs were to play an active role in the "*planning, designing, implementing, operating, maintaining and regular monitoring*" (p.12) of the IIP in their tertiary unit (Aziz, 1994). More specifically, WUAs were meant to help in selecting the type of mesqa they wanted, locating the mesqa turnouts, scheduling turns among users, mediating in conflicts and operating and maintaining the pumping station (MPWWR, 1998). In addition to these mesqa WUAs, branch canal WUAs were to be established, which would be able to take over part of the management and maintenance of the branch canal from the government. According to newly adopted the cost-recovery principle, farmers were charged for the mesqa improvements, which were thus conceived of as a loan to be paid back to the government over time (Allam, 2004).

The mixed package of measures involving both hard (creating continuous flow, placing downstream control gates, introducing one-point lifting system, lined/piped mesqas) and soft (establishing WUAs, training farmers) elements was ultimately supposed to lead to water savings, increased irrigation efficiencies, reduction in differences in access to water between the head- and tail-end of canals and mesqas, reduction of irrigation time and costs, land savings and increase in yield (Allam et al, 2005; Aziz, 1994).

[1] The word "mesqa" is used intermittently in this thesis for both the tertiary canal as the tertiary unit that is served by it
[2] The word "improved" is used to indicate that the project was executed in a certain mesqa and is not meant to say anything about the outcomes of the project

In fact, many authors report both the successful implementation of the full package as well as (some of) the positive outcomes outlined by IIP (Allam, 2004; Allam et al, 2005; Aziz, 1994; Hassabou and El-Gafy, 2007; Kotb and Boissevain, 2012; Mohsen Aly et al., 2013; MPWWR, 1998; WMRI, 2006). Below four of these studies are described in more detail.

Allam (2004) reports improvement of the mesqa system in 196,000 feddan, the creation of 1,100 fully operating WUAs and the training of 9,000 WUA leaders. This is supposed to have led to an improvement of conveyance efficiency in the branch canal and mesqa from 70% to 98%; reduction in irrigation time of 50-60%; improved water allocation equity between the head-end and tail-end of the mesqas; 2% land savings, to be used as agricultural land; reduction of irrigation costs of 51% in winter and 57% in summer; and reduction in the pumping of drainage water by tail-end farmers.

Allam et al. (2005) reports the same benefits as Allam (2004), but stated that as much as 4000 water user associations are operational in Egypt and added that an increase in crop yield of 5-30% has been achieved since the implementation of the IIP due to increased water availability.

Aziz (1994) states the same benefits, albeit with slightly different figures, as the studies above and specifies the overall irrigation efficiency to have changed from 40% before the IIP to 70-80% after improvements. Additionally, he refers to a survey in which the percentage of farmers experiencing adequate water supply increased from 35% to 90%; he reports that no major problems were experienced with either the pipelines or the valves; and describes how water conflicts have decreased among farmers.

Kotb and Boissevain (2012) conducted a field study in 2009/2010 and confirmed the figures of 2% land savings, conveyance efficiency of 98%, reduction in irrigation time of 50-60%, 5-30% increase in crop yields and added that overall water savings of 10% in summer and 5% in winter were achieved since the implementation of the IIP. The figures from this study are exactly the same as those from Allam (2004) and Allam et al. (2005), even though said to be based on primary field research. It seems unlikely though that the data would match so perfectly, which gives reason for doubt about the scientific quality of the study (see also Box 1).

Box 1 - Different reports, same data?

The reports of especially Allam (2004), Allam et al., (2005) and Kotb and Boissevain (2012) all repeat the exact same figures. Some of these seem to go back to the 1998 report of the Ministry of Public Works and Water Resources which gave a performance assessment of the IIP and first reported land savings of 2%, conveyance efficiency of 90-95%, 50-60% reduction in irrigation time and a 50% reduction in costs (MPWWR, 1998). The remarkable resemblance of the data in the different reports gives rise to the question whether IIP results have been incredibly stable throughout time and place, or (more likely) that a “truth” is being created by repeating the same figures for the last 15 years.

The studies outlined above have focussed on large areas and were often quantitative in nature, based on measurements and/or farmer questionnaires. Furthermore, many studies were done in the same branch canals, while others were largely ignored. In the Wasat command area in Kafr el Sheikh Governorate for instance, the Daqalt branch canal has been studied extensively (see El-Agha et al., 2012; NWRC, 2003; Kotb and Boissevain, 2012; Mohsen Aly et al., 2013; WMRI, 2006).

Apart from these rather uniform (in message, approach and area) studies, there are also some authors who paint a different picture. They describe the absence of continuous flow (NWRC, 2003), a lack of farmer participation and lack of proper WUAs (APP, 2007) and the presence of (unplanned) technical changes made by farmers to the IIP infrastructure to augment water supply (Dutta, 2013). This raises questions about what is actually happening in the areas where IIP is implemented.

A final critique on most studies done so far on the implementation and outcomes of IIP is that they have a very linear perception of IIP interventions, consisting of neat successive steps of design, implementation, outcomes and evaluation. Hence they ignore that local actors will continue to reshape the system long after the project is considered complete by outsiders, and that they will do so in ways which might conflict with the project's initial intentions (Long and Van der Ploeg, 1989).

In summary, IIP is a project which aims to intensively change irrigation and water management practices in the Nile delta. Reports so far have been mainly positive, but these have also been contested by others. What is certain is that most studies are based on a solely quantitative approach, often focussing on the same areas and ignoring the agency of local actors to continue to shape the system and its outcomes after the official implementation of the project has been concluded. This has resulted in a limited and partial understanding of how IIP has actually influenced water use practices and how local actors have continued to reshape the intervention.

This thesis aims to address the above mentioned lacuna by applying a case study approach in the little studied Abo Moustafa canal in the Kafr el Sheikh governorate. It focusses on two specific mesqas and uses the concepts of re-ordering (Law, 1994) and appropriation (Mackay and Gillespie, 1992) to study the interactions between the newly placed technology, the proposed IIP institutional structure and the water users in these tertiary units. Eventually it answers the question how re-ordering at canal, mesqa and field level during and after the implementation of IIP, influenced the performance of the collective of technical and social elements in two mesqas in the Abo Moustafa canal command area.

The aforementioned concepts are further described in chapter 2, followed by the research questions (chapter 3) methodology (chapter 4). After this, four empirical chapters describe and analyse the situation in Abo Moustafa canal, and especially in the two case study mesqas. The thesis ends with a conclusion and discussion of results.

2. Concepts and theories

The analysis, but also the methodology, of this thesis is based on concepts inspired by actor network theory and on the idea of technology appropriation.

2.1.Ordering in a water network

From actor network theory it borrows the conceptualisation of any system as being comprised of human and non-human actors, forming a network. In this network, the relations between different actors are both shaped by and constitutive of them. In other words, actors can actively influence relations in the network and their form depends on those same relations in a recursive shape. (Law, 1994)

For this study, a specific kind of network is studied: a water-network (Bolding, 2004). It is a network revolving around water use and includes material objects, institutions, technologies, skills, procedures and humans. These elements are related to each other in a particular order, which is not rigid but instead constantly changing. This (re-) ordering takes place according to certain 'logics' called" modes of ordering", much comparable to a mini-version of the discourses of Foucault (Law, 1994; Law, 2008), which can be seen as the principles according to which a network is structured. In this Egyptian case for instance, the government's intervention attempts to re-order water management in line with ideas of modernisation and the formal collective organisation of farmers, while farmers try to reshape relations to in line with notions of independence and flexibility.

A government intervention like the IIP causes a major shift in the water-network's actors and represents a rather abrupt re-ordering of that same network. However, some relations and some actors in a network are more durable than others according to Law (2008), implying that some ensembles or collectives are thus less easily changed. First of all, Law states that once social arrangements are materialised in physical structures they tend to remain more durable than when they only depend on human interaction. Secondly, he adds that deliberate strategies to reinforce the relations in a network can indeed make it sturdier. Think for instance of attempts of development projects to change not only the physical, but also the institutional set-up in a project area, in an attempt to increase the chance of achieving desired outcomes. Thirdly and lastly, Law emphasises discursive stability, which refers to the modes of ordering which persist over time and might reinforce the current order.

Apart from its modes of ordering, a water-network's dimensions can be expressed in terms of span, durability, outcomes and employed expertise. The span of the water network is the coverage it has and the actors which are included in it. As stated before, these actors can be irrigation technology, but also fields, water users and management institutions. The durability of a network depends on how well it deals with the behaviour of water: Can it capture sufficient? Can it deal with droughts and floods? The outcomes as produced by the network can be assessed in different areas, depending on the interests of the researcher. This study looks specifically at outcomes in terms of water users' performance around daily management (operation and maintenance, fee collection, water scheduling) and decision-making processes in the two mesqas. The expertise dimension of a network entails the kind of knowledge which is mobilised to construct and maintain it (Bolding, 2004).

2.2.Appropriation

The concept of technology appropriation as described by Mackay and Gillespie (1992) can be seen as a constitutive part of the re-ordering process. It places an emphasis on how technologies are actively changed by their users, emphasising that the process of social shaping of technology does not end with its initial design and production. Users will appropriate the technology or, in other words, adapt it to fit their needs. Through changing the use or the properties of a technology, users re-order the relations between (the heterogeneous mix of) actors and thereby change the network. Mackay and Gillespie refer to the open or closed nature of a technology to indicate how easy it is to appropriate it. They recognise that the design of a technology makes certain things possible, while excluding others. However, within those limits there is a certain freedom for different forms of use. A water pump for instance, seems a fairly closed technology: it pumps, and that is all it does. However, changing whát it pumps is also a form of appropriation. In other words, if the pump is used to lift drainage water instead of canal water it is a form of appropriation, and by establishing new relations between actors, also a form of re-ordering the network.

In general, water networks are very open systems in which there is plenty of room for appropriation and re-ordering, as has become apparent from many case descriptions from all over the world. Whether there is such a thing as a "steady state" in a water network can be highly questioned, even though engineering projects often aim for it. These attempts to control the fluid nature of water are most likely the very source of the re-ordering that takes place by water users after almost every intervention.

3. Research questions

MRQ: How did re-ordering at canal, mesqa and field level during and after the implementation of IIP, influence the performance of the collective of technical and social elements in two mesqas in the Abo Moustafa canal command area?

SRQ1: What are the main attempts that have been undertaken to re-order water use by mesqas along the Abo Moustafa canal over the last 50 years?
SRQ2: How do the water management practices at canal level in the Abo Moustafa canal compare to the ones prescribed by the newly 'imposed' IIP order?
SRQ3: How did two mesqas in the mid-section of the Abo Moustafa canal re-order, appropriate and transform the social and technical elements of the imposed IIP order?
SRQ4: How do farmers mitigate the outcomes of the mesqa-order by re-ordering the social and technical elements in the water-network?

4. Methodology

To answer the research questions outlined above I conducted field research in the Nile delta of Egypt from June to August 2013. In this chapter, I will describe and explain my methods and choices during both the field work and the analysis of data afterwards.

4.1.Research set-up and methods

The research took place at different levels (canal level, mesqa level and field level) and focussed on different elements. I used a combination of observations, interviews, participatory mapping, GPS mapping and EC measurements to gain insight in water management at those different levels. I conducted the research together with a female Egyptian agricultural engineer, who also acted as a translator.

The initial phase of the research consisted of taking questionnaires along the Abo Moustafa canal. This canal was selected with the help of my supervisors at the International Water Management Institute (IWMI), the organisation which commissioned this research. It was chosen it had not been studied much before and because it was known that there were issues around IIP and water availability. 21 questionnaires were conducted at different improved mesqas along Abo Moustafa canal, making sure to include a variety of pumping stations (with electricity, without electricity, functioning, not functioning) spread over the entire canal. For each mesqa one questionnaire was conducted, asking questions around the following themes: basic information of the mesqa, technical implementation of IIP, organisational changes caused by IIP and the effects of interventions. The selection of respondents for the questionnaire was based on their availability in the mesqa, and especially around the pumping station. The data from these questionnaires were used for the selection of the mesqa case studies and to contribute to creating an overall image of the Abo Moustafa canal (as presented in chapter 5 and 6).

Based on these questionnaires, two case studies were selected. In selecting these, it was important that the mesqas had a water user association, that they had gone through some technical changes since the implementation of IIP and that they were larger than 50 feddan[3]. These elements were taken as indicators that it would be possible to study collective action and re-ordering. Finally the willingness of farmers to co-operate in the research was of crucial importance.

After two mesqas in the mid-section of the Abo Moustafa canal had been chosen, we started out by asking farmers for the responsible people for the IIP pumping station and interviewing those. This led us to interview the key figures in the mesqa, including the operator, the treasurer and different WUA members. After this, we went daily to both mesqas to observe water management practices and interview farmers who were present in the mesqa. We used a GPS device to map the location of the valves, the mesqa and individually owned pumps and create a google earth image. Through participatory mapping and field observations we then created a map including farm boundaries, crops and land owners. In total we visited PS33 19 times and PS31 18 times, with the visiting time varying from 1 to 5 hours. During these visits we talked to farmers and observed water management practices. During the last weeks of our research, we took EC measurements in the different drains and in the Abo Moustafa canal. We also did semi-structured interviews with the BC-WUA president

[3] One feddan equals 0.42 hectares

and treasurer, the irrigation director of Eastern Kafr el Sheikh and the district engineer responsible for Abo Moustafa canal.

4.2.Data analysis

This thesis is the result of combining the different sorts of data and moulding them into one rather consistent story. However, this does not mean that interviewees always agreed with each other or that everything was clear-cut. Reality is always messy, and in this thesis I have ordered the data to tell a slightly less messy story. In this I am actively re-ordering reality. I am aware of this fact, yet could not escape it. In case of disagreeing interviews, I have chosen to include the narratives of some, while excluding others. This choice was based on how narratives compared to other data (such as observations done in the field), but also largely to intuition.

When necessary, I have referred to the interviews through footnotes stating who I interviewed, where and when. The names of interviewees have been replaced with fictitious ones to protect their privacy.

5. Re-ordering of water abstraction in recent times

This chapter functions as an introduction to the Abo Moustafa canal and the different attempts that have been undertaken by both state interventions and farmers to re-order water abstraction during the last 50 years. It argues that where the re-ordering attempts of farmers have been aimed at gaining more independence, flexibility and, ultimately, water security, the government has tried to reverse this in an attempt to gain more influence over water use along the Abo Moustafa canal. Attention is paid to the process of introducing IIP and the corresponding creation of the collective pumping station and water user association. With each new order different aspects were introduced, seemingly having nothing to do with previous orders. However, other elements of the collective seem to have been sustained over the years, regardless of re-ordering attempts. The last section of this chapter tries to identify those persistent elements.

5.1.Re-ordering attempts: saqia, individually owned pumps, IIP

Traditionally the saqia (water wheel) was used for lifting water from the canals below field level, a technology already introduced in Egypt around 323-30 BC (Chesworth, 1994). While in the mesqas that formed the main case studies of this research the saqias were all completely removed, they could still be seen in other mesqas along Abo Moustafa canal (Figure 2).

Figure 2 - Abandoned and covered saqia next to an IIP valve; the pumping station has taken over the former water-lifting role of the water wheel

One of these saqias would be placed at the head of a group of fields where it would lift water from the mesqa. The water was then divided through a rotational system containing about three to five feddan and several farmers. The location of the saqias in the study area can be seen in Figure 3 and Figure 4. The circles represent the saqias, the white line around which they are placed indicates the old open mesqa. Blue lines indicate the Abo Moustafa canal and the drains surrounding the mesqa.

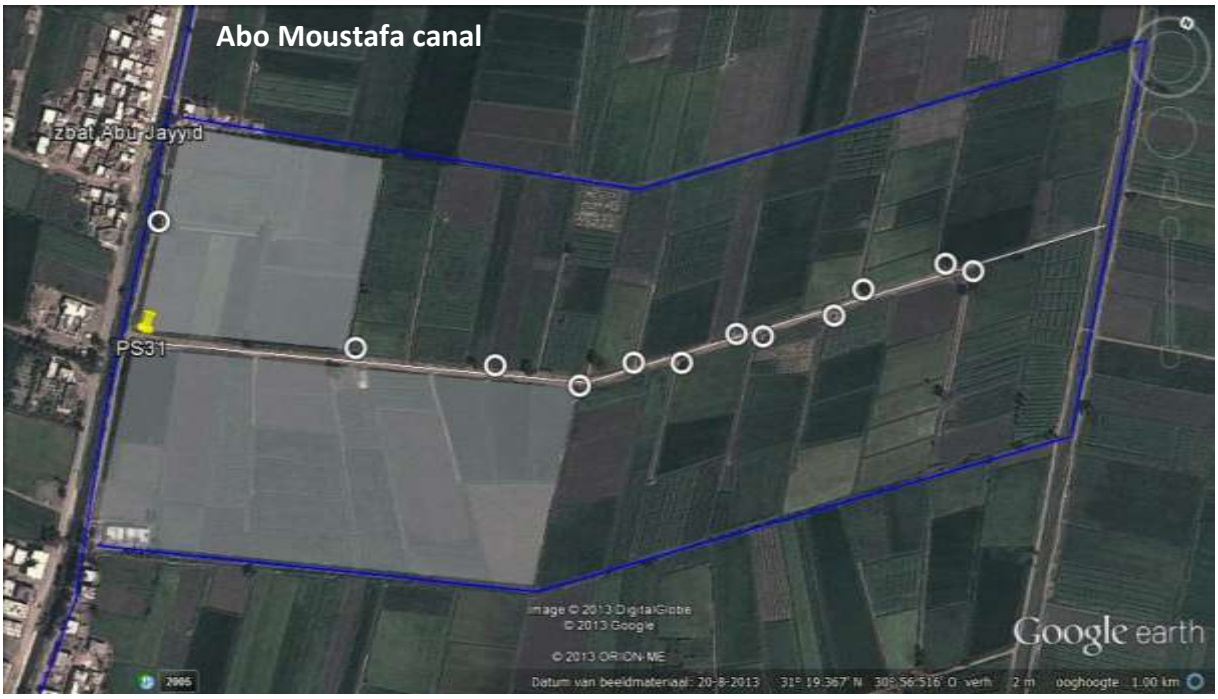


Figure 3 - Saqias in PS31

The location of the saqias on the mesqa of pumping station 31 (PS31) is somewhat remarkable because the head end plots did not have their saqia on this mesqa (indicated by the white shading), but directly on the canal or on a mesqa on the other side (parallel to the now still existing drain).

The other mesqa had a more straight-forward lay-out, as can be seen in Figure 4.

Figure 4 - Saqias in PS33

Farmers owned, operated and managed the saqias and the mesqa, as ordained by the 1960s and 1984 irrigation and drainage laws (Aziz, 1994). Saqias were originally powered by cattle, but these were slowly replaced by diesel engines. Eventually, farmers replaced the saqias with individually owned pumps. The introduction of the individually owned diesel pumps put an end to the sharing of water altogether, as each farmer would use his pump to lift water directly from the mesqa onto his

field. The canal would still have to be cleaned every now and then, which was organised by the older, more influential people in the mesqa. While farmers could not recall exact dates for the replacement of saqias by individually owned pumps, a farmer in his thirties did claim to have seen the saqias as a little boy. This would mean that the change to individually owned pumps in the Abo Moustafa canal took place in the eighties, an estimate which is supported by Barnes' (2012) statements on the introduction of diesel pumps in Egypt.

Over the years, irrigation required less labour and less collective action and coordination between farmers. Farmers were said to be completely free in turning their individual pump either on or off, resulting in a head and tail difference in water distribution along both the mesqa and the canal.

Scholars and the government blamed farmers for over-irrigating and wasting water (chapter 1). At the same time, the costs of maintaining the widespread Egyptian irrigation system were rising. The biggest recent attempt to re-order the social and technical order of Egyptian mesqas started: the Irrigation Improvement Project.

5.2.Implementing IIP: boundaries, design and WUA creation

IIP came to the farmers with two main components: a technical and a social one. They would receive a pumping station, connected to a piped mesqa and valves to deliver the water to the fields. "Receiving" is a word that was frequently used by interviewees, but in fact farmers were supposed to pay for the intervention themselves through an addition to their taxes. In both case study mesqas, this payment was yet to be implemented, even though the pumping stations were constructed about ten years ago[4]. Hence so far, farmers along the Abo Moustafa canal have not been forced to repay the investment in the pumping stations.

Next to this, connected to the ideas of participation and irrigation management transfer, a water user association (WUA) was to be created for each pumping station by following a five step program. The first phase consisted out of building a relationship between the water users and the Irrigation Advisory Service (IAS) and identifying initial problems. After this, during the second phase, an introduction to IIP and its benefits followed. At the same time, the idea of a WUA was introduced and WUA leaders were elected. In the next phase, these WUA leaders would help in creating the custom design for the WUA. This design was then implemented (step 4) and the improved mesqa turned over to the WUA. In the final phase WUA members received training on operation, maintenance and financing and developed rules for water use in the mesqa. In each phase there was also room for evaluation and monitoring, to make sure the WUA was properly established (Aziz, 1994).

The processes described by farmers in the two individual case study mesqas seem to be similar, yet have little to do with the procedures outlined above. Both mesqas do have the mandatory WUA, consisting out of five men, but in neither an election seems to have been the foundation of this organisation. This is perhaps also a good moment to clarify that a WUA along Abo Moustafa has little to do with the democratic water governing body described for instance by Hassabou and El-Gafy (2007). Hassabou and El-Gafy describe how all farmers in a mesqa are members of the WUA and that these attend meetings, after which decisions are taken by the elected WUA board, following democratic principles and taking into account the interests of all. The case study WUAs do have

[4] Interview farmers PS31, 17-07-2013; Interview farmers PS33, 25-06-2013

members, but these members are only those who are in the board. Other farmers do not consider themselves to be a member of the WUA. There is no democratic representation, there are no meetings and no records are kept. It is certain that no elections have been held since the initial creation of the WUAs, and farmers do not even find this something to consider. Several members of the initial WUA have in fact died and have not been replaced. This does not necessarily mean that decision-making processes in the mesqa are not democratic or that there is no management of the pumping station. It mostly indicates that these things do not happen through the IIP WUA.

It seems that the IAS steps were not followed in these mesqas, as farmers do not mention the agency, only the construction company tasked with implementing IIP. This company had as sole objective with regard to the soft component (WUA) to come back to the IAS with five signatures of the alleged board members of the WUA. As a result, farmers were asked to sign a list to agree to the project. If they refused to sign, others would be approached. The farmers who signed were told to be the official members of the water user association. The signatures should have been of elected farmer representatives, but instead the ones who signed were appointed to be these representatives. It seems that larger land owners or otherwise influential men were favoured by the engineers, but not exclusively so. It is likely that the selection of WUA board members was partially influenced by coincidence and by farmers' availability and willingness to sign at the time of collecting signatures. Some of the currently most influential figures in the mesqa are no members of the WUA board, while some selected WUA board members do not play a central role in the local power arena. In PS31 for instance, one of the two remaining members (two are dead, one moved away) is now still respected and influential in appointing operators and treasurers, while the other is said to know nothing and be a problematic man[5]. In PS33 most WUA members are mentioned as honest men to be consulted before any changes to the pumping station can be made. Emphasis is put on the fact that this is because they are "honest" men representing different families, not because they are WUA members. One member was not mentioned in this list and one non-member was[6]. The "honesty" (AR: *amana*) of these men is not only linked to them not lying or stealing, but includes a notion of piety and following the rules of God.

Unlike stated in the 5-step plan, the WUA did not exert any influence on the design of the pumping station. The engineers designed the system and constructed it, without further consultation or negotiation. Something remarkable happened though: valves were installed in the places where the saqias had previously been. Especially in PS31 this is easy to observe as the first fields, which were historically served by different mesqas, are now also not served by the pumping station. Why and how this happened did not become clear during this research, but the old collective of fields and families has been reproduced or reconfirmed by the IIP design. It is imaginable that the IIP engineers were guided by the visible remnants of the saqia era, which left an imprint on the landscape in the shape of open places, often surrounded by trees, where the cattle used to tread.

The fact that the collective remained largely unchanged possibly had a positive effect on the level of collective action and water sharing – as it is known from other IIP areas that the merging of groups of farmers from previously separate mesqas resulted in conflicts over water (Dutta, 2013).

[5] Interview Karim PS31, 14-08-2013
[6] Interview two farmers in PS33, 13-7-2013

5.3. Changes and patterns in the technical and social order

Looking back at the recent history of these mesqas, there are some patterns and some changes that stand out. Technical changes are easily observed and described, and seem to be invasive: technology went from cattle-driven to engine-driven, open mesqa canals below field level were replaced by low pressure piped systems and many individually owned pumps were replaced by one communal one. However, the lay-out of the mesqa and the location of the technology have remained surprisingly unchanged. The intake, the mesqa canal and the off-takes to the fields (first saqias, now valves) are still in the same spot. The former system can be easily detected on aerial photos; with the open mesqa covered, but not used for cultivation. The geographical boundaries of the mesqa have remained the identical over time. This also has had an impact on the social order: the same families that were once united by an open mesqa are now united in and tied to a pumping station. The level of collective action was augmented, especially compared to the time of the individually owned pumps, and water management was formalised in a WUA, but it was done by enrolling the same human actors. The rotation scheduled used in times of the saqias is now used again for the valves – since the location and area served by each outlet has remained the same.

5.4.Concluding remarks

This chapter shows that the order within the water network(s) in Abo Moustafa changed over time and that while some relations stay the same, others change. The IIP was the biggest intervention in water management in the Abo Moustafa canal in recent history, but its implementation did not exactly happen as described in the original plan. This has given shape to a whole new process of re-ordering, as water users and local water managers had little influence on the way IIP restructured water use. Where the network of water users was based on individuality and freedom, the one of IIP was based on collectivity and control over water abstraction. Ever since the start of IIP water users have been re-ordering and in the process re-shaping both technical and social aspects at canal, mesqa and field level. These attempts at trying to make IIP work, are described in the next chapters.

6. Practices at canal level – Abo Moustafa canal

When visiting Abo Moustafa canal and talking to the farmers, it becomes clear quickly that the outcomes described in the reports mentioned in chapter 1 are in fact questionable. This chapter is structured along some key observations disputing claims around continuous flow, state of the pumping stations, use of waste water, use of individually owned pumps and the functioning of the branch canal water user association. Its aim is to show in both imagery and descriptions, how the water use situation at canal level is much less clear-cut and much more varied than portrayed in most official reports.

6.1. Observation 1: canal levels are frequently low

Water levels in Abo Moustafa canal in June, July and August were often low (Figure 5).

Figure 5 - Low water levels in the Abo Moustafa canal, indicating a rotational system (6/6/2013; 12/6/2013; 16/6/2013)

This is in direct contradiction with the claim that continuous flow is implemented in the IIP areas. In reality, there is a rotational system in which water is shared between two canals: Abo Moustafa and Elmelaha (Figure 6). The canal of Dail Elkased does have water continuously, largely because it is used to supply a drinking water station[7]. One could thus say that there is a continuous flow maintained from the main canal of Meet Yazid until the point where Dail Elkased branches into Abo Moustafa and Elmelaha. Farmers describe the rotation as 4 or 5 days of water and 4 or 5 days without water[8]. During field visits however, it became clear that in reality the schedule is much more erratic. There were times when there was water in the canal for 8 days straight, but also prolonged periods without water. This led to a high sense of water insecurity among farmers: "*we never really know whether and when the water will reach us*"[9].The irrigation director of the irrigation district of Eastern Kafr el Sheikh explained that the rotation is not as much based on a fixed amount of days, but rather on water reaching a certain point. The entire canal is 14.1 km long[10] and when the water has reached somewhere around the 10th km, the gates to Abo Moustafa are closed by an operator appointed by

Figure 6 - Canal system from Meet Yazid to Abo Moustafa

[7] Interview irrigation director of Eastern Kafr el Sheikh, 29-07-2013
[8] Interview farmer Ezbet ar Rasif, 11-06-2013; Interview farmer PS31, 12-06-2013
[9] Interview farmer PS33, 20-07-2013
[10] Based on measurements in Google Earth

the irrigation district. This means that fresh water almost never reaches the end of the canal during the dry season[11]. It is the irrigation director who decides on setting the limit at km 10 or elsewhere, and it seems rather arbitrary. The time it takes for the water to travel to the 10th km depends on the amount of water used upstream, the water level in the Dail Elkased and the opening of the gates. This results in the varying on- and off-periods with daily changing water levels and low transparency.

These on- and off-periods also vary along the canal: where there might be water at the head end, there is no water in the mid-section. On the same day the middle picture in Figure 5 was taken near the end of the canal, 4 km upstream things looked quite different (Figure 7).

Figure 7 - Abo Moustafa canal at km 8 (12/6/2013)

The high variability in water levels and the resulting high water insecurity are a source of conflict and cooperation at mesqa level, as will be discussed in chapter **Error! Reference source not found.**. ithin one day or one rotation, water might be enough for some, but not for others. The way this is dealt with differs per mesqa and per farmer, as illustrated in this chapter and following chapters.

One issue that farmers from different parts of the canal seem to agree about however, is the uselessness and water obstructing nature of the IIP AVIS-gate. This downstream control structure at km 5 should respond to low water levels by increasing the inflow, but water levels are often so low that the sill alone actually blocks the water (Figure 8). In fact, the structure does not function at all as it is supposed to, even though the side gate seems to be operated at times.

Figure 8 - AVIS gate in Abo Moustafa canal blocking water at low levels (6/6/2013)

[11] Interview Irrigation Director of Eastern Kafr el Sheik, 29-07-2013

The structure itself entraps the trash floating in the water, resulting in further obstruction and blockage of water. Its regulatory function is non-existent in the current rotational system, which is not only recognised by farmers, but also by the district engineer[12]. On May 30th 2013, a group of farmers from different mesqas went to the district engineer to complain about the AVIS gate in Abo Moustafa canal[13]. On the way there, they met with an IWMI research team and told about their wish to have the structure removed (Figure 9).

Figure 9 - Farmers from Abo Moustafa canal inspecting the AVIS structure and sharing their stories with IWMI research team (source: E. Rap, 30-05-2013)

This district engineer explained ten days later that even though he knows farmers are not happy with the gate and that it is no longer useful, he cannot remove it: he would need permission from the departments of irrigation and drainage and the Irrigation Improvement Project. He put it clearly: "*It is not possible to remove it, because it was put there by the project*"[14]. This does not mean that complaints of farmers are totally ineffective, because by the end of August the district engineer had arranged to have a concrete pipe constructed alongside the AVIS gate to bypass the structure and allow more water to flow downstream (Figure 10).

Figure 10 - Newly constructed pipeline past the AVIS gate in Abo Moustafa canal (3/8/2013)

[12] Interview district engineer, Kafr el Sheikh, 10/06/2013
[13] E. Rap, p.c., 2013; Interview farmer PS33, 20/07/2013; Interview Youssef PS33, 24/06/2013
[14] Interview district engineer, Kafr el Sheikh, 10/06/2013

Some of the farmers who initially went to protest against the AVIS gate and have their fields about 3.5 km after the structure, stated that the bypass was not enough to increase their water availability. They felt that the pipe benefitted maybe 20 feddan right after the gate, but not much more than that[15].

This struggle between the farmers and the district engineer illustrates the remarkable dichotomy that exists around IIP: on the one hand it is clear to those directly involved that the outcomes of the project are not as expected, but on the other hand this cannot be confirmed to higher government levels by doing something as permanent as removing the IIP structure. Instead, both farmers and engineers find ways to work around the system, upholding a sense of success for the outside world. The branch canal and mesqa water user associations are other examples of such a performance of success in the face of failure, as will be described later in this thesis.

6.2.Observation 2: a wide diversity in the adaptation of pump stations

The way IIP materialised itself seems to have had a fairly uniform face along Abo Moustafa canal initially: a pumping station with barred windows, two diesel pumps inside, a tower outside and mostly piped mesqas with valves. Now however, the variety in pumping stations and their state of operation is quite large. Some pumping stations have been deserted, some have been broken down, some have been equipped with new pumps, some pumps were stolen or sold, some have additional electricity connections and some work according to plan. Towers have been heightened to increase pressure in the pipes, new intakes have been constructed and in some places the tower and pipe are no longer connected to the pumping station, but water instead flows in an open canal. A variety of pumping stations as found along Abo Moustafa is depicted in Figure 11.

Figure 11 - Variety of IIP pumping stations along Abo Moustafa. They differ in operational status, engine type, power source and tower

In general, it seems that farmers are increasing the capacity of their pump station by either installing different diesel pumps or electric pumps. In most cases this was done collectively by raising money among farmers of the mesqa. In one case part of the farmers

[15] Interview farmers PS33, 30-07-2013

could not pay their share in the new pump after the old ones got stolen. This resulted in the exclusion of more than half of the farmers in the mesqa, especially smaller farmers and sharecroppers[16].

Farmers feel it is necessary to increase the capacity of their pumps because the time that water is available at their mesqa intake has been reduced compared to what was initially promised by the project. Pump stations in the head-end of the canal seem to be functioning more in line with their design than those in more water scarce areas in the mid- and tail-section. The latter sections are where you find most changes and most deserted pumping station. The branch canal WUA president estimated that 90% of the pump stations changed something in their technical set-up since instalment about 10-12 years ago[17].

Unused pumping stations, now empty, used for storage or destroyed, were left because pumps were never delivered, pumps were stolen or water supply was simply insufficient for the pumping station to be useful (this last reason was mostly found in the tail of one of the sub-branches of Abo Moustafa, where farmers relied almost solely on drainage water for irrigation). Often the pumping station is replaced by individually owned pumps, pumping either directly from the canal or drain, or from a newly constructed canal situated below field level. This last situation was found in one special case, where farmers specifically said they changed their system to avoid the collective management of the pumping station and regain their independence through individually operated pumps tapping water from the newly constructed canal[18].

At the time of research, there were both diesel shortages and frequent electricity cuts (which are not quantifiable from this research), which was given as a reason for diversifying energy sources by some of the interviewed farmers. Those using electric pumps say it is cheaper, those using diesel say they are afraid of the electricity cuts on top of the irregular water supply; having one of each could be seen as a way of spreading of risks.

The irrigation district is aware of the changes made by farmers, which it says are not allowed, but is as of yet not intervening[19]. At canal level, downstream farmers do not blame upstream farmers for putting in more powerful pumps and thereby worsening the downstream water availability. They see this as a logical development and would do the same if they would have had the opportunity. It is perceived as equitable that all try to maximise their own water intake.

6.3. Observation 3: drain water re-use by government, collective and private pumps

While drain water use was meant to be reduced after the implementation of the IIP there are several forms of re-use that can be observed along the Abo Moustafa canal. One of the most obvious sources of re-use is the big pumping station at the end of the Abo Moustafa canal, pumping back water from drain number 7 (Figure 12). This pumping station was put there by the government to mix the water of Abo

Figure 12 - Government water re-use station at the end of Abo Moustafa canal (6/6/2013)

[16] Interview sharecropping farmer at km 5, 11-06-2013
[17] Interview BC-WUA president Abo Moustafa canal, Ezbet Bakr, 03-08-2013
[18] Interview farmers at km 8.5, 24-06-213
[19] Interview irrigation director of Eastern Kafr el Sheikh, 29-07-2013

Moustafa canal with the drain water, thereby making more water available to farmers at still an acceptable water quality. In the summer however, the two types of water hardly mix as the canal water almost never reaches the end of the canal. The end of the canal thus irrigates almost solely with drain water during the rice season.

The inflow of water from the back of the canal creates an interesting situation: the classical head-tail gradient along the canal has changed into a situation in which not the end, but the middle section of the canal actually receives the least water. This situation is mirrored at mesqa level, where farmers use the drains around the tertiary unit to irrigate their land. Being at the tail end at these times of increased water insecurity and scarcity has become an advantage, as the access to drain water is more reliable. Where the head-end is using canal water and the tail-end drain water, the mid-section is the new loser in terms of water quantity and reliability of supply.

However, drain water is said to be of inferior quality and irrigating with it would cause damage to the crops. EC-measurements taken in the medium and small drains in the mid-section of the canal show that water quality is fairly good the first few days of the "off"-period after which it deteriorates (see also chapter 8). The quality of the water should be taken into account when assigning a status of "winners" or "losers" to farmers in any location, if one wishes to do so.

In some mesqas, the use of drain water is purely individual: farmers use privately owned pumps on the drain when it suits them and pay for the costs themselves. In other mesqas, drain water use displays a more collective nature. In several cases, farmers were seen to have constructed a system in which a collectively owned and run pump pumped drainage water into the mesqa pipe, after which the IIP structures conveyed the water to the land according to a fixed schedule. In one instance, the pump used was even a diesel pump from the IIP pumping station (Figure 14). As one of the farmers cleverly remarked: "*we are not allowed to use individually owned pumps, but this is not an individually owned pump, it's communal*"[20]. At another mesqa, the pumping station was hardly used anymore, but farmers attached two collective diesel pumps to drain number 7 which pumped water into the mesqa pipe continuously[21] (Figure 13).

Figure 15 - Individually owned pump pumping water from a small drain onto a rice field (30/7/2013)

Figure 14 - An IIP diesel pump attached to the mesqa to pump drain water into the system (24/6/2013)

Figure 13 – Two newly bought diesel pumps attached to drain number 7 pumping water into the piped mesqa (16/6/2013)

[20] Interview farmers at km 1.8, 18-06-2013

[21] Interview farmers at the end of Mukhezin canal, a branch of Abo Moustafa canal, 16-06-2013

6.4. Observation 4: individually owned pumps pump straight from the canal

In the previous section it was already mentioned how private pumps are used to take water from the drain, while it is formally not allowed to use individually owned pumps besides the IIP pumping station. However, at many different places one can find clusters of private pumps lifting water directly from the Abo Moustafa canal (Figure 16). Especially on the eastern side of the canal, where there is no paved road between the canal and the fields, there are many farmers who use their own pumps as supplement to the pumping station or as sole source of irrigation water. At times, the pumps are only used for the field directly next to the canal, in other places surface canals lead further into the mesqa. Who has access to the canal through a privately owned pump seems to differ per mesqa and where some use the IIP intake of the pumping station, others seem to have private intakes.

Figure 16 - Clusters of individually owned pumps along Abo Moustafa canal (13/6/2013; 6/6/2013; 9/6/2913)

The use of private pumps is valued for two main reasons. First of all, they provide a level of independence to the user which is not there when one is part of the collectively owned and operated pumping station. Secondly, the intake (either a hose directly from the canal or a separate intake) is often lower than the IIP intake. This means that water can be accessed at lower levels. Apart from the lack of continuous flow, the height of the intake of the IIP pumping stations is one of the things the farmers often complain about when referring to the IIP project as a failure[22]. They feel the intakes are situated too high and they try to lower them when the funds are available. Apart from the instalment of more powerful pumps, this is the most popular alteration of the pumping stations.

Both the independence and the lower intake ultimately increase water security, as the private pump can be turned on and used whenever there is water and the lower intake makes the pump function with less water in the canal. The disadvantages of this switch to private operations, mostly higher operation and maintenance costs, were never mentioned by interviewed farmers. As most farmers still own a pump from before the implementation of IIP, the initial investment costs are low.

[22] Interview farmer at km 0.7, 10-06-2013; Interview farmer at km 5.6, 11-06-2013

6.5.Observation 5: Influence of BC-WUA is questionable

Not easy to capture in pictures, but supposedly the most important farmer managed institution at canal level is the branch canal water user association (BC-WUA). Supposedly aiding in mitigating conflict at canal level and taking care of cleaning the canal, the BC-WUA of Abo Moustafa was found to play no such roles. One tell-tale sign is that it took more than one month of research to locate the BC-WUA by accidentally running in to one of its members. Initially interviewed farmers had claimed no such thing existed and that there was no organisation in the canal. As one WUA member said: "*There is no such thing as a BC-WUA. The branch canal is managed by the government and the irrigation engineer*"[23]. In the same fashion, none of the interviewed irrigation engineers or members of the agricultural cooperative indicated the existence of the BC-WUA[24]. The irrigation director did state that he would "*talk to some guy at the end of the canal*"[25] to hear about water levels. This "guy" turned out to be the BC-WUA president. The BC-WUA does not seem have any funds or power to influence things at canal level. It claims to listen to the complaints and wishes of the farmers and convey these to the irrigation engineers. The BC-WUA was started by the ministry of irrigation and has a formal structure: one president, one secretary, one treasurer and 10 members. There are two female board members, as demanded by law, who are tasked with raising awareness about pollution of the canal through garbage deposition. The members are elected, but as stated earlier, most interviewed farmers did not know about the BC-WUA, let alone that they ever voted for it.

The president of the BC-WUA was a rich and influential man however and his name was recognised by farmers; not as being a member of the BC-WUA, but as being a "*good man*"[26].

In general the BC-WUA does exist physically and on paper: there is a president with an office, there are members, they attend trainings and they keep records. However, its influence in the management of the canal seems to be limited and more dependent on the character of its president than on the authority of the BC-WUA.

6.6.Concluding remarks

This chapter clearly illustrates that the outcomes of IIP are not as anticipated by the project and differ from one place along the canal to the next. It shows that both technical and institutional arrangements that were put in place by the IIP have been modified by its users. Irrigation engineers have found it impossible to supply canal water continuously to both Elmelaha and Abo Moustafa, and have thus resorted to a rotational system and the re-use of drainage water in the tail-end of the canal. However, there are still large differences in water availability along the canal, with especially the mid-section losing out. Water users experiencing water shortage have tried to mitigate this by increasing the capacity of their pumping station and lowering the intake or by resorting to the use of drain water, either collectively or individually. In certain cases, users have abandoned the pumping station completely and have gone back to the system of individual pumping that was there before the implementation of IIP.

[23] Interview Ahmed PS31 28-7-2013
[24] Interview engineers of the agricultural cooperative in Ezbet Ar Rasif, 05-08-2013
[25] Interview Irrigation Director of Eastern Kafr el Sheikh, 29-07-2013
[26] Interview farmer PS33, 13-08-2013

This overview at canal level gives a first introduction to how farmers have re-ordered and appropriated the technology of IIP. The next chapters look at this in more detail and also delve into the institutional re-ordering that has taken place at mesqa level.

7. Re-ordening of IIP at mesqa level

The two mesqas discussed below are located in the mid-section of the Abo Moustafa canal (Figure 17), where canal water and pumped back drainage water meet. The area is thus at the end of both flows, which makes it one of the most water scarce stretches along this canal. While both mesqas were given the typical IIP package of a pumping station, a piped mesqa, valves and a WUA, they dealt with it in different ways. Below, I tell the accounts of the two mesqas separately, after which I zoom in on the differences and similarities between the two.

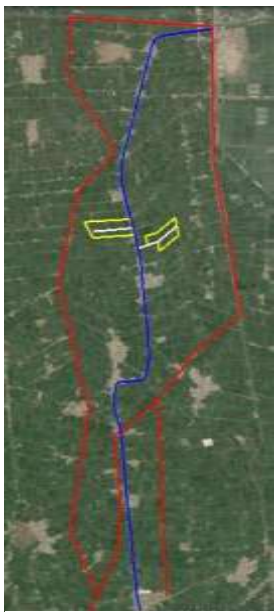


Figure 17 - Case study mesqas' locations (in yellow) along Abo Moustafa canal

7.1. PS31 – An introduction

Pumping station 31 is located on the east side of the Abo Moustafa canal and serves 52 feddan, cultivated by about 20-30 farmers. The mesqa is 850 meters long and there are 13 valves – of which 12 were designed by IIP[27] (Figure 18). The farmers comprise a mix of land owners, renters and sharecroppers[28]. The major summer crops are rice, maize, cotton and melon, with a clear preference for rice. Fields are mostly oriented parallel to the mesqa. The drains along the mesqa are small (about 1-2 meters wide with variable flow) and are both called Hosha. They drain in the larger Mukhezin drain, which also collects domestic waste water from an upstream village and always carries water.

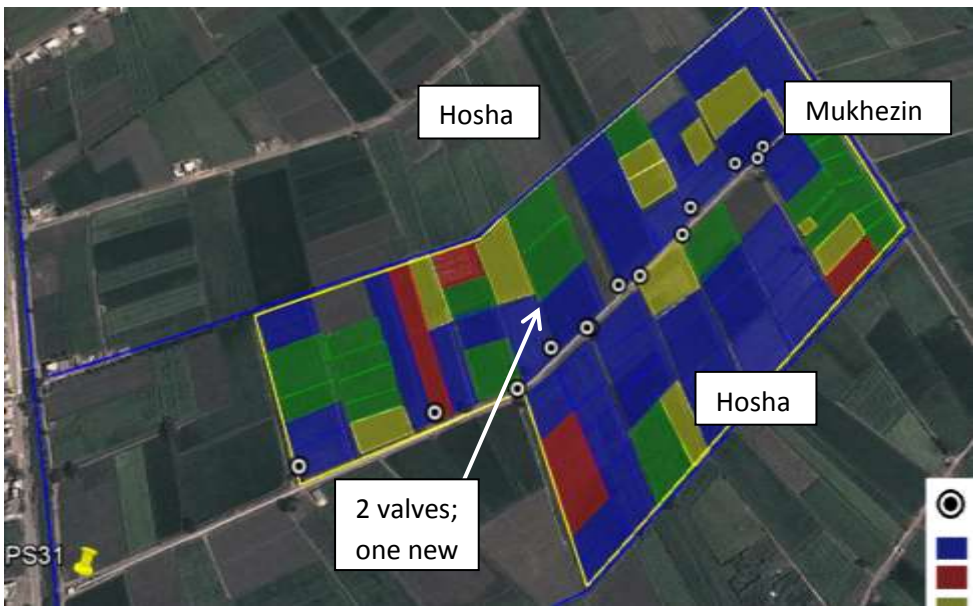


Figure 18 - Lay-out and crops of PS31 in August 2013; the uncoloured plots were not cultivated

[27] Interview farmers PS31, 05-07-2013
[28] Interview Khaled PS31, 29-06-2013

The pumping station was built around 10 years ago and a WUA was created to receive the PS, which exists until today[29]. Initially the WUA comprised five men, but with three of them dead or away, now only two men remain: Ahmed and Khaled. When asked, farmers claim that the tasks of the WUA are to operate and maintain the pumping station, to collect money and to manage conflicts among farmers[30]. In short, the WUA is the responsible authority for all management aspects of the pumping station. However, as the narrative below will show, the farmers merely repeated the official IIP story, which does not necessarily reflect their practices.

Since the implementation of the IIP, many things have changed in both the technical and the social order of the pumping station. The new technology required changes in management, but the technology itself was also altered to better accommodate the needs of the farmers. I start out below by outlining the technological interventions, followed by the social and organisational ones. I conclude by analysing who has had a leading role in which changes, and what exactly was the role of the WUA in all this.

7.2. PS31 – Re-ordering the technical order

When the pumping station was installed ten years ago, there were two diesel pumps and 12 valves. Now there is one electric pump and one diesel pump, both with larger capacities than the initially installed pumps[31]. Furthermore, as said before, one valve was added to make a new total of 13. Finally, a second, lower intake was constructed to capture water at lower levels[32]. The changes in intake and pumps were driven by a desire to pump more water from the canal; both by increasing the time water could be pumped and by increasing the volume that could be pumped in that time. Electricity is cheaper than diesel[33], but the supply is irregular. Having one diesel and one electric pump combines the benefits and risks of the two. The 13th valve was said to have been added to prevent conflict. This new valve serves only one feddan, which was given to the community after the death of a rich farmer in the area[34]. The profits of the field are donated to benefit poor people, something which is seen as so important that there should be no discussion over its irrigation turn. Therefore, farmers arranged and paid for a new valve to be constructed which would solely deliver water to this field.

These interventions clearly illustrate the two main problems farmers have with the current system: they experience a water shortage and are unhappy to be forced to take turns in using water. In PS31, the limited freedom and forced collective action is perceived as a larger problem than the water availability[35], which has been increased through the appropriation of the pumping station. However, it is clear that the two issues are reinforcing each other: if water was more plentiful, taking turns would be less of a burden.

[29] Interview Khaled PS31, 05-07-2013
[30] Interview farmer PS31, 13-07-2013; Ibrahim PS31, 12-07-2013;
[31] Interview with Omar PS31, 15-07-2013; Interview with Karim PS31, 14-08-2013
[32] Interview Karim PS31, 14-08-2013
[33] Interview Omar PS31, 15-07-2013
[34] Interview farmers PS31, 05-07-2013
[35] Interview farmer PS31, 02-08-2013; interview Karim PS31, 14-08-2013

When asked about IIP, the first thing most farmers say is that the project is a failure[36]. Plans are even made to take out all the IIP infrastructure, sell it and construct a new system[37]. This would mirror the approach of a neighbouring mesqa, where farmers already took these steps (Box 2).

Box 2 – PS32: From a collectively run IIP pumping station to a system based on individuality

Downstream of PS31 there is another intake, including a brand new trash rack. At first glance however, there is no pumping station in sight. Until you look at the ground, you see the remains of a structure and asks for clarification from farmers: there used to be a pumping station, but the farmers decided to demolish it. They also took out the mesqa pipe, the aeration pipes and the valves; selling anything they could, from bricks to iron. With the money thus obtained, and an additional 1500 LE/feddan, they built a new system. This system combines the old below-field-level mesqa and individual pumps with the IIP idea of having a piped system to prevent losses. There is a large concrete, underground pipe which takes in water from the canal by gravity flow. At the location of the valves, there are now access points to the main pipe where farmers can hook up their individual pumps. Whether this intervention has resulted in a larger overall water use by this mesqa has to be studied, but it is clear that it has given independence back to farmers who can now irrigate whenever they want. However, the low position of the pipe makes it more difficult to drain the water and has even led to an inflow from the Mukhezin drain into the mesqa. A gate at the end of the pipe, closed during the off-period and open during the on-period has to prevent drainage water from flowing in and allow for flushing during the on-period.

[36] Interview farmer PS31, 21-7-2013; interview villager Ezbet ar Rasif, 29-6-2013
[37] Interview farmer PS31, 12-07-2013/13-07-2013/21-07-2013; Interview Khaled, 05-07-2013

The different collective interventions and their costs are summarised in Table 1.

Table 1 - Overview of interventions/events, including year and costs

Year	Event/intervention	Costs	Costs in USD[38]
2003	IIP – pumping station built	Not charged for to date, expected 400 LE/year[39]	58 USD/year
2003?	Valves stolen and replaced[40]	?	
2003	2 Diesel pumps break down; replaced by 2 dual-piston diesel pumps	16,000[41] - 20,000 LE[42]	2,323-2,903 USD
2009	Electric pump replaces one diesel pump	12,000[43] - 15,000 LE[44] - 27,000 LE[45]	1,742 – 2,177 – 3,920 USD
2010	Lower the intake	3,000 LE[46]	435 USD
	Total (max) per feddan, already spent	961 LE	140 USD
2013/2014 – planned	*Remove all IIP infrastructure and create a new system with a large concrete pipe and individually owned pumps*	*80,000*[47]	*11,165 USD*
	Total planned (max)	*130,000 LE*	*18,874 USD*
	Total planned (max) per feddan	*2,500 LE*	*363 USD*

Estimates of actual costs and the precise years changes were effected differ between interviewees. The valves have reportedly been stolen in 2003 – some accuse the construction company workers for this, who would need the parts for other IIP areas[48]. This kind of accusation has been levelled also at other places in the canal, where farmers suspected the construction company of stealing the pumps it previously installed[49]. The costs of the electric pump vary from 12,000 to 27,000 LE, which can probably be explained by including the costs of the electricity connection in the 27,000 LE.

Especially replacing the IIP infrastructure altogether is a big and costly intervention, but so were the other alterations to the pumping station. This raises the question where these ideas for radical change come from, who decides on this and ultimately, who pays for it.

[38] Exchange rate as it was on 26-11-2013
[39] Interview farmers PS31, 17-07-2013
[40] Interview Karim PS31, 14-08-2013
[41] Interview Omar PS31, 15-07-2013
[42] Interview Karim PS31, 14-08-2013
[43] Interview Omar PS31, 15-07-2013
[44] Interview Karim PS31, 14-08-2013
[45] Interview Khaled PS31, 29-06-2013
[46] Interview Karim PS31, 14-08-2013
[47] Interview Karim PS31, 14-08-2013
[48] Intervie Karim PS31, 14-08-2013
[49] Interview farmer tail-end of Abo Moustafa canal, 13-06-2013

Before getting into this, it makes sense to first take a closer look at how farmers have organised water management in their mesqa. I describe the operation and maintenance of the pump, the fee collection, water allocation and scheduling and finally conflict management. Thereafter, I will return to the issue of decision-making around interventions – both technical and social, as the section below will illustrate that not only the technical practices divert from the IIP design.

7.3.PS31 – Re-ordering the social order

The social order is more difficult to observe than the technical order. By describing the different water management practices in the mesqa, I try to analyse how people relate to each other and what their different positions are within the collective.

Operation and maintenance

The operation and regular maintenance of the pump officially comes down to one operator, Ibrahim, who receives a salary of 200 LE/month. He buys the diesel, turns the pumps on and off and changes the oil[50]. Ibrahim is the third one since the start of the pumping station[51] and was selected by two influential men in the mesqa: Ahmed and Omar. Ahmed is a member of the IIP WUA board and Omar collects the fees for operating the PS and functions as a treasurer. Ibrahim's connections to them are obvious: he is related to the Ahmed and rents land from the Omar[52]. However, farmers' opinions about his performance are mixed: there are accusations of him not being around and not taking care of his job[53]. In fact, it does not seem to be a respected job, as farmers indicate it is a job for people with little other income and too much time on their hands[54].

In fact, having enough time is crucial to operate the pumping station. Water levels fluctuate to such an extent that the pumps may have to be turned on and off several times during one day (including during night time). An operator thus has to be around to watch the water levels 24/7, or be reachable by other farmers to be informed about the need to turn the pumps on or off. In PS31, there were several instances when farmers were looking for Ibrahim and could not find him. The fact that he does not have a phone or refuses to carry it does not contribute to his availability[55]. Since the operator is the only one who has a key, his frequent absence this leads to frustrated farmers who cannot irrigate when it is their turn. However, it is possible for farmers to track down Ibrahim and receive the key from him, so they can operate the pumping station themselves when he refuses to come down (Box 3). This clearly shows that while the brunt of the work is done by the operator, farmers do have a role in operating the pumping station.

[50] Interview Ibrahim PS31, 12-07-2013
[51] Interview Karim PS31, 14-08-2013
[52] Interview farmers PS31, 02-08-2013
[53] Interview farmer/former operator PS31, 20-07-2013
[54] Interview farmers PS31, 02-08-2013
[55] Interview farmers PS31, 21-07-2013

Box 3 - Operating the pumping station

It is the 17th of July and a man approaches pumping station 31 and climbs in the tower, carrying a black jerry can. He starts throwing water from the bottom of the tower into the pipe leading to the electric pump, as if to drive out the air. He climbs out, enters the pumping station and pushes the button for the electric pump. He jumps on his donkey and goes to the first valve, to see whether there is water flowing. Before he reaches there, the pump stops. He comes back, and starts again. This time aided by another farmer who just arrived. The Ibrahim is nowhere to be seen.

It turns out that Ibrahim is busy taking care of his animals and does not want to come to the pumping station. The two men are supposed to have their irrigation turn now and do not want to miss it, which is why they got the key from the operator. The water is there unexpectedly, which is why they did not prepare the pumps earlier.

Operating the pumping station is not easy and involves a lot of coordination between the man in the tower and the man in the pumping station. It seems as if they know what they are doing though, indicating that it is not the first time they replace the operator.

In other pumping stations along Abo Moustafa canal, farmers bring their own diesel to the pumping station when it is their turn to irrigate[56]. In PS31 however, the operator is meant to supply enough diesel for everybody to operate. To buy it, he relies on money given to him by the treasurer of the mesqa (more on this below).

So while the job of operator in PS31 is not a well-respected one, it is a crucial position and involves trust when it comes to handling the money and being available when needed. In the past of PS31, some of the biggest problems around the pumping station have been about an unreliable operator (Box 4).

Box 4 - The first operator of PS31

Before the current operator started, there were two others. The first one was a member of the WUA and was the operator for about five years, while at the same time he also collected the money. His name is Khaled. He caused trouble in the mesqa, because he would refuse to operate the pump if people did not pay their fee. He would take the key and refuse to give it to anybody. He would argue that his family owned half the mesqa, as most people were related to him. To get him to leave, the mesqa farmers had to threaten him with being reported to the police and claimed they had found a cheaper operator. They then asked him to leave the pumping station altogether, but he refused. Before IIP, farmers never quarrelled, but the project brought these things out in people. The problems are not about the water here, but about the people.

- Story as told by Karim, an informal WUA member, 14-08-2013

[56] Interview farmer head-end Abo Moustafa canal, 10-06-2013; interview farmer mid-section Abo Moustafa canal, 11-06-2013

Fee collection

Diesel, electricity, oil and the operator himself all cost money, not to speak yet of the larger technical changes made to the pumping station. This money is collected by one man who is selected by the farmers: Omar. He is not part of the WUA and has been collecting fees for four years[57]. Before Omar, the first operator, Khaled, would do it, but people did not trust him because he would not keep any accounts. They collect a 100 LE/feddan and wait for the money to be finished[58]. Once all the money is spent, they collect the same amount again. This requires a certain level of coordination between the farmers, Omar and Ibrahim: the operator needs to inform the treasurer that he needs a certain amount of money, the treasurer needs to keep an eye on expenditures and farmers need to be informed that they have to pay again soon. This summer, it went wrong, with the diesel getting finished and the pump not working for two days. This event brought out some of the frustrations and inequalities within the mesqa: whose fault was it that there was no money and no functioning pump? (Box 5)

Box 5 - Running out of money and diesel

On the morning of August 2nd, there is some commotion in the mesqa of PS31: there is water in the canal, but the diesel pump is not running because there is no fuel. Farmers are looking for Ibrahim, but cannot find him. It is Ibrahim who needs to buy new diesel, but word goes around that the money has finished. The farmers that gather have land in the upstream part of the mesqa and explain that their valves run dry if only the electric pump is operated. The people who are responsible (Ibrahim, Ahmed and Omar) have land in the downstream part. They do not suffer when there is only one pump operating.

It is not clear what led to the current lack of money: some say that farmers are refusing to pay the fee, others say that Ibrahim is not doing his job and again others say it is Omar who prefers to sleep rather than fix their problems.

A lady shows up and begs the men to do something: she is a widow and is afraid her turn will pass before a solution is found. When the men are reluctant to collect money to buy new diesel because they fear free-riding, she exclaims: "*You are men, you do something. I am a lady, I cannot do anything*". Indeed, she does not join the group when they go to find and confront the operator; she stays waiting at her field.

After about two hours Ibrahim pitches up at the pumping station. Farmers are angry with him and blame him for his situation. He tries to defend himself, saying that it is the job of the treasurer to make sure there is enough money. One of the farmers has brought a jerry can of diesel and the pump is finally switched on.

The next day there is no water and the money is collected in time for the next on-period.

- *Based on observations and interviews in PS31 on 02-08-2013*

[57] Interview with Omar PS31, 15-07-2013
[58] Interview with farmer PS31, 13-07-2013

The person who is farming the land, is responsible for paying the regular operation and maintenance fee[59]. This means that sharecroppers and renters pay, not the person who owns the land they cultivate. When it concerns bigger expenditures for the pumping station, with lasting benefits, only the owners pay. The logic behind this is that sharecroppers and renters are only there temporary, while the owners will go on to profit from investments for a longer time.

Water allocation and scheduling

The schedule in PS31 is made by the farmers from the mesqa themselves, even though it is unclear from this study who exactly had the lead. It is not written down anywhere, but farmers are all very much aware of when it is their turn to irrigate. Initially, there was no schedule regulating water use. The pumping station had been installed just before the winter, when water was plenty, and farmers felt no need for a schedule. When the summer season started and water became scarce and demands high, the schedule was put in place to prevent conflicts between farmers[60]. Even now, the schedule is only effective from April to September, after which it changes to an on-request system[61].

There are two main principles underlying the current schedule: water is divided proportionally to the size of the irrigated area[62], not per person, and irrigation turns continue according to schedule, irrespective of water availability. With highly fluctuating water levels, this means that it is possible that the canal is dry during your turn as a farmer, and you have to wait for the next turn[63]. The 52 feddan of the mesqa are divided in two equal parts of 26 feddan. One half irrigates odd days, the other even days, making it easy to remember whose turn it is after water disappears for a longer time. The halves are again divided in quarters of 13 feddan. It is important to note that the fields in one quarter are not clustered. They are spread over the mesqa and served by different valves. Each quarter gets 12 hours, resulting in 55 minutes per feddan. However, several valves open at the same time, which means that a feddan gets a smaller flow, but more time. If four valves open for instance, a field receives four times 55 minutes (equalling 3 hours and 40 minutes)[64]. The schedule is fairly intricate and difficult to explain to an outsider ("*you'll need one week to understand the schedule!*"[65]), but as it has been the same schedule for 10 years, farmers have no trouble with it[66]. An example of the schedule as valid on odd days in August 2013 is given in Figure 19. The rectangles represent the valves, with inside indicated the amount of

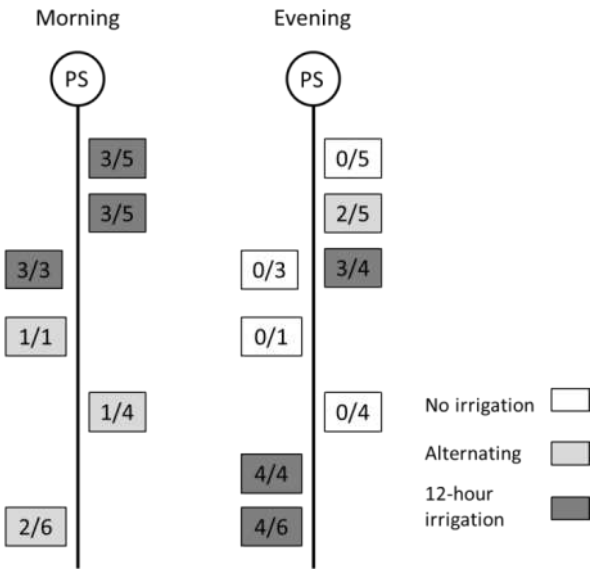


Figure 19 - Schedule of PS31 (interview farmer PS31, 04-08-2013)

[59] Interview Karim PS31, 14-08-2013
[60] Interview farmer PS31, 21-07-2013
[61] Interview Ibrahim PS31, 12-07-2013
[62] Interview farmer PS31, 13-07-2013
[63] Interview farmer with land in PS31 and land with private pump, 13-07-2013
[64] Interview with Farmer PS31, 13-07-2013
[65] Comment farmer PS31, 12-07-2013
[66] Interview farmers PS31, 5-7-2013

feddan irrigated/not irrigated and the colour showing whether the valves open for 12 hours or only part of the time. In the morning, three valves open the full time, with one of the remaining valves being alternately added. In the evening, three valves open continuously, with one other closed after some hours. The morning/evening division changes in every turn: if you are in the morning group this time, you will be in the evening group next time. The figure also shows that some valves irrigate on both odd and even days. The division over odd and even days also changes, as there are sometimes more odd than even days in a month.

One can say that this mesqa has chosen to open more valves for a longer time, where they could have also decided to open fewer valves for a shorter time, but with a higher flow (higher main d'eau). Now there were instances of farmers complaining, because it takes more time to irrigate their field[67]. On the other hand, a turn lasts longer and farmers are thus less affected when the pumps do not run for some time. Pumps can be stopped for anything from 30 minutes to several hours in a day, for instance when upstream use is high and water levels drop, or when the electricity is cut. At the same time, there are the more regular off-periods, in which there is no water for about 5 days.

Another choice is to open valves at the end of the mesqa and valves at the beginning at the same time. Some farmers said this was unfair, because the water distribution across the valves was unequal[68]. This was confirmed by other farmers, but seems to depend on whether one or two pumps are working. If there is only one pump, the last valves get water but the head-end ones do not. Farmers blamed it on the slope of the pipeline, which causes the water to go to the tail-end of the mesqa, with pressure in the pipeline not high enough to let water flow out of the first valves. If both pumps work, the head-end valves get more water. This means that if there are problems with diesel or electricity, the head end farmers suffer. However, they benefit if both pumps function well[69]. Most farmers however, felt the schedule was fair and equal and prevented conflicts among farmers.

The schedule outlined above is strictly adhered to when water is scarce, but is more loosely defined when there is more water[70]. Farmers with different time slots might swap turns or might not want to irrigate at all. In July, there was a day only one pump was running, because it was the fifth day of water and there were no farmers who wanted to irrigate[71]. Farmers also decide on their own rotation at valve level, which is not fixed in the general schedule (more on this in Chapter 8).

The schedule takes into account night irrigation, which most farmers find cumbersome[72], but is especially difficult for some: There are four widows who run into problems because women are not expected to go to the field at night. At valve level, farmers try to arrange things in such a way that these ladies have their turn during the day. Still, as one widow explained, the fixed turns are difficult as the women often have other jobs next to farming to earn enough money for their families. They would prefer the independence provided by an individually operated pump, which gave them the freedom to irrigate whenever they wanted[73]. Apart from the widows, women are hardly involved in

[67] Interview farmer PS31, 21-07-2013
[68] Interview farmers PS31, 02-08-2013
[69] Interview Khaled PS31, 05-07-2013
[70] Interview farmer PS31, 13-07-2013
[71] Comment Ibrahim PS31, 13-07-2013
[72] Interview farmer PS31, 13-07-2013
[73] Interview widow farmer PS31, 15-07-2013

irrigation practices in the field and they do not own land. Before IIP, they would sometimes operate the individually owned pumps, but now they are no longer involved[74].

Conflict management

Conflict management is interpreted as the mediation in disagreement between farmers and the punishment of infractions by farmers within the mesqa. While the initial narrative promoted by both IIP and the farmers is that the WUA mediates in all conflicts, in practice things are a bit more diversified. Whenever there is a disagreement, farmers first confront each other and try to resolve the issue themselves. Discussions about when somebody should close their valve exactly or whether one or two pumps should be operated were dealt with swiftly, either by the two parties or by bystanders. If this is not enough, the discussion can be dealt with by a group of influential men in the mesqa, or by something called the *Kadat Orfia (EN: customary leaders)*. Counted among the influential men in the mesqa of PS31 are the treasurer (Omar), one member of the WUA (Ahmed) and one other man who was described to be "*very strong*" and to have more money (Karim)[75]. Karim explained that farmers have to pay when they do break the schedule repeatedly or when they infract on the rules in other ways. One man once destroyed the electricity connection and was fined 250 LE; another broke the door of the PS and had to pay 150 LE. The amount is set by the three men mentioned above, which act like an "*informal WUA*" [76]. Karim said he used the word "informal" because his name and the name of the treasurer are not officially registered at IIP. The official WUA is the initial group of five men, of whom three are now dead or away.

If farmers do not want to go to the informal WUA, or if the problem is too big, they can also contact the aforementioned *Kadat Orfia*. This is the traditional judicial system of the area, consisting of a group of respected, wise men. When a problem is presented to them, they hear both sides and take notes. Afterwards, they revise these notes and pass judgement on who is found guilty. This person is forced to write out a cheque to the other party, which cannot be cashed immediately: after one or two months the case is reviewed again, and if all are happy, the cheque is destroyed. It is a traditional conflict management mechanism which does not involve the government or the police[77]. The people in the *Kadat Orfia* are not linked to the irrigation units and deal with many different problems, not just related to water. None of the people in PS31 are part of the *Kadat Orfia*, but they will attend the meetings as spectators[78].

7.4. PS31 – Decision-making around re-ordering

While the initial decision-making around introducing IIP was top-down (see chapter 5), the current way of deciding on technological changes seems to be more democratic. The WUA is not a platform for these changes though, as it is mostly a paper entity which exerts very little influence on management tasks – as described in the previous section. Instead, it seems that influential people come with new ideas, which they then propose to the rest of the farmers. There is an indirect voting mechanism through the fee collection: money to invest in technological interventions has to be

[74] Interview group of women, Ezbet ar Rasif, 15-07-2013
[75] Interview farmer PS31, 21-07-2013
[76] Interview Karim, 14-08-2013
[77] Interview farmers PS33, 13-08-2013
[78] Interview farmer PS31, 01-08-2013

collected separately from the regular maintenance fee. If owners do not agree with the change, they can refuse to pay. In between the issuing of a new idea and implementing it, there is therefore always a time in which it is discussed and farmers are convinced.

Because only the land owners pay for these larger changes, such as installing electricity, buying new pumps or lowering the intake, they are also automatically the only ones with a say. Even though a sharecropper or renter might have been living in the area for many years, and be affected by the introduction of a new technology, he does not have the same influence as a land owner.

An example of this process is the instalment of electricity in the pumping station. Karim started out by trying to convince farmers that it was a good idea to install electricity, as it would be cheaper. Initially farmers did not like the idea and were afraid to take any risks. Karim was supported by one of the WUA members, who has passed away since that time, and eventually people agreed to pay for setting up the electricity connection. The connection is in Karim's name, as none of the other farmers wanted to be responsible for it[79].

All farmers, renters and owners alike, do have the power to object to expenditures on diesel or question the pumping station altogether, simply by withholding the regular fee. If they feel the pumping station is giving them fewer benefits than costs, they can refuse to pay. However, with no other clear source of irrigation, this is highly unlikely at the moment.

Things work differently when it comes to organisational changes, for instance to replace the operator or to change the schedule. The current operator for instance has been selected by Ahmed and Omar, with none of the other farmers having a say in it. Farmers who want to change the schedule say that they cannot, because Ahmed refuses to listen to them[80]. This indicates that the organisational decisions seem to be solely controlled by the "informal WUA" – the three most influential men in the mesqa. As it does not involve fee collection, the indirect voting system is not activated. Farmers might be asked for their opinion or informed, but in general decision-making appears to be concentrated in the hands of those few men.

As women rarely own land and are not represented by anyone in the WUA (formal or informal) they do not play a direct role in any kind of decision-making around the pumping station.

7.5. PS31 – Concluding remarks

While PS31 started off according to the IIP textbook, farmers have re-ordered the system through their practices to fit their needs. Through technological changes, they have tried to increase water availability and reduce the burden of taking turns. Soon, they will attempt to evade most forms of collective action by investing in a new system which is based on independence, as before IIP.

A simplification of the water network is shown in Figure 20. The wide arrows show flows of money, with the money eventually leaving the boundaries of the mesqa (a part of the network outside the scope of this research) to eventually return as goods or services. The thin arrows show the influence or interrelation between different actors, the level to which they can influence or be influenced by the other. A thicker line means a higher level of interrelation. It is a highly simplified depiction of the actual network, as the total amount of relations and their nature would become too complex to

[79] Interview with Karim PS31, 14-08-2013
[80] Interview farmer PS31, 02-08-2013

depict here. What should stand out is the central role for the treasurer and the operator and the difference in influence between sharecroppers and renters when it comes to the pumping station. Furthermore, all water users are strongly related to their valve, even when they are less strongly related to the pumping station. The composition of the diagram is further explained below.

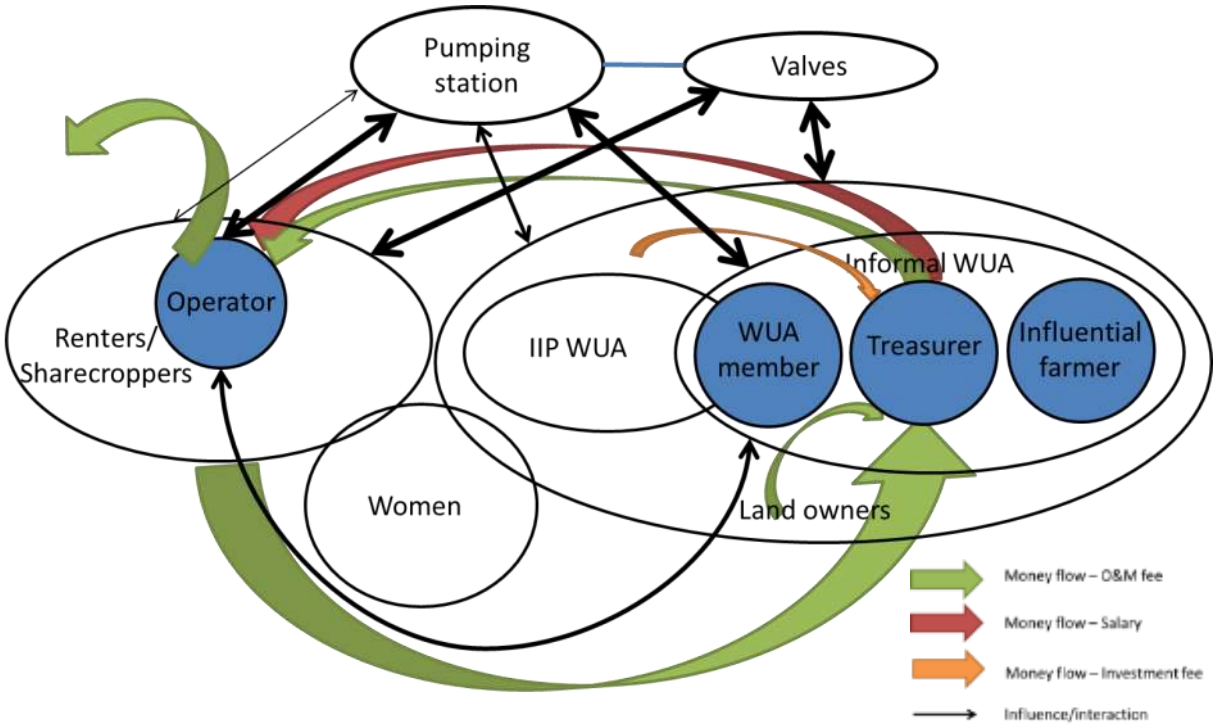


Figure 20 - simplified representation of the water network at mesqa level in PS31

The WUA has been replaced by an informal WUA, containing three influential men. Their influence seems to be based on seniority, wealth and education. One of these men used to also be part of the formal WUA. However, while one of the three men came up with the term informal WUA, most farmers do not recognise it as an institution: they simply see three individuals who manage water in the mesqa. They do however mark these three men as being the most influential, taking up a special position in the management of the mesqa. The WUA is also recognised as a separate entity, its boundaries being defined by who signed for the receiving of the pumping station and whose names are listed at IIP.

There is a sharp distinction made between sharecroppers/renters and land owners, mostly embodied in the practices they are involved in and the rights and obligations they have. All water users have the same rights and obligations when it comes to using water on a daily basis (valve level), but when it comes to larger decisions, the land owners are the ones that matter. The operator is recognised by all to be responsible for the operation of the pumping station, but he is also a renter and the job is one without (much) status. Women are pretty much left out of any irrigation matters, even though some widows own or rent land.

One can thus say that there are different social groups within the mesqa, becoming active at different moments:

- Renters/sharecroppers: pay regular fees and involved in day-to-day irrigation

- Land owners: pay regular fee (if cultivating themselves), pay and decide on larger technological interventions
- Women: exert little influence in irrigation matters, unless owning or renting land, which only happens when they are widows
- IIP WUA: for outside representation and keeping up appearances
- Informal WUA: decides on social interventions, taking the lead in technical interventions, involved in conflict resolution, collects money
- Operator: daily management of the pumping station
- *Kadat Orfia*: manages conflict (does not fall within the boundary of the mesqa, and therefore not depicted in Figure 20)

Actors absent from this list are the irrigation engineers or other government representatives. They are left out because of the geographic boundary of the mesqa and also because there seems to be little interaction between the farmers and these engineers: the rotational schedule is normally determined without consulting the farmers, who just have to make do with what appears at their mesqa intake. However, in times of prolonged off-periods, farmers have been known to complain to the irrigation engineer.

With the story of PS31 in mind, I now turn to the other case study, PS33, in order to eventually compare and analyse the similarities and differences.

7.6.PS33 – An introduction

PS33 is located on the west side of Abo Moustafa canal, just downstream from PS31, at km 8.7. The pumping station was installed ten years ago and was designed to serve 81 feddan through two diesel pumps and 17 valves[81] (Figure 21). Also here the cultivated crops are rice, melon, maize and cotton, with the addition of berseem – a fodder crop which is harvested in May and mostly not followed by another summer crop. The mesqa is referred to as the "Baz" mesqa, as the majority of farmers belong to that family[82]. Farmers comprise a mix of owners, renters and sharecroppers, about 30 in total[83]. The mesqa is surrounded by three drains: the Bakr drain (named after the neighbouring village) and Hosha drain which both flow into the larger Hindauwi drain. Fields are mostly perpendicular to the mesqa and the drains, unlike in PS31.

[81] Interview Ali PS33, 23-06-2013
[82] Interview farmers PS33, 29-06-2013
[83] Interview Youssef PS33, 13-07-2013

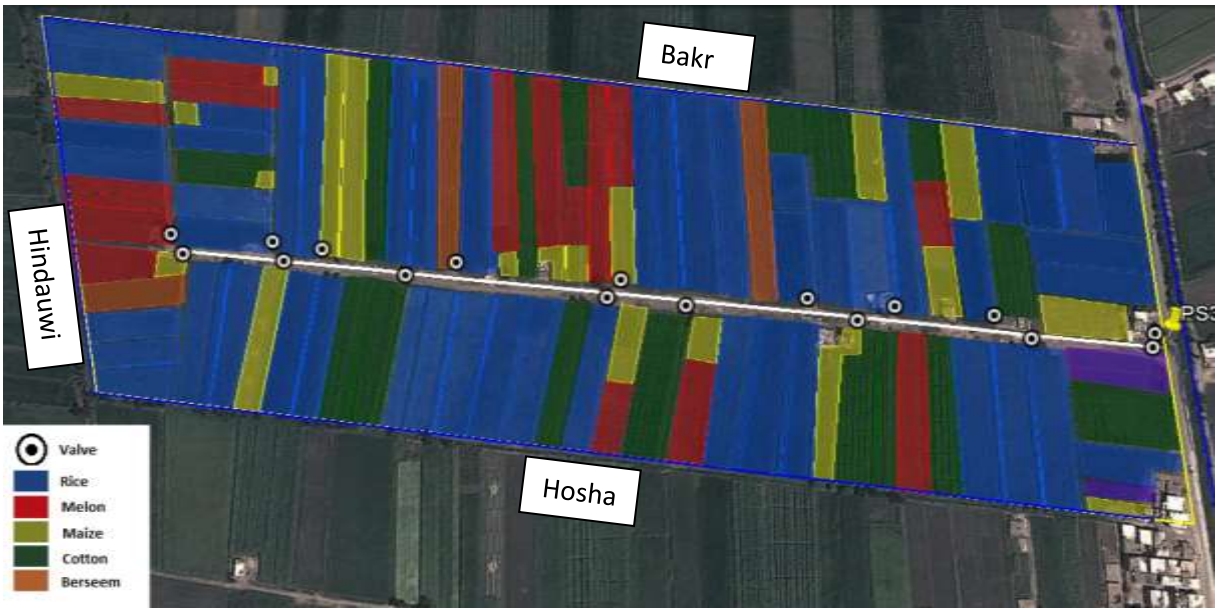


Figure 21 - Lay-out and crops of PS33 in July 2013

This mesqa is located in a unique spot where drain water and canal water meet, which can be spotted easily when water levels are low (Figure 22). It means it is located at the tail of both water flows and dealing with the consequent uncertainty in water supply, aggravated by the technology that has been put in place (further explained below). The causes of this uncertainty were clearly explained by one of the farmers of PS33: "*We never really know when and whether the water will reach us. Upstream farmers might use more water and the water might not reach here. The gate might also be closed before water gets here*"[84]. Farmers believe that their situation was better before IIP. At that time, they would not have to irrigate at night, there was no sharing, everybody was responsible for their own pump[85] and they did not have to use drainage water[86] (see chapter 6 and 8). They felt tricked by the project, which promised them continuous flow and enough water[87]. The project is described as "*a failure*"[88]. However, if there would be continuous flow, some feel the project could be successful[89].

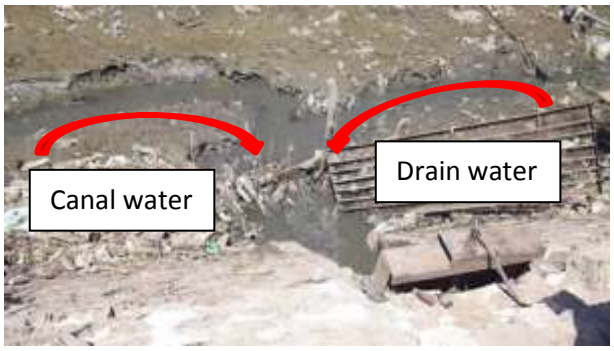


Figure 22 - Canal and drain water meeting in front of PS33 (24-06-2013)

This last statement has been expressed in other mesqas as well, and it illustrates the real frustration of farmers: the new technology has decreased their water access, while at the same time increasing the level of drudgery (collective action). They now have to co-operate and follow schedules in order to share water, but it does not give them enough additional benefits outweighing the fruits enjoyed before IIP was introduced. In theory, the claimed benefits of cheaper and more efficient irrigation

[84] Interview farmer PS33, 20-07-2013
[85] Interview Ali PS33, 23-06-2013
[86] Interview farmer PS33, 25-06-2013
[87] Interview Youssef PS33, 24-06-2013
[88] Interview WUA member PS33, 24-06-2013
[89] Interview farmer PS33, 25-06-2013

have been realised, but emphasising these benefits while not acknowledging the costs of collective action would be misleading. Even more so, you can wonder whether these benefits mean anything, if a farmer's access to water declines. Farmers in PS33 do not seem to think so.

The WUA belonging to PS33 has a similar origin as the one of PS31[90] and has also not nominated any new members or held elections since its founding[91]. One member has died, and has not been replaced[92]. Farmers in PS33 reproduce the same official narrative as the farmers in PS31, even though they are more willing to let it go. Initially when asked, they would explain that the "*WUA could speak to the construction company in the name of all the farmers*", but later they acknowledged that "*the WUA does not do anything*"[93]. The son of the passed away WUA member went as far as to say: "*even if all people in the WUA die, we will not replace them*"[94]. The WUA seems to once have had its function, but in recent times its activities have been reduced to very little.

This shift is the result of a re-ordering of tasks that is at odds with the IIP order. This social re-ordering, as well as the associated technical re-ordering is described below. As for PS31 I will then analyse the decision-making process in the mesqa around interventions and re-ordering, to conclude with a short analysis of the overall mesqa.

7.7.PS33 – Re-ordering the technical order

As stated before, PS33 started out with two diesel pumps and 17 working valves. Since its instalment, changes have been made to the pumping station, though with different results than in PS31.

The initial pumps were replaced after five years by two other diesel pumps with a larger capacity[95]. These were preferred over an electric pump because creating an electricity connection and buying the pump would be more costly than installing larger diesel pumps. In addition, there was a fear of power cuts making the electric pumps unreliable[96]. No new valves were created, but the first valve at the start of the mesqa has never been used by the farmers in that section of 6 feddan: they prefer to use their individually owned pumps which pump straight from the canal[97](Figure 23).

Figure 23 - From left to right: PS33, individually owned pumps, unused valve (28-06-2013)

[90] Interview farmers PS33, 13-08-2013
[91] Interview Youssef PS33, 24-06-2013
[92] Interview farmers PS33, 13-08-2013
[93] Interview Farmer PS33, 25-06-2013
[94] Interview farmer PS33, 13-08-2013
[95] Interview Ali PS33, 23-06-2013
[96] Interview Youssef PS33, 13-07-2013
[97] Interview Ali PS33, 23-06-2013

The farmers in that section do not interfere with the pumping station and do not pay fees for this part of their land. One owns another piece of land, further away from the canal, which he does irrigate with water from the pumping station. However, when water was scarce this summer, he dug a small canal from his individually owned pump to this field to supplement the irrigation from the PS. The remaining 16 valves now irrigate 75 feddan (Figure 24).

Figure 24 - Mesqa PS33; the non-PS area and un-used valve highlighted

Most of the valves are leaking and at times the top is missing or broken; without tops they are closed with straw and stones (Figure 25).

Figure 25 - Valves in PS33, varying from absent to broken to intact

Farmers in PS33 want to lower their intake badly, but have so far found it is too expensive[98]. The new intake would have to go under the road, and this makes the construction more difficult and costly[99]. So far, they only managed to change the pit in which water is collected before it is being pumped (Figure 26). It is now outside the pumping station (it used to be under it) and is lower than before. It is believed to collect more water now[100], but also to be a first step towards constructing a new, lower intake, which is seen as the most crucial change the pumping station

Figure 26 - Newly constructed pit for water collection (23-06-2013)

[98] Interview lady farmer PS33, 23-06-213; Interview farmers PS33, 30-07-2013
[99] Interview farmers PS33, 13-08-2013
[100] Interview Ali PS33, 23-06-2013

needs. The works were only done one year ago, because farmers were not able or willing to pay for it earlier[101].

The influence of a lower intake can be easily spotted at PS33, by comparing the individually owned pumps with the pumping station. On several occasions this summer the pumping station was not running, while the other two pumps were working fine[102]. This is because the individually owned pumps have a separate intake, which is much lower than the IIP intake. The same distinction can be made between PS31 and PS33, with the PS31 intake capturing water more often than the one of PS33.

Farmers in PS33 are also contemplating changing their IIP infrastructure for the new system with individually owned pumps and a large concrete pipe. The reasons that they want it, is that they believe it will make them more "*comfortable*" and that it will give more water[103]. The comfort would stem from the fact that they can irrigate whenever they want, no longer bound by any schedule. They will sell all the IIP materials and raise the rest of the required investment funds from the land owners; each paying according to the number of feddan he owns[104]. The intended sale of the materials poses the question whether farmers have the right to do this. According to IIP, farmers are only given a loan to install the pumping station and mesqa, which they are meant to pay back over time. Farmers ultimately thus become the owners of the infrastructure (albeit involuntarily). However, as in PS31 and most other mesqas, farmers in PS33 have not yet started paying[105]. With no representatives of IIP visiting the area since the instalment of the pumping station[106], farmers most likely do not have to worry about repercussions any time soon.

While the benefits of the new system are clear to most farmers, they also see some downsides. First of all the costs[107] (1000 LE/feddan), but also the difficulties it creates in draining the water. The pipe is has to be put at a considerable depth, to facilitate gravity flow from the canal at low water levels. This makes it difficult to drain the water into the existing drains. If the water inside the pipes stands still for long, they fear it might get very salty and damage the crops[108]. Especially farmers at the tail of the mesqa are afraid of these aspects and in addition fear that the head-end of the mesqa will receive more water and benefits than the tail-end[109].

At the moment, opinions in PS33 are still mixed and it is not quite sure what will happen in the near future. Possibly, in one year time there will be no more pumping station to be seen. Just as likely, and based on accounts about the construction of the new intake, the pumping station will still be there because of a lack of investment funds. A summary of interventions, both executed and planned, is given in Table 2.

[101] Interview farmers PS33, 30-07-2013
[102] Observations 25-06-2013 and 28-07-2013
[103] Interview treasurer, 13-07-2013
[104] Interview treasurer, 13-07-2013
[105] Interview farmers PS33, 25-06-2013
[106] Interview farmer PS33, 25-06-2013
[107] Interview farmers PS33, 30-07-2013
[108] Interview treasurer, 13-07-2013
[109] Interview farmers PS33, 30-07-2013

Table 2 - Overview interventions PS33, including year and costs

Year	Event/intervention	Costs	Costs in USD
2003	IIP – pumping station built	Still not charged for; anticipated costs: 400 LE/feddan/year[110]	58 USD
2008	Replaced 2 diesel pumps	20,000?[111]	2,903 USD
2012	Lowered pit	4,000 LE[112]	580 USD
	Total (max) per feddan, already spent	320 LE	46 USD
2013?	*Lower intake*	*12,000 LE[113]*	*1,742 USD*
2013/2014?	*Remove all IIP infrastructure and create a new system with a large concrete pipe and individually owned pumps*	*75,000 LE[114] – 112,500 LE[115]*	*10,889 USD – 16,334 USD*
	Total (max)	*148,500 LE*	*21,560*
	Total (max) per feddan	*1,980 LE*	*287 USD*

All the re-ordering attempts described above, are alterations made to the implemented IIP design. However, farmers in the mesqa of PS33 (and PS31 for that matter) have also rejected one of the outcomes that would have stemmed from the IIP order. The IIP assumed that the new system would lead to land savings, as the old open mesqa would be covered up. Indeed, a stretch of about 12 meters wide and 800 meters long is now running through the mesqa, where before the open canal used to be (Figure 27). However, unlike the plans of IIP, farmers prefer not to use this land (≈2 feddan; ≈2.5%) for the cultivation of crops. Instead, they use it for transportation and to keep some of their animals.

Figure 27 - Farmers using the open area of the closed mesqa to take their sheep to graze

Apart from the fact that the future of IIP infrastructure is uncertain in this area, farmers also explain that the land is communal land. If they would try to divide it, it would only lead to conflict[116].

7.8.PS33 – Re-ordering the social order

Much like the example of not using the newly availed land of the mesqa, most social re-ordering in PS33 also consists out of largely denying and ignoring the IIP order and adopting a totally different

[110] Interview farmers PS33, 25-06-2013
[111] Based on data from PS31
[112] Interview farmers PS33, 30-07-2013
[113] Interview farmers PS33, 30-07-2013
[114] Interview Youssef PS33, 13-07-2013
[115] Interview farmers PS33, 30-07-2013
[116] Interview farmers PS33, 20-07-2013

set of practices. Below these are again described around key performative tasks like operation and maintenance, fee collection, water allocation and scheduling and conflict management.

Operation and maintenance

Like in PS31, the operation and maintenance of the pumping station comes down to one operator: Ali. He also receives a salary, of 215 LE/month[117], and performs similar activities as in PS31: protecting the pump from being stolen, starting and stopping the pumps, buying fuel and changing the oil. In winter, farmers buy and bring their own fuel and the Ali's tasks are few. He has been doing this job since the beginning and is the only one who has a key of the padlock on the door of the pumping station, making him a central figure.

What sets the operator of PS33 apart from the one of PS31, is the status and respect that comes with his job. Farmers do not question Ali's judgement or commitment and chose him because he is found to be a responsible man[118]. When asking for the person responsible for the pump, people do not refer to the WUA, but to Ali[119]. Farmers assist in the operation of the pump by warning Ali when water levels are low or high and by preparing the tower as described for PS31[120]. At the same time, it is Ali who bears final responsibility and who would always be there quickly when needed.

In July 2013, the left pump needed to be remounted on the frame below it, as it was shaking and losing energy[121]. The men organising this were the operator, the treasurer (Youssef) and one other young farmer from the mesqa. They brought a mechanic and tools and helped repairing the pump (Figure 28 and Figure 29).

Figure 28 - The operator and treasurer discussing with the mechanic about the problem

Figure 29 - From left to right: the operator, young farmer, treasurer and mechanic going to fix the pump

Two days after the left pump was fixed, the right pump was experiencing problems. This time it was only the operator and a mechanic who were there to fix the malfunction. The following days, farmers in the mesqa did not show particular interest in the repair or its costs[122]. They were simply happy the problem got taken care of, and did not desire any involvement in it.

[117] Interview Youssef PS33, 24-06-2013
[118] Interview farmers PS33, 20-07-2013
[119] Observation in PS33, 23-06-2013
[120] Interview farmer PS33, 28-06-2013; Interview farmer PS33, 06-07-2013; Interview farmer PS33, 12-07-2013
[121] Interview Ali PS33, 16-07-2013
[122] Interview farmers PS33, 20-07-2013

These events again show the trust farmers have in their operator, but also the level of involvement of the operator in the performance of the pumping station. At the same time, it is telling that the young people are the ones involved in fixing the pump, rather than the old WUA members who were never mentioned when talking about these repairs.

Fee collection

Farmers in PS33 pay 150 LE/feddan/summer for the operation and maintenance of the pumping station[123]. The money is collected by a young farmer from the mesqa, Youssef, who is also a primary school teacher[124]. He was only appointed recently, and before him an older man did the job. This man was not only involved in the fee collection, but also helped setting up the schedule (see below). Like Youssef, he was not only a farmer but also a teacher[125]. Being honest and being able to read, write and account are decisive qualities for being chosen as the treasurer in PS33.

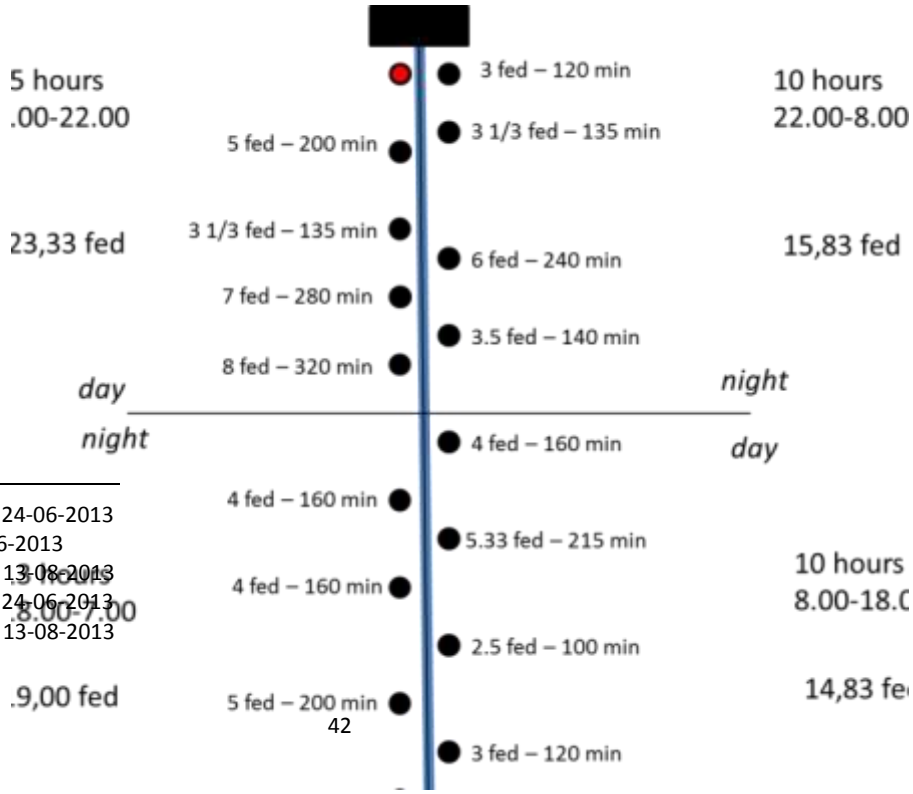
Paying the fees is a precondition for being allowed to irrigate. Normally all people can pay, as money is raised at the end of the winter harvest. If people cannot pay, they might take out a loan. This year, all people paid and all are irrigating with water from the pumping station[126].

Unlike in PS31, no problems were observed or described here when it comes to running the pumping station. Farmers blame low water levels and the IIP, but do not speak badly about the men running the pumping station.

Schedule and water allocation

The schedule of PS33 was made by a respected, intelligent farmer/teacher and was developed in steps. After the instalment of the pumping station, it became clear that the water scarcity problem would lead to conflict between farmers. The first step was to divide the mesqa in two halves of about 38 feddan. After this, they divided these halves again, to end up with four similarly sized quadrants, each containing four valves. From these four valves, two will open at the same time. While the first few times the farmer/teacher was in charge of organising the schedule, soon farmers knew when it was their time to irrigate[127].

Now the schedule (Figure 30) is fully developed and operational, according to the same principles as in the beginning. Each feddan gets 40 minutes of full-flow irrigation and 80 minutes when two



[123] Interview Youssef PS33, 24-06-2013
[124] Interview Ali PS33, 23-06-2013
[125] Interview farmers PS33, 13-08-2013
[126] Interview Youssef PS33, 24-06-2013
[127] Interview farmers PS33, 13-08-2013

Figure 30 - Irrigation schedule PS33 (Farmers PS33, 29-06-2013)

valves and two pumps are open, which is the norm[128]. If they would open less than two valves, the pressure would be too high; if they would open more, the flow would be too low[129]. Two valves open according to their time, then when one closes, the next one opens. The first half and the second half of the mesqa irrigate on alternate days[130], as in PS31. Day and night irrigation switch between the left and the right side: if you were the first to irrigate in the morning last time, you are last in the night next time[131]. Turns continue, even if there is no water and the schedule is only valid in summer[132]. At valve level, the same principle of changing orders applies: the farmer who is first to irrigate this time, will not be first next time[133]. All monitoring is done by the farmers themselves.

Farmers stick to the schedule in water scarce times. Missing your turn because water is not there in the canal is seen as a case of bad luck[134]. It is possible that one field gets water twice in a rotation, while another does not get water at all. In these situations, farmers can trade among each other, but this is based on free will and not on a change in the schedule[135]. Farmers do not express any resentment or envy towards those who get more water in a certain rotation. It is all determined by coincidence, and as the schedule is perceived to be fair by all, they accept their water turns.

Conflict management

Farmers describe their mesqa as one with very little conflict[136]. If problems do occur, they happen during summer, especially at the beginning of the rice season[137]. If people disagree, they mostly manage to solve their differences in the field[138]. If this does not work, they might call the oldest members of the families to mediate[139]. The role of the elders seems to be more pronounced in PS33 than in PS31, where such a role was not mentioned by the interviewed farmers. In case things get out of hand, they can bring the case to the *Kadat Orfia*. As in PS31, none of the farmers are in the *Kadat Orfia*, but they do attend the meetings.

The ways in which conflicts are approached are thus very similar across the two mesqas. Another thing that stands out is that water conflicts are not necessarily dealt with differently from other problems. The same institution is consulted to deal with a fight between two stubborn kids as for a disagreement over water[140]. The custom of seeking advice from senior, respected community members is present at the different levels of conflict management.

7.9.PS33 – Decision-making

Decision-making in PS33 again displays many similarities with PS31. The fact that regular fees are only for operation and maintenance, means that the same indirect voting system through payment exists. The WUA is not a platform for negotiations, but rather a relic from initial IIP times. Small

[128] Interview Ali PS33, 23-06-2013
[129] Interview farmers PS33, 25-06-2013
[130] Interview Youssef PS33, 24-06-2013
[131] Interview farmers PS33, 28-06-2013
[132] Interview Ali PS33, 23-06-2013
[133] Interview farmer PS33, 28-06-2013
[134] Interview Youssef PS33, 24-06-2013
[135] Interview farmer PS33, 25-06-2013; Interview farmers PS33, 29-06-2013
[136] Interview Ali PS33, 23-06-2013; Interview Youssef PS33, 24-06-2013; Interview farmer PS33, 25-06-2013
[137] Interview farmers PS33, 01-08-2013
[138] Interview Youssef PS33, 24-06-2013
[139] Interview farmer PS33, 25-06-2013
[140] Interview farmers PS33, 01-08-2013

decisions, about for instance repairing the pump, are taken by the operator and the treasurer. These were actually chosen by farmers, and are appreciated for their work. Unlike in PS31, farmers thus seem to have a say in the social changes. It should be noted though, that although the re-ordering in the face of the ideal IIP order is huge, the mesqa itself has had a very similar management and social structure over the last ten years. Except for replacing a treasurer and introducing the schedule in the early days, things have remained much the same.

PS33 has witnessed fewer technical interventions than PS31, and therefore the opportunity to analyse the decision-making process around these is also smaller. However, unlike in PS31 it is not a few influential men who are respected for their affluence or education who initiate and dominate these changes. The system in PS33 is rather based on families and their representatives. When talking about wanting to introduce a new system, farmers plan to get together with four men from different families[141]. These men are at times members from the WUA, but not always[142]. They will consult their families, talk about the pros and cons, come out with a decision and try to convince their family members. This then normally leads to a majority, which is needed to implement the new system[143].

Women were not yet mentioned in this section of PS33, and they do not seem to play much of a role in decision-making on mesqa management. There are no women owning land, even though they are the ones most seen weeding and working the land during the summer. Youssef explained the reason why women cannot have a leading position in the mesqa: "*It would be difficult for them. Sometimes it is necessary to irrigate at night and it is also difficult for them to speak to men*".

7.10. PS33 – Concluding remarks

As in PS31, PS33 underwent changes since the beginning of IIP. However, overall this mesqa is more characterised by stability and continuity than by change. The operator has been the same man for ten years, the biggest technological intervention was changing to a different kind of diesel pump and generally conflict and problems have been limited.

The water network is, once again highly simplified, depicted in Figure 31.

[141] Interview farmers PS33, 30-07-2013
[142] Interview Youssef PS33, 13-07-2013
[143] Interview farmer PS33, 13-08-2013

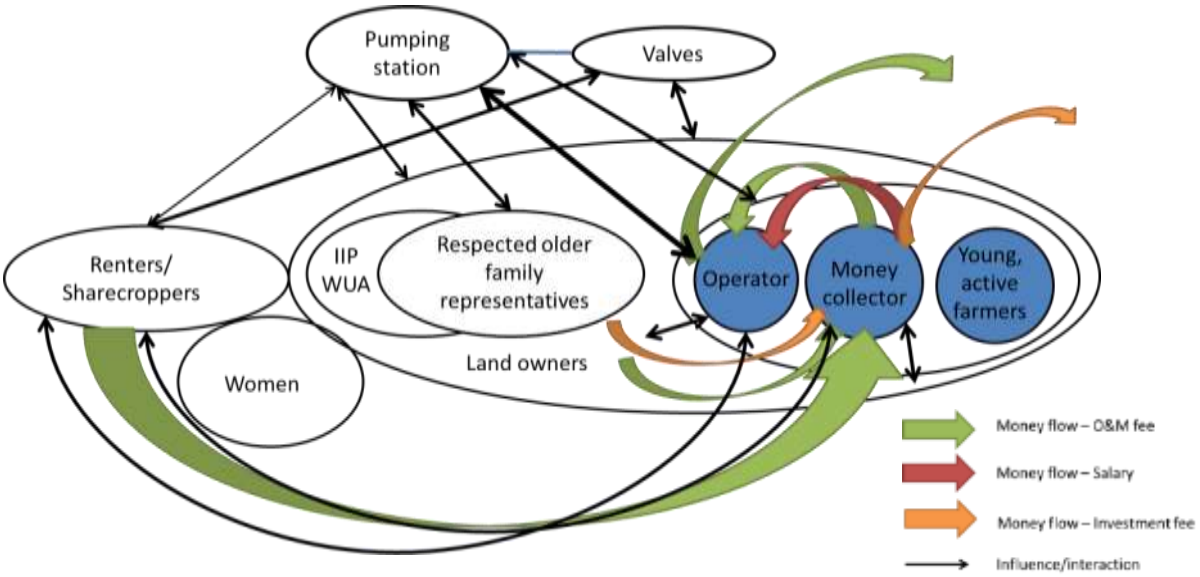


Figure 31 - simplified representation of the water network at mesqa level in PS33

The distinction between renters/sharecroppers and owners is also present in PS33. Women do not own land in this mesqa, do not operate the pumps and hardly ever open valves. They have very limited direct interference with the pumping station. Within the group of land owners, there are some separate collectives that take care of specific tasks or decisions in the pumping station. A group of younger farmers, including the operator and the treasurer deal with the day-to-day management and decisions. They are the ones fixing the pump, operating it, dealing with immediate issues. They are also the ones who are most present in the mesqa on a daily basis. Then there is the IIP WUA, which does not have a large role anymore after its initial function as a precondition for the pumping station. However, part of the WUA members are also respected family representatives, which convene and discuss about new plans for the pumping station. It seems that these new plans are largely fuelled by the younger group, but no clear examples were found of this.

The biggest difference in the relations shown Figure 31 and those in the diagram made for PS31, is that there are much stronger links between all water users and the operator and treasurer, as these are selected by those same water users. This is tied to the seemingly better relationships among farmers in PS33.

7.11. Comparing PS31 and PS33

While many things are similar between PS31 and PS33, there are also differences in the way they approached their attempts at re-ordering IIP. Tale-telling is perhaps the amount of money spent per feddan: it is three times higher in PS31 than in PS33. PS31 has invested more in trying to re-order the technology, in an attempt to increase water availability and reduce the burden of working together. In a way, you could say they are trying to buy their way out of collective action and potential conflict. This difference is surprising, because PS33 started with a more disadvantaged position when it comes to water availability: their mesqa is 50% bigger and they are slightly more downstream than PS31. Especially the size of the mesqa seems to be important, as the pumped volume has to be shared among more land and more farmers, thereby decreasing individual water availability.

Why PS31 invested more than PS33, while the issue of water availability seemed more problematic in PS33, is not clear, even though there are some indicators pointing in a certain direction.

First of all, PS31 seems to witness more conflicts than PS33 over day-to-day water sharing, possibly stimulating investments to increase water availability and to become more independent water users. The level of conflict apparently does not come down to quantities of water, but rather to relationships between people and to the behaviour of some key people. Where in PS33 most people are related or befriended in some way or another, there is more animosity in PS31. The operator is not a respected figure as in PS33, but regarded as a mere labourer, resulting in distrust among farmers and a lack of commitment on the part of the operator.

However, other factors might be an overall sense of cautiousness among farmers in PS33, higher costs for certain changes (such as the intake) or a lack of available funds. Most likely, it is an interplay of different features.

This analysis then assumes that the level of conflict preceded the investments. One could also turn it around and assume that the increase in water availability decreased the need of collective action. However, looking at the described history of conflicts in PS31, one might conclude that the problems between farmers were brought about by uniting them in one pumping station through IIP, triggering the investments to alter the pumping station.

One of the biggest things the two mesqas do have in common is their dislike of IIP and their claims that it has worsened their situation in terms of water availability and comfort. It is somewhat ironic, that they condemn the fact that they have to work together, and that the best examples of collective decision-making are attempts to re-order the system back into a more individual one. Comfort seems to be as important as water availability, as water stress is relatively low in PS31, but they are still willing to pay large sums of money to change their system. The idea to irrigate whenever you want without having to discuss with others, seems to be leading in this.

The ordering patterns described above, both social and technical, take place at mesqa level, but continue at field level. The next chapter looks at how individual farmers operate within the mesqa order in an on-going daily attempt to mitigate the outcomes of the mesqa order.

8. Re-ordening of mesqa order at field level

Farmers in both mesqas cultivate their fields in the conditions created by the mesqa-order. Especially the farmer-made schedule for water turns and the technology in place (pumps and intake) determine quite precisely how much water a farmer can use and when. This often means that a field cannot be completely irrigated or that an irrigation turn is missed[144]. However, within these mesqa limits, farmers still re-order or expand the water network in which they operate. They use a certain level of flexibility in the schedule to share water at valve level or between valves and adapt their choice of crops to concentrate water in one field. Drain water is included as a water source, while it is not an issue taken into account by the mesqa-order.

Below the different re-ordering attempts are addressed, using examples from both PS33 and PS31.

8.1.Flexibility in the schedule

The way the schedule is presented in chapter 7 is rather rigid for the sake of clarity, but in practice there are plenty of examples in which farmers play around with it. In PS33, a farmer was observed opening a valve to fill the mesqa so his sheep could drink[145], another who missed his turn got some hours from a friend, who could miss the irrigation time[146] and in another case two farmers exchanged hours: you can have my hours this rotation for your rice, but then I want your hours the next rotation for my maize. Whether or not this trading takes place, depends on how comfortable farmers are with each other. There seems to be no such thing as a water market, in which a farmer would be able to pay for the time of another. Having good connections and relations with other farmers in the mesqa will benefit you more than having money to spend.

The combination of dry and wet crops is one that is frequently used by farmers to concentrate the water they get on one field. In PS33, a majority of farmers cultivate melons, cotton, maize or berseem (dry crops) next to their rice. From a drainage perspective this might not be ideal as seepage from the rice damages the dry crops, but for farmers it has clear benefits. Having one feddan of rice and one feddan of melon (which needs to be irrigated twice in a season) for instance, means that most of the time you can concentrate all the water you get for the two feddan on one feddan. Several interviewed farmers gave this as a reason for cultivating both wet and dry crops, emphasising that if they grew only rice they would not have enough water to irrigate all their fields[147]. Additionally, cultivating berseem in winter means that you do not have a crop in summer and you can start the cultivation of sugar beet early. Being an early seller will lead to higher profits[148]. The cropping calendar of the most important winter and summer crops grown along the Abo Moustafa canal is shown in Table 3.

[144] Interview farmer PS33, 28-06-2013; Interview farmers PS33, 20-07-2013
[145] Interview farmer PS33, 28-06-2013
[146] Interview farmer PS33, 29-06-2013
[147] Interview treasurer and WUA member PS33, 25-06-2013; Interview farmer PS33, 28-06-2013; Interview farmer PS33, 20-07-2013
[148] Interview farmer PS33, 20-07-2013

Table 3 - Cropping calendar Abo Moustafa canal (adapted from FAO, 2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem												
Cotton												
Maize												
Melon												
Rice												
Sugar beet												
Wheat												

While the mix of crops in the field is thus a reflection of water insecurity, it is also part of common practice to rotate crops and diversify income.

Where the schedule assumes giving 40 minutes of water to each feddan, practices divert and often lead to irrigating some (rice) fields regularly while leaving other fields dry. This is a subtle type of re-ordering, but one which makes it easier for farmers to cultivate rice in summer.

8.2.Re-use of drainage water

Apart from the subtle changes through crop choice or flexibility in the schedule, the use of drain water through individually owned pumps has a big impact on the performative outcomes of the current mesqa order. Drainage water is not within the scope of the regular mesqa order, with rules and practices focussing solely on canal water. There are no mesqa wide rules on the use of drain water; no allocation, no scheduling and no common facilities (unlike in other mesqas, see chapter 6). Farmers use the drain water on an individual basis when they think is right. In practice this means that the drain is used during and just after the on-period[149], and especially at the beginning of summer when the rice has to be transplanted. The reason that the pumps in drains are only used during and just after the on-period is that farmers feel that the water quality deteriorates quickly when there is no new inflow[150]. This was confirmed by a series of measurements in July-August 2013 on different locations in the drains of both PS31 and PS33 (Figure 5).

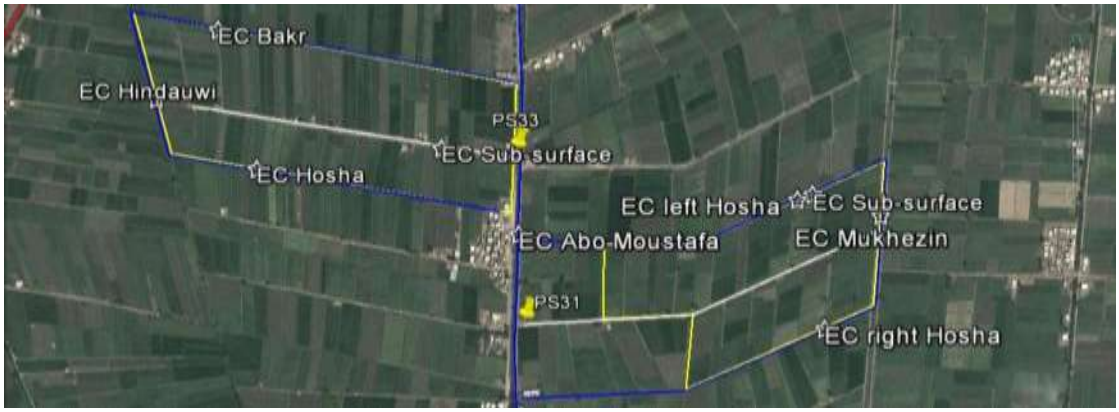


Figure 32 - Location of EC measurements in PS31 and PS 33

[149] Interview Ahmed PS31, 17-07-2013; Interview Youssef and WUA member PS33, 25-06-2013
[150] Interview Khaled PS31, 05-07-2013; Interview Ahmed PS31, 17-07-2013; Interview Youssef and WUA member PS33, 25-06-2013

The measurements showed that the salinity values of the drain exceeded the recommended maximum values in all places (Figure 33-Figure 34). The EC values used here are corrected for the temperature of the water. The measured EC values, water temperature, corrected EC values and exact coordinates of the different locations of measurements can be found in Annex I.

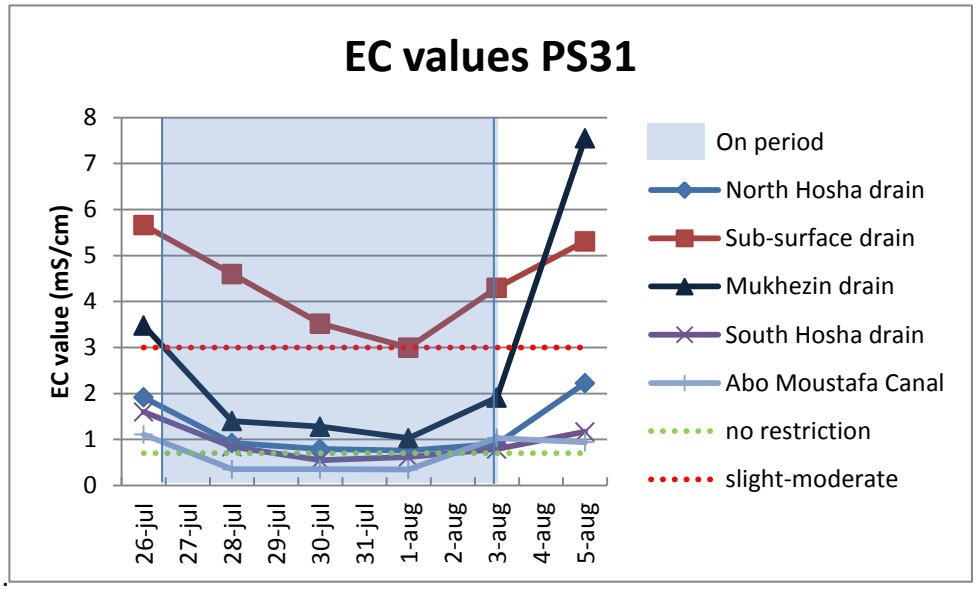


Figure 33 – EC measurement values PS31

Measurements in the three drains and a sub-surface drain of PS31 show that the sub-surface drainage water is constantly exceeding the limit for a slight to moderate restriction, meaning there is a severe restriction for use. The canal water has no restrictions for use during the on-days (blue shading). The Hosha drains vary a bit, with the EC-values getting higher during the off-period. The Mukhezin drain water quality quickly deteriorates after the on-period has ended, most likely because domestic waste water becomes the largest influx. The categories (Abrol et al., 1988) used are meant to be an indication of water quality, indicating how harmful the salinity of the water is for the crops. This also depends on which crop is cultivated and on management practices, but for the aim of this research this simplified classification is deemed sufficient.

The graph shows that even though drainage water can supplement canal water, this is mostly true during the on-period, because the quality deteriorates quickly after. This sheds a light on how to interpret the benefits and risks involved in using drainage water.

Similar measurements were taken in PS33, with the result depicted in Figure 34, in which the 28-07 measurement for the Bakr drain was considered an outlier due to its very high value with regard to the comparable Hosha drain. The difference is difficult to explain, but possibly caused by a measuring error.

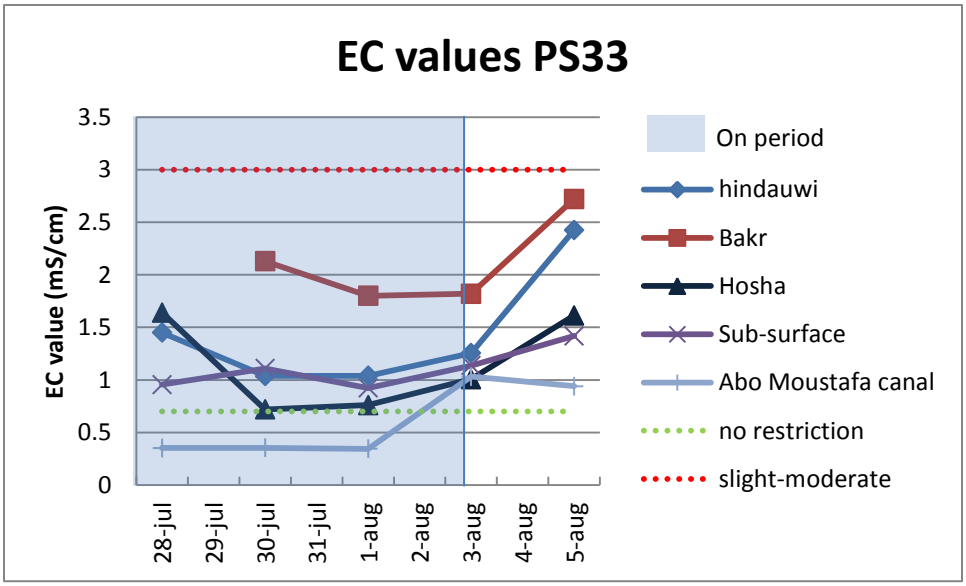


Figure 34 - EC measurement values PS33, minus one deviating value

This graph shows even more clearly how the surface drain water quality deteriorates quickly after the on-period has ended. Two days after, the Bakr drain is approaching the critical value for severe restriction on use.

As stated before, farmers use the drain water during the on-period and one or two days after. It is a back-up to supplement canal water supply if the allocated amount does not suffice to irrigate the field fully[151], if the turn was missed because of a lack of water in the canal[152] or if more water is required during for instance transplanting. It is thus not as much used to bridge the lack of water during off-periods, but rather to try to increase the irrigation time during the on-periods.

The drains are small and carry little water. Farmers in PS31 have blocked the drain permanently in two places, to make sure the water level rises and it is possible to irrigate with the individually owned pumps (Figure 35). Other farmers did not mind this practice[153]. There is no competition or coordination among farmers for abstracting the drainage water. Whenever drainage water use was observed during July and August, there would be a maximum of one person irrigating per drain. This was said to be a coincidence though, and not based on any agreements[154].

Figure 35 - Farmers have blocked the north Hosha drain in PS31 (26-07-2013) (See also: Figure 38)

[151] Interview farmer PS33, 28-06-2013
[152] Interview Youssef PS33, 24-06-2013; ; Interview farmer PS33, 06-07-2013; Interview farmers PS33, 30-07-2013; Interview farmers PS33, 20-07-2013; Interview Khaled PS31, 05-07-2013;
[153] Interview Ahmed PS31, 28-07-2013
[154] Interview farmers PS33, 20-07-2013

The individually owned pumps are placed next to the drains surrounding the mesqa and normally not moved during the season[155]. The question arises why it is that these pumps do not run the risk of being stolen, while the pumping stations have to be locked and looked after. Possibly it has something to do with the difference between private and communal property, but this is quite unclear. Pumps normally belong to one farmer and date back from the time before IIP, some being reported to be about 20 years old[156]. The pumps which were once on the mesqa, are now on the drain; something which was hardly the case before the implementation of IIP[157]. For both mesqas, the individually owned pumps were mapped. The results for PS33 can be seen in Figure 36, where the black lines indicate farm boundaries and the markers individually owned pumps.

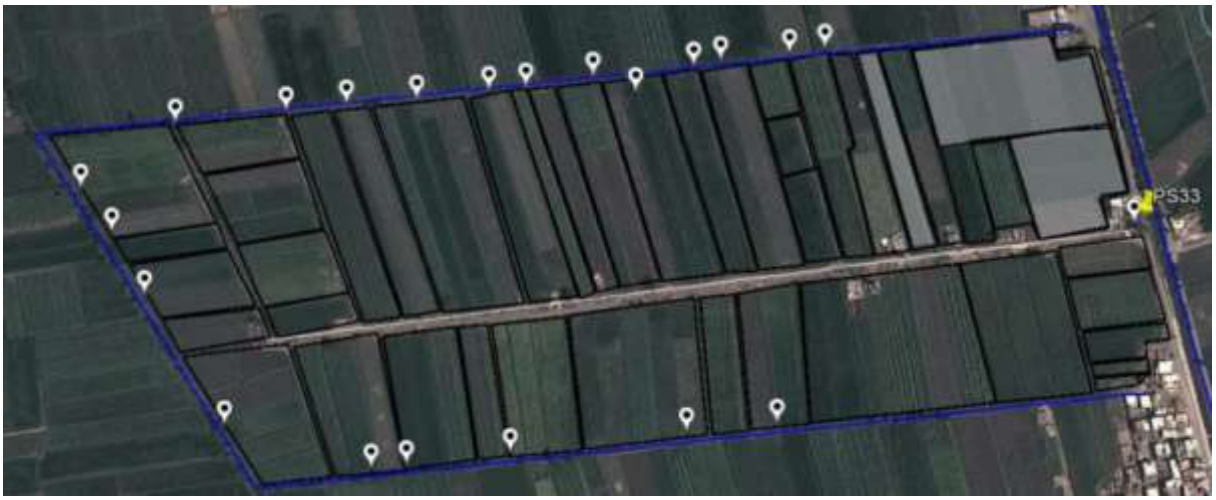


Figure 36 - Individually owned pumps on the drains of PS33

It is remarkable how almost every farmer has his own pump on the drain. Only at the beginning of both drains, where they are so small that they are practically non-existent, there are none. The areas indicated in white are served by individually owned pumps on the canal, and thus do not need the drain. One farmer on the Hosha drain does not have money for his own diesel pump. He uses a portable diesel pump of smaller capacity to irrigate his land when needed[158]. It is important to note how the perpendicular character of the fields to the drain contributes to the accessibility of drain water. Where the fields are parallel to the drain, the inner fields do not have private access. However, this does not mean that they do not use drain water.

A farmer on the Hindauwi drain pumps water with his pump into a ditch along the fields. From here, the farmers use a small, portable pump to transfer the water onto their fields (Figure 37). This agreement is based on trust and understanding, with receiving farmers paying no other fees than the diesel costs of the pump on the Mukhezin drain[159].

Figure 37 - Sharing of drain water in PS33

[155] Interview farmers PS33, 25-06-2013
[156] Interview farmers PS33, 30-07-2013
[157] Interview farmers PS33, 13-07-2013; Interview Ahmed PS31, 28-07-2013
158 Interview farmers PS33, 06-07-2013
159 Interview farmers PS33, 06-07-2013

Only one farmer in PS33 has installed his IP directly on the sub-surface drainage system.

The pumps are generally owned by the person who also owns the land, but sharecroppers and renters do have full use rights of the pumps as long as they pay for its operation[160].

When looking at the individually owned pumps on the drains of PS31 (Figure 38), it is immediately clear that this mesqa has fewer of them than PS33. Even taking into account the smaller size of the mesqa, does not explain the smaller numbers. In PS33 there is one pump per 3.6 feddan, in PS31 this is 6.5 feddan.

Figure 38 - Individually owned pumps on the drains of PS31

There is only one pump on the Mukhezin drain, even though it carries the most water of all the drains in both PS33 and PS31. This pump is supposedly shared with other users in times of high water demand[161], but this was not observed during July or August 2013. One farmer reported being able to rent the pump of a neighbour for 20-30 LE/hour[162].

The lack of pumps in PS31 indicates that the available water supply is meeting the demands of farmers in such a way, that drain water use is not appealing to them. At the same time, it is possible that the lay-out of the mesqa has something do to with it. Where PS33 has perpendicular fields, PS31 has fields mostly parallel to the drain. This makes it more difficult for farmers along the mesqa to irrigate from the drain.

IIP has not reduced the use of drain water in this specific area, but has rather encouraged it. It should be noted, that this is strictly speaking illegal according to the 1982 law 12, article 48: "*The use of drain water shall not be allowed for irrigation purposes unless with a license from the Ministry of Irrigation and according to the conditions determined by the Ministry*" (Wahaab and Omar, undated).

[160] Interview farmer PS33, 20-07-2013
[161] Interview Ahmed PS31, 28-07-2013
[162] Interview widow farmer PS31, 15-07-2013

8.3.Concluding remarks

This chapter shows that farmers manage to expand their collective of natural and social elements, by opting for a different water source, using additional pieces of technology and constructing another set of practices around exchanging and concentrating water turns. Where the technology of the PS has a communal character, the pumps on the drains have an individual one. The practices of sharing are not based on a schedule or rules, but rather on mutual trust and whether or not they are comfortable with each other. This expanse in the collective leads automatically to different outcomes in terms of water availability. Especially in PS33, the addition of pumps on the drains means an increased water security for a lot of farmers. It makes the flaws in the mesqa- and IIP-order (uncertain and irregular water supply and dependence on each other) more bearable, by providing an alternative water source. The quality of this water is clearly worse than the canal water and it is only available/useable at certain points in time, but it allows farmers to irrigate their rice when it would have otherwise been standing in a dry field.

It stands out that PS31 has much fewer pumps on the drains than PS33. The most straightforward explanation for this is that the water availability is larger in PS31, as it has fewer feddan to irrigate and both more time and capacity to do so (as explained in chapter 7). This makes using the inferior drainage water less necessary, leading to fewer pumps. One could say that PS31 has appropriated the pumping station in such a way that it makes it less necessary to use drainage water. PS33 has not been able to do this, therefore changing the water network in a different way and expanding it to include the drains. The different changes in the schedule seem to be more pervasive in PS33 than in PS31 as well. This indicates a higher level of collective action, tied to the level of water scarcity. This resonates with the idea of Wade (1988) that water scarcity and collective action are linked, a notion further elaborated upon in the discussion chapter of this thesis.

9. Conclusion

The IIP was a major effort at re-ordering the socio-technical water network in the Abo Moustafa canal, at both canal, mesqa and field level. The biggest impact had the newly introduced one-point lifting system, requiring farmers to act collectively around water use. The relations between farmers were thus redefined, from being rather individual actors in a mesqa to being dependent on each other for water. Where farmers before were mostly tied to their individually owned pump, they were now forced to interact with the pumping station. Their individually owned pump had allowed them to irrigate freely at any given time, but the pumping station forced farmers into scheduling water turns. To execute the schedule and operate the pumping station, an operator was needed. Resultant salary and diesel costs also required collecting money among water users, while before each person bore the costs of his own pump.

The mode of ordering of the IIP was based on collective water use, control of water abstraction through the reduction of lifting points, institutional formalisation and a rather aquacentric mind-set. This in no way resembled the mode of ordering prevalent in the mesqas along Abo Moustafa canal. There, water users operate according to a logic of independence, freedom and institutional diversification, reflected in the previous orders around saqias and individual pumps.

As soon as the IIP 'improvement' package had been implemented, water users started appropriating its technology and re-ordering the network. One of the drivers informing this re-ordering was that the rotational system was never replaced with continuous flow, while the pumping station's capacity was designed for meeting water needs through pumping continuously. This resulted in an induced water shortage at times of high water demand and made night irrigation and strict scheduling necessary.

The configuration of the IIP-based network aimed to have the pumping station as its only water lifting technology. Its envisioned role in the network would be guaranteed through a strategy of embedding the pumping station in the community of water users through a process of participation in design, operation and maintenance, embodied by the creation of a WUA. However, the relations between water users and the pumping station turned out to be weak. Partly because the participation was only paid lip-service to, partly because the idea of collective pumping did not fit the local mode of ordering of independence and flexibility and finally because the technology of collective pumping induced water scarcity in a waterscape with irregular and low water levels.

Despite the weak relations between the pumping station and the water users, it has remained part of the network until now. The pumping station is linked to the pipeline and the valves, anchoring it structurally in the landscape and giving it a certain durability. Removing the pumping station would also mean taking out the pipeline and valves, in order to facilitate going back to a system based on individuality. This requires a large amount of investment funds, which do not seem to be available within the network at this time. However, even though the pumping station has remained within the network, its position is not as envisioned by the IIP order. It is not the only source of water; rather it is supplemented through drainage water lifted by individually operated pumps. The practices around the use of drainage water reflect those around the use of canal water before IIP: each farmer decides for himself when and how much water he wants to pump; there is no organisation and no regulations. It shows how there is a strong, durable relation between technical aspects of the order (individually operated pumps) and the social aspects (no regulations on use) leading to the desired

flexibility and independence for users, tuned into and mitigating the irregularities in water supply. The implementation of the IIP led to the move of the technology from the open mesqa to the drain (changing the “software” from canal water to drainage water), but the relations have kept the same characteristics.

It is thus clear that the position of the pumping station in the IIP network was not durable in any way. Its current status however, seems to be rather unchanged over the last 10 years. Both social and technical re-ordering have incorporated the pumping station in the network in a way with fits better with the local mode of ordering. The idea of a central WUA with high user involvement has been replaced by a system in which tasks are divided over a limited number of individuals and regular water users have few tasks in operating or maintaining the pumping station. A schedule which has been the same for the last 10 years regulates which valve can open at what time, limiting the need for interaction between water users. In a way, the most important level of co-operation between farmers has been brought back to valve/saqia level, mimicking the order that was there before the implementation of the IIP. Tying this to the increase in pump capacity and a consequent increase in water availability, the burden of sharing water has been brought down to a more acceptable level for water users, especially in the light of the ability to supplement irrigation through the individually managed pumps.

The durable relations in this network are those which fit best with the mode of ordering of independence and flexibility, and are geared towards dealing with the irregular water supply the mesqa is facing. While the system of low collective action and individually owned pumps is most tuned in to this, the social re-ordering and technical appropriation of the pumping station have partly secured the pumping station’s spot in the network. However, a large part of this durability is due to the fact that it would require too many investment funds to radically re-order the water network and remove the pumping station, pipeline and valves altogether. Therefore it is likely that at some point in time, the water network in the case study mesqas will return to a system of individual pumping, as can already be observed in other areas along the Abo Moustafa canal.

10. Discussion

This final chapter reflects on the results, the methods and the concepts used. It starts off by discussing the representativeness of the results, both within the IIP area and for the larger field of large scale canal irrigation in general. It then continues with a reflection on the methodology, outlining especially the challenges and limitations of this study. Finally, the strengths and weaknesses of the used concepts are discussed.

10.1. Discussion of results

This section is divided in two sub-sections: one discussing how the results of this research should be read in the light of the larger Irrigation Improvement Project and one comparing some of the issues found with results from research done in other parts of the world.

Representativeness within the IIP area

By comparing the two mesqas, it becomes already clear that there is a wide variety of ways in which water users re-order their system. When looking at the entire canal, this is even more true – in both technical and social aspects. One of the main factors in choosing different pathways, ranging from massive to minimal re-ordering after IIP, is water availability. It seems that pumping stations at the beginning of the canal function more in line with the IIP plan than those in the mid- or end-section. Reduced water availability thus seems to increase the level of re-ordering undertaken at mesqa level. Extending the notion that water availability impacts the level of re-ordering and noting that Abo Moustafa is located in the tail-end of the Meet Yazid canal command area, it is likely that the situation is quite different in the head- or mid-section of Meet Yazid. If the pattern of Abo Moustafa can be extended to system level, it would mean that the IIP package is increasingly altered when travelling downstream. However, unlike at system level, none of the mesqas along Abo Moustafa canal experience abundance in water supply, making this statement a very tentative one.

Apart from water availability due to location, size is also of big importance. It seems that small mesqas (<50 feddan) experience less problems irrigating from the pumping station only, as they have relatively more water per feddan and probably face less transaction costs in organising themselves.

The two case study mesqas have almost the same position in the canal, but differ in level of conflict and problems they face, and also in the amount of technical adjustments they have implemented. PS31 is smaller and has for that very reason witnessed less severe water scarcity from the very start of the IIP, due to its more beneficial pump capacity/area ratio. Later water availability was further augmented by increasing the number of pumping hours by lowering the intake and by increasing the capacity of the pumps. Water scarcity is often said to induce successful collective action, as farmers are forced into and benefit from collaboration. Wade (1988) found that there is a relation between water scarcity and the level of collective action. Later this was specified by Uphoff et al. (1990) into a curve, with little collective action taking place at very low and very high levels of water scarcity, while the most occurs somewhere in between (Figure 39). It does seem that PS33, experiencing more water scarcity, has higher levels of collective action than PS31, with more interaction and more water sharing between farmers. This indeed supports the theory outlined above.

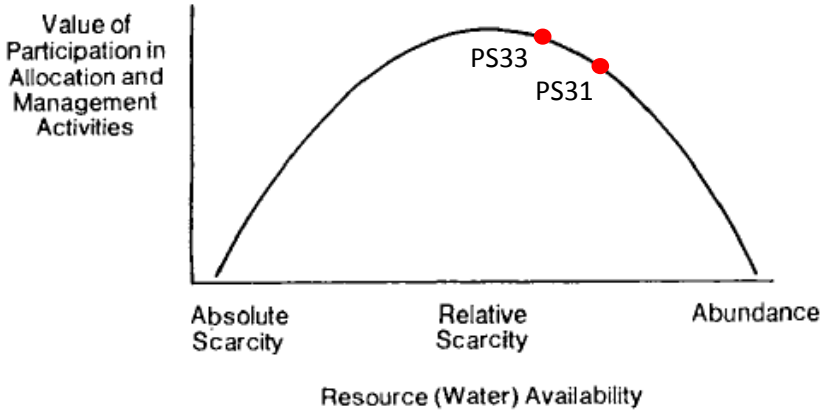


Figure 39 - Curve describing the relation between collective action and water scarcity (adapted from Uphoff et al., 1990)

However, where Wade sees water scarcity as the main driver behind the level of collective action, this can be questioned when looking at the mesqas along the Abo Moustafa canal. Farmers are willing to invest in a new system which might not increase their water availability, but will indeed reduce the level of collective action. In the mesqa of PS31, farmers are not experiencing the same level of water shortage as in PS33, but they are in fact more bothered by the lack of freedom in their system. They do not want to act collectively and are planning to create a system which will give each farmer his own pump. This means that they will drop vertically, off the curve and settle for a similar level of water security, but with less collective action, a situation not taken into account in this theory.

This indicates that not only water scarcity is a major determinant of collective action, but for instance also the drudgery and problems that come with this collective action. Very simply put: In areas where farmers are able to work together more easily, collective action is more likely to occur. The mesqa case studies point out that, especially in a small collective of people, the behaviour and nature of individuals play a big role in this. PS33 has strong family ties among water users, which could be beneficial for collective action. PS31 has a similar level of kinship however, without the same positive outcomes. Family ties as such are thus not an indication of strong collective action. The difference between the mesqas seems to be not the number of relations between people, but rather the nature and quality of it. Farmers in PS33 spend more time in and around their fields, which seems to make them closer to each other. Unlike in PS31, where on most days people spent little time in the mesqa and operate more on an individual basis. One result of the good relations between people in PS33, is the trust farmers have in their operator. It makes that they do not worry about the daily operation of the pumping station, lowering the level of drudgery and facilitating collective action. It is also part of a self-fulfilling prophecy: choose a good man for an important job and he will do good work – choose an inferior man for an inferior job and he will do inferior work.

On the basis of this analysis, a hypothesis can be formed for extending the results of this case study to the rest of the IIP command area: "*A head-end location, a large pump capacity/area ratio, a low level of water scarcity lead to a more successful functioning of the IIP order at mesqa level*". There are many more factors to consider, one of which is the effort it costs farmers to act collectively, which in turn depends on many aspects which this study has only touched upon.

General relevance of results – conjunctive use and irrigation efficiency

The conjunctive use of fresh canal water and agricultural drainage water is common practice in many canal irrigation systems in arid regions (Qadir et al, 2007). So far this seems to have led to two main types of research: a first group looks at describing the negative effects (reduction in yield, salinization of soils or negative impacts on human health due to direct contact with toxic components or bacterially infected water) and possibilities for mitigating those (e.g, Willardson et al., 1997), and a second group has opened up the impact of re-use on the concept of water use efficiency (e.g. Molden et al., 2010; Lankford, 2006).

The case study described in this thesis is yet another example of how re-use can contribute to achieving higher water use efficiencies and illustrates that scale is important in this: water reuse takes place at both branch canal and mesqa level. It contests the notion that farmers in the Nile delta would waste water by over-irrigating, but rather emphasises that water efficiency is already high through extensive reuse. The possibilities for further water savings should be viewed through this lens. The case study also shows how farmers' reuse practices minimize the downsides of lesser water quality and optimise water availability at plot level. However, the fact that farmers make it work to some extent does not mean that the water has the same quality as the canal water. Salinity levels in the drains are always higher than those in the branch canal. Formalising the use of drain water, as is done in Abo Moustafa canal at branch canal level, carries the danger that tail-end farmers are going to have to make due with water of an inferior quality. This raises questions of water equity not only encompassing quantity, but especially quality issues.

This case also describes a shift in water availability as a result of the reuse that seems to be less documented so far, or at least not emphasised by many scholars. The re-use of drainage water, in combination with the piped mesqa system, has created a gradient in the mesqa in which water availability is *higher* in the tail-end than and *lower* in the head-end. Canal water is divided rather equally among the head- and tail-end plots, but drainage water is not. The IIP has changed the classical head-tail end situation at mesqa, as drainage water has become an important supplementary source of irrigation and is more available in the tail-end. This is also reflected at canal level, where water is pumped into the canal at the beginning and at the end, creating a situation in which water is least available in the middle.

The multitude of water flows in irrigation systems should be kept in mind when thinking of issues like water equity, water availability and water use efficiency, as many cases, including this one, have demonstrated that water hardly ever simply flows from head to tail. At the same time, the dichotomy between "fresh" canal water and "dirty" drainage water might deserve some rethinking, in places where the mixing of water sources is becoming increasingly popular and institutionalised.

General relevance of results – Modernisation of irrigation systems

The IIP fits into the larger trend of irrigation modernisation projects, in which technological and institutional change ought to lead to increased productivity and water use efficiency. Van Halsema (2002) describes two major schools of thought in irrigation modernisation, where one focusses on meeting crop water requirements and the other on meeting users' demands. The IIP is in fact a combination of both. The designed system is one which depends on continuous flow and downstream control, thus giving users the freedom to irrigate when they want. However, with the

idea in mind that farmers most likely will over-irrigate when given the chance, their water abstraction is restricted through the technology of single-lift pumping stations which are designed to meet crop water requirements.

Van Halsema's "canal safari" (p2-4) describing modernised irrigation in the Peshawar valley, mirrors the situation along Abo Moustafa: an initial impression of a successful project, quickly followed by the feeling that something is not quite right. Striking is how in both locations the story of irrigation modernisation is advertised and told, while practices display a different situation. Whether they are outlets in Pakistan or AVIS gates in Egypt, infrastructure remains most visible as proof of the successful modernisation, even though it is obvious to all that they are not in use.

While some (eg. Plusquellec, 2009; Burt, 2013) keep insisting that reported failures of modernisation are due to introducing the wrong technology and inadequate institutions, an argument could be made that in fact the "right" technology and "right" institutions cannot be 'designed' for large-scale irrigation projects. Possibly, every system will be reshaped by its users until it fits; and the fit will likely change over time. In the process, the system will produce new outcomes, unexpected and changing. Engineering in such a context requires a whole new attitude, one which recognises that the *links* between technical and social actors are crucial and that a network has to be created in which these are strong, meeting users' ideas of ordering. Veldwish et al. (2009) propose an engineering approach based on the prototyping of water networks on the ground, built on interaction and flexibility, rather than on the rigid design-cycle and black box technologies often used in current projects such as the IIP. Apart from a shift in the mind-set of engineers, this also requires a whole new structure of funding and project planning from donors; making it an ambitious but necessary change.

General relevance of results – Participation of who?

The case studies described in this thesis point at the existence of different groups within one mesqa, partially divided along the lines of tenure status: land owners and land renters/sharecroppers who have different sets of rights and responsibilities. Where land owners are expected to pay for the alterations to the pumping stations, water users (including sharecroppers and renters) pay for its daily operation and maintenance. Those who agreed to the new system were all land owners, which seems to be one of the requirements for members in the WUA board. Bypassing for now the fact that none of the water users had any real choice in accepting the IIP, the project's focus on land owners a priori gave no voice to sharecroppers or renters in deciding on the implementation of the new system.

Focussing on land owners, who are clearly and legally attached to the land for a longer period of time, might make sense for projects where there is a large investment which farmers are supposed to pay back. However, interests and roles of absent land owners and water users are likely to be different. Projects like the IIP should think about whose needs they want to cater for, what those are and how costs and benefits should be divided. Water users are ultimately the ones influencing the much talked about water use efficiency and productivity, much more than those who own land but are not directly involved in water management practices. However, looking at the current implementation of IIP, the involvement of any of the water users would already be a big step forward.

10.2. Discussion of methods

I conducted this study in the summer of 2013 against the back-drop of nation-wide social and political unrest, which influenced the study in different ways. First of all, it limited the number of days when field work was possible, causing restrictions on data collection. Secondly, it naturally occupied the minds of most Egyptians, making them less eager to talk about other issues than the political situation. This limited the topics that could be discussed during interviews. Finally, the stressful and at times scary moments caused by the revolution coloured my perceptions and reduced my ability to focus on collecting and analysing my data.

I worked together with an Egyptian female agricultural engineering student, which proved to bring its own challenges. Integrating university requirements and personal interests from both her and my side was difficult, leading at times to struggles and uncertainties about the research objective and research methods. A basic example of misunderstandings was the use of the word “system”, from which she understood the technical lay-out of pumps and pipes and I the socio-technical water-network as described in this thesis. It once again illustrates the challenges in conducting interdisciplinary research and the necessity of establishing a shared language and understanding.

Working in Egyptian rural society, the fact that we were both women brought both advantages and disadvantages. We were able to talk to women freely and enter houses without problems that might be encountered by male researchers. This gave us the freedom to interview some of the widows and other women in the mesqa, giving us information on how the IIP had impacted them specifically. People felt a need to take care of us, as we were “only” two girls. This gave us the comfortable position of being able to ask many questions, as people were quite patient with two girls of the same age as their daughters. However, our freedom was also limited, with one farmer forbidding us to go into the mesqa because it would be too dangerous. My research partner at times felt uncomfortable talking to men, which was especially a problem in the beginning of the field work. For me it was difficult to understand why and when these problems arose, which was also part of the cultural barrier between us. Eventually we stayed in the same area and got to know the people, which made things less complicated.

Looking at the different positions of men and women in Egypt, working with a female engineering student was a definite advantage. At the start of the research, I worked with several male engineers, who would sometimes be more reluctant to translate what the farmers were saying and would rather explain the situation to me themselves. This attitude made it very difficult to connect to the farmers and get a better understanding of the various components of the system.

Being a Westerner brought out some fear in people. They were sometimes afraid I was a spy from Israel or Ethiopia, the last country being in the news for building a dam which farmers believed would reduce their water availability. The suspicions would be raised time and again, with interviewees being convinced that we were not actually students, that I was not from The Netherlands and that we were there to harm them. At some point, our supervisors even had to come to the field to explain to some of the farmers who we were and what we were doing. Near the end of the research, most of these fears were no longer expressed and a certain relationship of trust had been established.

The translation from Arabic to English often resulted in quite some information being lost, worsened by my limited understanding of traditional Egyptian society. Certain things that are automatically understood by Egyptians were difficult to grasp for me, especially the wide set of normative rules

and cultural practices that exist in society. My research partner was not an experienced translator and sometimes not able to translate all that was said. Because of the language and cultural barrier, I experienced difficulty in understanding when interviewees were no longer interested in talking, uncomfortable or nervous.

While I tried to keep an open mind in this research and not bring too many prejudices to bear around the IIP, there were certain biases inherent to the study. First of all, we chose case study mesqas that were in the most water short area and had pumping stations that were altered in some way. We had a bias towards looking for a location where farmers reshaped their system, in order to shed light on that much ignored aspect. However, as also indicated elsewhere in this thesis, the large majority of pumping stations had gone to some sort of appropriation since the implementation of the IIP. Furthermore, the concepts I used required to let go off many assumptions about how a system is structured (for instance the division between social and technical elements) and while I tried, it proved to be much more difficult than I expected. This last issue is addressed more in the section below: the discussion of concepts.

10.3. Discussion of concepts

The central concepts in this thesis were technology appropriation and re-ordering, based on actor-network theory. In this section these concepts are again discussed, with the results of the research in mind, to assess their capacity to guide the collection, structuring, analysis and explanation of the data.

First of all, I argue that employing the concept of re-ordering is as much a methodological choice as a theoretical one. It opens up the mind to study relations between actors, without assuming to know their nature beforehand. While this is one of its strengths, it is also one of its biggest challenges for the researcher: how do you let go of assumptions that are so built into all aspects of society and after you let go, what guides your research? The level to which it is possible to succeed in this seems to depend on the methodology, reflection on analysis and quite a bit of practice. I mention the practice and reflection because using actor-network theory requires the researcher to let go of the thought patterns he/she is used to. This is not something which is done overnight and requires quite some perseverance. While I do not claim to have grasped the concepts and approach fully, I feel using the concept of re-ordering has given me a better understanding of how certain results are produced, and why some relations/situations are more durable or likely to come back than others. It allows for an all-compassing analysis of a system, persuading the researcher to not focus on merely one aspect of it.

In this study, boundaries were set around water use in two tertiary units and the studying of the network was guided by clear research objectives and a time constraint. As the network is not a nicely delimited area or group of actors, any boundary that is put in place is artificial. However, it seems unavoidable as any study will face a limitation in time and means.

Using the theory of re-ordering, with its lack of assumptions, in this thesis, led to very different conclusions than those published in the previous studies on the IIP. Those were centred around notions of conveyance efficiency, land savings, yield – measurable things – and based on quantitative methods. They did not leave room for studying *how* outcomes are produced; rather they looked at a

limited number of factors. The theory of re-ordering (and appropriation for that matter) is well suited to answering how-questions. It is less equipped to explain the why-questions that inevitably follow. The concept of durability and its three different sources (physical structure, strategy, mode of ordering) are a good start to overcome that gap, but could be further extended. For example, actors in a network are also limited in their capacity to re-order certain relations, simply by not having the resources within their network. For instance, a mesqa with a lot of farmers having secondary non-agricultural incomes has a larger network, tied to more monetary resources, than a mesqa in which all farmers depend on agriculture. This is likely to influence the ability to invest in changes to technology for instance. This line of reasoning argues for including notions of network size and make-up in the concept of durability.

The incorporation of technology appropriation within the concept of re-ordering is a fairly easy one, leading to a larger focus on technology and the relations it has with other actors. In the light of intervention, it gives a good understanding of how and why technology is reshaped. It matches the notion of modes of ordering – in that users will try to fit a technology to their needs – and it adds the idea of open and closed technologies. The level of openness can be linked with durability through physical presence, but expands that notion by saying that some physical presence is more durable than others.

A final note on the concept of re-ordering, is the inescapable ordering that is done by any researcher who attempts to write down his/her data in a coherent way. A thesis or paper cannot be written without a structure, and this structure is artificial to the world it is trying to describe. This thesis is caught up in this same paradox already described by Law (1994): it is studying the process of re-ordering while being a part of it. One can regard this statement as a disclaimer that the author of this thesis is fully aware of this fact and in no way claims to have written the only version of the truth.

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Annex I – Tables of corrected and uncorrected EC values PS31, PS33 and Abo Moustafa canal

Location	**Hindauwi drain**		
N	31°19'25.1		
E	030°55'35.3		

Date	on/off	EC (mS/cm)	EC-T (mS/cm)	T (°C)
28-jul	on-day 2	2	1	25.4
30-jul	on-day 4	1	1	25.2
1-aug	on-day 6	1.24	1.04	25.3
3-aug	off-day 1	2	1	26.1
5-aug	off-day 3	3	2	26.4

Location	**Bakr drain**		
N	31°19'32.3		
E	030°55'38.8		

Date	on/off	EC (mS/cm)	EC-T (mS/cm)	T (°C)
28-jul	on-day 2	9	7	25.6
30-jul	on-day 4	2.71	2.13	26.4
1-aug	on-day 6	2.2	1.8	26
3-aug	off-day 1	2	2	26.8
5-aug	off-day 3	3	3	26.7

Location	**Hosha drain**		
N	31°19'21.9		
E	030°55'46.6		

Date	on/off	EC (mS/cm)	EC-T (mS/cm)	T (°C)
28-jul	on-day 2	2	2	25.1
30-jul	on-day 4	0.864	0.719	25.4
1-aug	on-day 6	0.9	0.76	25.1
3-aug	off-day 1	1	1	26.1
5-aug	off-day 3	2	2	26.8

Location	**Sub-surface drainage**		
N	31°19'28.2		
E	030°56'02.8		

Date	on/off	EC (mS/cm)	EC-T (mS/cm)	T (°C)
28-jul	on-day 2	1	1	26.2

30-jul	on-day 4	1.35	1.11	26.3
1-aug	on-day 6	1	0.923	26.2
3-aug	off-day 1	1	1	26.1
5-aug	off-day 3	2	1	25.9

Location	**Hosha drain, left side**			
N	31°19'32.9			
E	030°56'36.8			
Date	on/off	EC (mS)	EC-T (mS)	T (°C)
26-jul	Off	2	2	25.6
28-jul	on-day 2	1	0.926	26.7
30-jul	on-day 4	1.01	0.797	28.8
1-aug	on-day 6	0.934	0.758	27.5
3-aug	off-day 1	1	0.904	28.4
5-aug	off-day 3	3	2	25.6

Location	**Sub-surface drain near Hosha drain. left side**			
N	31°19'33.7			
E	030°56'38.1			
Date	on/off	EC (mS)	EC-T (mS)	T (°C)
26-jul	Off	6.70	5.66	24.7
28-jul	on-day 2	5.39	4.60	25.0
30-jul	on-day 4	4.15	3.52	25.3
1-aug	on-day 6	3.56	3.00	25.1
3-aug	off-day 1	5.07	4.30	25.3
5-aug	off-day 3	6.24	5.31	24.9

Location	**Mukhezen drain**			
N	31°19'33.6			
E	030°56'44.9			
Date	on/off	EC (mS)	EC-T (mS)	T (°C)
26-jul	Off	4.25	3.48	27.5
28-jul	on-day 2	1.78	1.40	28.6
30-jul	on-day 4	1.62	1.28	29.4
1-aug	on-day 6	1.27	1.03	27.8
3-aug	off-day 1	2.24	1.91	29.2
5-aug	off-day 3	9.13	7.55	26.3

Location	**Hosha drain. right side**

N	31°19'23.0		
E	030°56'43.2		

Date	on/off	EC (mS)	EC-T (mS)	T (°C)
26-jul	Off	1.93	1.60	25.3
28-jul	on-day 2	1.03	0.84	26.5
30-jul	on-day 4	0.69	0.55	28.5
1-aug	on-day 6	0.76	0.62	26.6
3-aug	off-day 1	0.97	0.79	26.8
5-aug	off-day 3	1.43	1.17	26.8

Location	**Abo Moustafa canal**		
N	31° 19.385		
E	030° 56.208		

Date	on/off	EC (mS/cm)	EC-T (mS/cm)	T (°C)
26-jul	off	1.36	1.11	27.1
28-jul	on-day 2	0.45	0.35	29.1
30-jul	on-day 4	0.46	0.35	30.3
1-aug	on-day 6	0.44	0.35	29.1
3-aug	off-day 1	1.32	1.03	29.6
5-aug	off-day 3	1.14	0.94	26.3