The Paradox of Water Distribution in Tuweir Minor Canal: Lessons Learned from Gezira Scheme, Sudan

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Abstract

Gezira Scheme was designed for cotton production. It was designed to serve water to 50% of its gross command area in two consecutive growing seasons (summer and winter). But later, in the 1960s, a crop diversification and intensification policy was implemented in the Scheme. That results to operate the system over its capacity; together with an increment of the actual sedimentation rate from the Blue Nile's catchment, silt to enter the canal system has increased. Consequently, operation and maintenance costs have risen to a point that is beyond the capacity of the government. This in turn could affect water distribution. However, it was not clear, where and how the water distribution change in the scheme. This paper investigates the water distribution on a minor canal called Tuweir which is a part of a big project, the Blue Nile programme, implemented to analyse the situations on operation and maintenance in depth. Both socio-economic and bio-physical data were collected through interviewing, field observations, and measurements. The result implies, though it is difficult to claim that water distribution in the past was well planned and optimal, there was at least relatively formal, predictable and specified water indenting system that

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Introduction

The Gezira Irrigation Scheme reclines south of Khartoum between the Blue and White Nile Rivers. The scheme is one of the largest and oldest irrigation schemes **(880,000 ha)** on the African continent. The Gezira Scheme gets its irrigation water from the Sennar and Roseires Dams on the Blue Nile River. The irrigation system comprises two main canals (Managil and Gezira) running from the head-works at Sennar Dam to a common pool at the cross-regulator at 57 km. At this junction, the Managil canal divides into 4 branches, to divert water to the Managil extension; while, the Gezira main canal flows an additional 137 km northwards.

The annual water discharge of the Blue Nile is estimated on average to be 50 billion cubic meters measured at Roseires (Ahmed 2000-cited by Eldaw 2004). Based on the Nile water agreement between Sudan and Egypt in 1959, the allocated water for Sudan was 18.5 billion cubic meters (37% of the Blue Nile). The Gezira Scheme is entitled to approximately 35 % of this share, which is 6.5 billion cubic meters (Eldaw, 2004). This has been used to irrigate 50% of the gross area in a season. The scheme was established by the British purposely for the cotton production before 1925 (Sennar Dam was completed in 1925). But in the 1960s with the diversification and intensification policy of the government, other crops like groundnuts, wheat, and vegetables had been introduced in the scheme.

X bufs! e jtusjcvujpo! jt! 'ui f! qspdftt! pg actual water proportioning in practice - 'ui f! dpodsfuf! e jtusjcvujpo! pg! x fux bufs - it is about water scheduling that is a certain amount of water per a certain area for certain time duration (Boelens, 2008) and (Uphoff, 1986). Ui f!sfmbujpo!cfux ffo!'i zesbvmjd!nbx t !ui f!'dpouspmjoh!sbtusvduvsft !jo!vtf!boe!ui f!tpdjp-ufdi o jdbmnjpl bhft! cfux ffo! ufdi o jr vft!)e f t jho ! pqfsbujpo ! n bjoufobodf ! 'vtfst ! boe! 'qspwje st ! pguo! nfibe! up! uzq jdbmq buufsot! pg e jtusjcvujpo!)Usfggofs! fu bm/! 31 21 /! Vtfst! and Providers refer both technical and social actors (operators, irrigation engineers and management bodies at different levels of the network). The typical patterns of distribution are proportional flow, rotational system, request or supply system, and head-end or tail-end control, along the command of irrigation canal.

The water distribution in the GS is the Gezira main canal conveys water to branches. From branch water flows to major canals as a continuous flow during the irrigation seasons (from July to April). From the major water is delivered to minor canals. The water distribution principle was at the beginning of the cropping season, the water requirement of the different crops in the minor first had to be calculated and transmitted to the engineer who would determine the amount of water that would be discharged to each reach of the minor canals. Accordingly, the required water from the higher levels to the minor had to be conveyed. From the minor canals water flows to Abu-Ishreens (Abu XX)-a small field ditch (tertiary channel) and from Abu XX to the field through Abu Sittas (Abu VI) - the smallest field channel. The Abu XX is designed to serve the ’Ovn c fs ! ps! ufsujbsz! vojt) 2 461 n ! y! 391 n 48/9! i fdubsf! rhoe ! bu gjyfe! joufswbmt pg 3: 3! n ! bnpoh! ui f! n jops! dboobmt)Bcv! YY t! ubl e off perpendicular of the minor canal). Field Outlet Pipes (FOPs) take-off the water at right angles (12 meters long with a 0.35 m diameter).

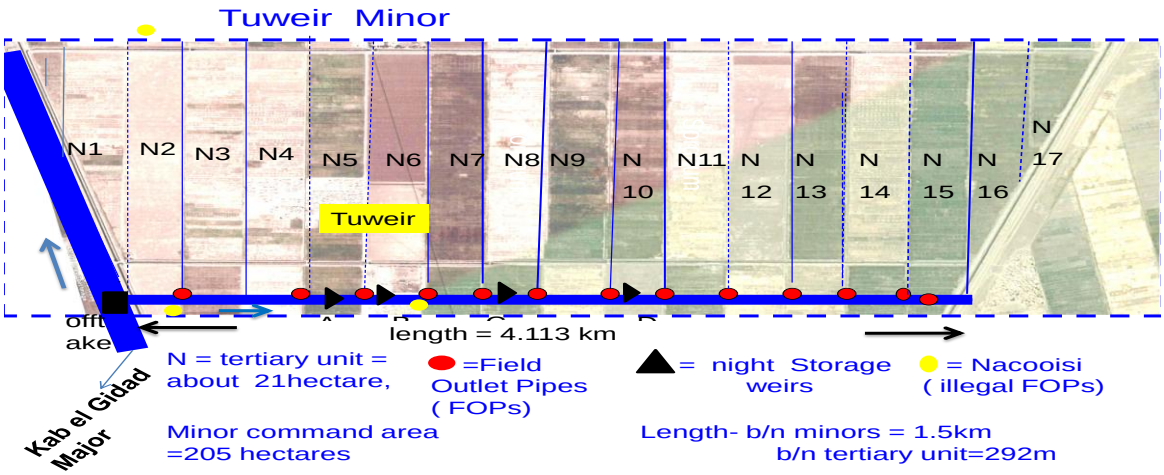

Figure 1: Tuweir minor canalization system

Generbmm! ui f! Tdi fn f! i bt! qmbzfe! b! tjhojgjdbou spmf! jo! ui f! dpvousz t! fdpopn jd! development. According to the World Bank (2000) report, the scheme has a long history of satisfactory performance, to the extent that it has been used as a model for designing and developing all other major irrigation systems in Sudan, especially up to the 1960s, when the scheme was operated at its designed capacity. However, in contrast to this historical appreciation before the 1960s, recently many studies showed that the scheme has deteriorated due to high siltation problems. This resulted in high sediment

accumulation problems in the scheme, and there is a need for high levels of financial capital to overcome this problem. However, the government supplied budget for O&M is insufficient to cover the capital outlay required to cope with the sedimentation qspcmfn /! Dpotfrvfoumz ! ui fsf! jt! b! nbdl ! pg! 'frvjuz! boe! sfmjbcjmjuz ! pg! x bufs! tvqqmz! up! tenants (World Bank, 2000). Therefore, this research was implemented to analyse what water distribution changes and impacts have taken place in the scheme.

Methodology

The study was conducted in 2010. The study area located 194 kilometer to the North from sennar dam, which is called Tuweir tertiary canal at the 'L bc! FmHjebe ! n bkps! canal at the tail of the Gezira irrigation scheme. The geographical location of the area is $14^{o}38^{1}$ longitude and $33^{o}34^{1}$ latitude; and altitude is 431m above sea level. The study area principal features are a level and nearly uniform topography of water retentive clay soils which keeps down losses from seepage. This soil slopes away from the Blue Nile and water therefore naturally runs through the irrigation canals by gravity. The annual rainfall is about 308 mm. The maximum mean temperature is 38^{o}c while the minimum temperature is about 22^{o}c. The main cash crops in the area include cotton and groundnut while sorghum is stable crop in the area.

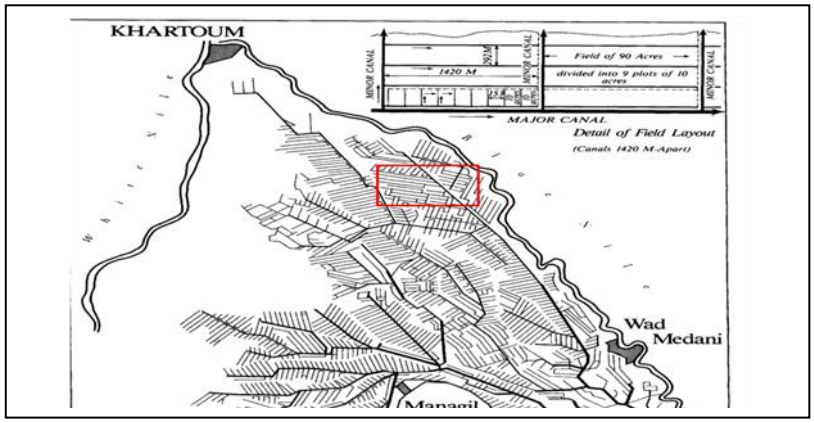

Figure 2: The Gezira Scheme)Tpvsdf ! 'Bhsjdvmuvsf! jo! Tvebo ! jo! X bmbdi ! 2: 99 , *the box in upper corner is the study site of the Kab El Gidad major*

The study was carried out between July and October of which six weeks were assigned to intensive fieldwork in the case study tertiary canal. Data were collected through

interviewing, field observations, and simple flow and water level measurements using float method. Three control points for flow (discharge) measurements are selected at Tuweir minor canal (minor 3); at the head, middle and tail. Design of the research and data cross-checking was done through a wide range of scientific literature and (local) policy documents.

Results and Discussion

The result will be discussed below on the basis of water distribution in theory (that is how water was intended to be distRibbuted among users in the scheme); and water distribution in practice (based on practical observations and interviews in Tuweir minor canal in 2010). The effects of water distribution changes on users, conclusions and recommendations will be also presented precisely.

Water Distribution in Theory

Indenting (Required water requesting)

As mentioned above, the principle of water distribution at each level up to the minor canals was based on the block inspector (BIs) request to the Sub Division Engineer (SDE). The request is made before the coming planting season; on the basis of the crop water requirements which are calculated by BIs. Actual distribution is done by considering the canal water carrying capacity (table 1) which is checked by the respective Engineers at each level. So, if too much irrigation water is requested by the BIs over the canal capacity which is checked by the engineers, the two actors need to negotiate to reach consensus.

During the planting seasons the request from BI to SDE occurs on weekly basis, i.e. every Tuesday as early as possible before 1:00 pm, but not later than 2:00 pm. After 2:00 pm indenting will not be considered for the afternoon change, it would only be jn qnfn foufe! jo! ui f! ofyu! n psojoh t! bnfsbujpo/! Ui jt! qspdfevsf! i fmqfe! up! n bjoubjo! b! steady uniform flow throughout the week in all the canals; and the indent is expressed in cubic meter per day (MOIHP, 1934). If a need arise to adjust the indents, it will be sent

to the Division Engineer on Saturdays. The adjustment should balance changes on different area within a major. So in this way farmers can irrigate according to their schedule.

Table 1. Gezira Scheme irrigation system components and their capacity

Canals	Number	Capacity(m^3/sec)	Length (km)	Av. width(m)
Main	2	354	261	50
Branches	11	25 to 120	651	30
Majors	107	1.2 to 15	1,652	20
Minors	1,500	0.5 to 1.5	8,119	6.0
Subtotal	**1068**	- - - - - - - -	**10,683**	- - - - - - -
Abu XXs	29,000	0.116	40,000	1.0
Abu VIs	350,000	0.05	100,000	0.5
Total	**380,068**	- - - - - - - - - -	**150,683**	- - - - - -

Source: Ahmed, 2009

Normally the above described indenting has become the norm with a long time history. Reports show that it has not been practised accurately since 20 years ago (Ahmed, et al, 1988). The researchers found many unclear indenting records, such as high peak indenting in October regardless of small area coverage for wheat during this time; peak crop water requirement records during the peak rain period of August. Water distribution in the scheme is continuously altered from time to time (Wallingford, 1991) due to different reasons. HRS and Wallingford (1988) reported that the indenting was not perfect- for instance without any change effected in the case of rain. It was reported in Tuweir minor, Kab El Gidad major, a severe reduction to less than 50% of the indent that lasted for over seven weeks in the 1987/88 season. World Bank also reported that ’vtvbmm!dmbjn t!pg!jofrvjuz!dbvtfe!cz!tjmbtion and weed infestation are frequently being n befc z!gbsn fst !)X psme!Cbol !2: : 1 !q/5 /!

Water Distribution in Practice

Nowadays, the above theoretically set indents are totally gone. WUAs have replaced the previous BI, but they are not functional. At present, WUAs may communicate the respective engineers just to give an overview of the type of crops that will grow in the

coming season based on their expectation. How much land will be covered and the actual crops to be grown in that particular season is not known to decide on the amount of water to be released from the dam and division box. Hence, the water distribution to each level could not consider the actual crop water needs or the canal capacity. No adjustment indenting in case of rain or peak crop water demands (interviews and observations). The operator at the off take of the minor responded that he will make a request to the respective engineer when he faces a serious problem like a canal breakout flow. But he will not make any request to facilitate a reliable, equal, on time water distribution bddpse joh!up!uif!dspqt !offe!ps!op!dbmmgps!bekvtun fout!up!i bwf!i fbmi z!boe! productive plant growth.

Water Distribution between Minors, in Kab El Gida Major

Without going through further analysis, the above explanation of ineffective indenting can create unequal water distribution between minors. Currently the water discharge which is released to each minor is based on a rough estimation instead of the theoretically restricting indents according to the crops need and canal capacity. Most of the minor off take operators were new employees who have no experience on fair water distribution to users. They were also influenced by some powerful farmers. For instance, the off takes of Tuweir and Kersh El Fil minors were operated by one operator, who has no experience on canal operation (new employed and he is a farmer). Simply from the observed gate opening of the two minors in the field one can see the difference of water distribution between these two minors (Figure 3). It shows, on the observed dates, mostly the Kersh El Fil minor gate was *fully opened* while, the Tuweir minor gate was opened partially. The difference was not originated from the actual share of water allocation for each minor, but simply frpn! Lfsti! FmGjmgbsn fst ! influence made on the operator. Because, the operator admitted that, the Kersh El Fil minor farmers come to him more frequently than the Tuweir minor farmers, to convince him to open their minor fully. This kind of water distribution is also practiced in other upstream and downstream minors of the Tuweir minor within the Kab El Gidad major. Evidently in some minors, it was observed that farmers themselves opened minor off take that can upset equal water distribution among water users.

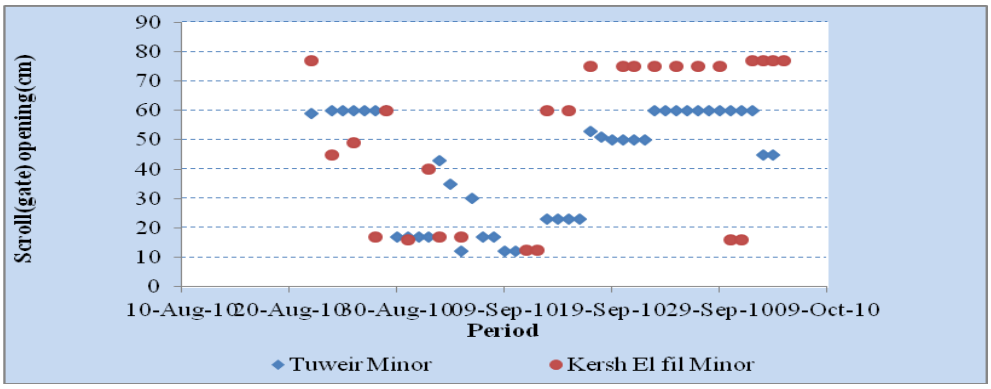

Figure 3. Gate opening of Tuweir and Kersh El Fil Minors showing poor irrigation water distribution in Gezira Scheme

Water Distribution between Numbers (tertiary units)

During the study, water distribution differences between tertiary units were realized. Some of the practical reasons for the water distribution difference that we understood during this assessment are presented below. These practices were important factors for water distribution differences among users not only between or within numbers but also between minors and majors.

Farmers Operation of Field Outlet Pipes

As mentioned above since there is no planned water distribution among users, farmers irrigate by their own perception about their crop water satisfaction. In this regard, one may irrigate his crop with too much or too little water. In Tuweir minor canal farmers x fsf! dpn qmbjo joh! bc pvu ui jt! t juv bujpo! bt! 'one takes more water than his crops need x i jmf! pui fst! bsf! tvggfs joh! gspn ! x bufs! ti psubhf! x jui jo! u f! n jops0ovn c fs / Figure 4 show that two farmers in this minor were irrigating their crops fully. Yet it was not observed that all of the farmers in Tuweir minor were irrigating their crops like what these gbsn fst! e je /! I fodf ! ui f! gbsn fst ! bdujpot! dbo! bggf du x bufs! bwbjmbc jmjuz! boe! f r ual water distribution for downstream users.

Differentiated management concerns amongst various types of farmers

There are different groups of farmers in the Scheme such as owners, sharecroppers, labourers and renters. These groups have their own sense of ownership and responsibility in managing the system. They also have different irrigation water

management experiences. In this scenario unequal water distribution between them is almost inevitable through one may leave the gate open to acquire more irrigation water than others; another one may not care about what will happen to others in the next day due to his action. Many owners in Tuweir argued that water management failures are experienced in the area, because most of the sharecroppers have insufficient experience to manage the water.

FOP1 **FOP6**

Figure 4: Two examples of excessively irrigated farmer fields while others are suffering from water shortage in Gezira Scheme

However, we argue that, rather than experience, as many sharecroppers do not own land, they want to maximize their yield as much as possible in a season. To do so, they pqfsbuf! ui f! tztufn ! jo! boz! x bz! ui bui fmqt! up! tbujtgz! ui f js! dspqt ! offe! bddpse joh! up! ui f js! perception. In addition this group of farmers have not been working in a fixed hawasha, number or minor. Instead they may move to another hawasha, number or minor every season. Hence, they may not care for what problem will occur next in one specific area as far as no rules have been developed to control their irrigating behaviour. Moreover, this group is not the only hoarder of water. The other groups (renters, owners or labourers) also displayed the same behaviour of carelessness/selfishness. As an example, Figure 5 benpx ! ti px t! tpn f! gbsn fst ! bdujpot! po! ui f! n jops! boe! Bcv! YY! section to irrigate their farms, which affect water distribution patterns for downstream users. Moreover, farmers are practising additional income generating activities outside the village. Usually, land owners give their land to the other groups of farmers when they are gainfully employed outside the scheme.

Nakoosi

’Obl ppt jf t !bsf!GP t0Bcv!WJ!x i jdi !gbsn fst!fn qmpz!up!jssjhbuf!cz!e jwfsujoh!x bufs!gspn ! downstream minor or Abu XX to upstream numbers or hawashas. These practices are jnfihbnboe!cfzpoe!ui f!n jops!ps!Bcv!YY!dbobnt!eft jhofe!dbqbdjuz!ui pvhi !jut!pof!pg! strategies farmers use to irrigate their higher level lands almost at the tail of every hawasha. There are two nakoosies FOPs from the Tuweir minor that have been used to irrigate the upstream minor command numbers. Within Tuweir minor there are many Bcv!WJ!gspn !epx otusfbn !Bcv!YY!up!jssjhbuf!vqtusfbn !’ovn cfs /!Tvdi !qsbdujdft!i bwf! been observed frequently in all numbers of Abu XXes of the Tuweir canal during our field work. Certainly these practices have significant impacts on water distribution differences between users of different minors and within the same minor.

Other practices

Other practices comprise of water use making a sudd- mud across the minor or Abu XX sections to back up the water levels and the closing of night storage weirs (NSWs), to push more water through the upstream FOPs or field inlet. These are also sources of water distribution differences among the farmers (figure 5). These practices are sources of conflict between farmers.

Using the canal water for household purposes is another practice in Tuweir minor (see Figure 5b below). Since, Tuweir villagers have no access to tap water; they use water from the minor canal for domestic purposes. One day we observed that villagers opened a fallowed FOP to divert water to their village, to irrigate ornamental trees inside the village and to serve other purpose like house building, while the downstream farmers in the same minor were suffering from water shortages. These practices may seem simple or normal in other places but they have significant effects on decreasing the level of water in the minor and creating inequitable water distribution between users.

Maintenance induced effects on water distribution

In many ways (lack of) maintenance can produce water distribution differences among numbers/minors. In Tuweir minor, silt removal was not taken place after the middle of

the minor since three years ago. This affected the reliability/equity or on time distribution of water for downstream farmers.

(a) (b)

Gjhvsf!6 !Obl ppt J boe!e jggfsfou!gbsn fst !jo!Hf jsb!Tdi fn f!jmmfhbmm!vtf!jss jhbujpo!x bufs! on a minor and Abu XX channel for multiple purposes

On the other hand, though it is an indicator of the poor water management, in the upstream parts accumulated silt raises the water level. That pushes more water into upstream FOP than downstream. Evidently, canal excavation was done in Tuweir minor on Sep 21-25/2010. Before the excavation was done, the upstream users were accessing excess water, due to the accumulated silt that raised the head and helped ease discharge of water into upstream FOPs. But after the silt removal, the water level in the upstream section of the minor canal decreased dramatically. As a result the amounts of water delivered to these upstream FOPs decreased, and relatively the discharge into downstream FOPs improved (Table 2). Though it cannot be generalized for other places as well, it was a problem for upstream users at that moment.

However, in general except for the above exceptional case as figures 4; 5 and 6 indicate, gspn !u f! bwbjmbcmf! x bufs! jo! u f! dbobm!u f! vqtusfbn ! vtfst! fokpz! u f! njpo t! ti bsf! pg u f! water at the expense of downstream users, because of poor management. In addition it was obvious to observe that after any irrigation of upstream users, there was excess water flowing to the road or to the fallowed land while the downstream farmers are not able to irrigate their crops. All in all, this results into unequal water distribution among users.

Figure 6. Water distribution difference because of absence of sediment management practice - on FOP 1 at Gezira Scheme. *N.B.* The first plate (a) shows in FOP1 water was flowing out over the suck-mud and this was most often the case before canal excavation. Plate (b) shows, after canal excavation, the amount of water discharging into this Abu XX decreased dramatically, so that farmers create a head across the minor.

Table 2. Water distribution estimation between FOPs of Tuweir minor canal at Gezira

Hydr-aulic level	**Field Outlet Pipe (FOPs) from the head to tail**	**Area / fedd an**	**Date of Observation (2010)**							**Aver age**	**-(+) 30% correction Factor**
			03-Sep	**12-Sep**	**17-Sep**	**21-Sep**	**25-Sep**	**29-Sep**	**02-Oct**		
			Estimated Discharge (at the head of each Abu XX) in liters/second								
Up stream FOPs	FOP1	60	26	32	0	0		10.2	25	15	11-20
	FOP2	90	0	51	116	56	25	60	44	50	35-65
	FOP3	83	48	0	68	53	45	100	19	48	33-62
	FOP6	90	0	0	54	40	0	0	0	16	11-20
	FOP7	90	111	11	94	82	11	43	45	57	40-74
	Average		**37**	**19**	**66**	**46**	**20**	**43**	**27**	**37**	36
Down stream FOPs	FOP9	90	27	0	12	6	44	96	68	36	25-47
	FOP10	90	16	0	13	26	61	83	100	42	29 -54
	FOP12	90	0	0	10	0	23	0	0	5	3-6
	FOP13	90	15	0	69	0	58	50	74	38	27-49
	Average		**15**	**0**	**26**	**8**	**47**	**57**	**61**	**30**	

Source: Round trip assessment of the Minor during the field work,

The above Table (2) is a rough estimation of discharges in operated (cultivated land) FOPs in 2010 season in Tuweir minor during round trip observations of the specified FOPs on the specified dates. The estimation was supported by simple flow measurements using orange method. The unmentioned FOPs in the above Table are left gbmpx fe! ps! x joufs! dspq! ovn cfst ! GP t!)j/f/! ui fsf! jt! op! x bufs! grpx ! joup! ui ftf! GP t! during study time). Generally the Table shows water supply at downstream FOPs was less than that of upstream FOPs before excavation was done. But after the excavation (after Sep 21-2010), the discharge to downstream FOPs (FOP 9 and FOP 10) was better than upstream FOPs (FOP 1) because of reduction of sedimentation effect (Figure 7).

Ui f! wbmvft! jo! ui f! ’bwfsbhf! dpnnn o ! pg Ubcmf! 3! joe jdbuf! ui bu GP ! 2! boe! GP ! 7! jo! ui f! upstream part have less discharge than downstream FOPs except for FOP 12. But the case especially which pronounced in FOP1 before the minor silt removal was always much water flow into FOP1. Evidently, excess water from FOP1 over flooded to the bekbdfou uf sujbsz! vo jux i jnfi! GP 2 t! hbuf! x bt! qbsujbmmz! ps! gvmmz! dmptfe /! Jo! ui f! Ubcmf! ui fsf! is area size difference between the cultivated FOPs. However, there are no functional discharge controlling structures that help water to deliver according to the area coverage of each FOP. For instance FOP 1 and FOP 3 have no pipe at all; the water runs into their Abu XX without control only controlled with mud filled-sack. In addition, there was also a case though FOPs were observed closed, after a moment these FOPs would be opened. So in reality there was no water shortage in these upstream parts. However, in downstream FOPs such as FOP 9, 10, 12 and 13 zero refers to the fact that the FOP was already opened, but there was no water that can be delivered to these FOPs. Especially FOP 9 and 12 face a problem of water to discharge into their Abu XX. As a sftvmt! n boz! ’obl ppt jft ! di boofmt! gspn ! GP ! 21! boe! GP ! 24! up! GP ! : ! boe! GP ! 23! respectively have been observed. Also during these round trip assessments, it was found that there are differences in water distribution between upstream and downstream parts of an Abu XX.

Figure 7. Grass cover difference between FOPs because of water distribution difference at Gezira Scheme

Moreover, photos in Figure 8 below show that water distribution differences between upstream and downstream parts along the Tuweir minor section. That means if the upstream FOPs are opened then the downstream FOPs cannot get enough water to irrigate their fields. This situation has been aggravated because there is no water distribution schedule among users. Consequently water distribution inequity can always be observed between upstream and downstream parts of Tuweir minor.

Figure 8: Water distribution difference in Tuweir minor Section (Plates were taken on September -17-2010)

Water distribution differences within a number

This is also a significant issue in the area. Farmers who have hawasha (farm) at the head of an Abu XX received water relatively more reliably and on time than the downstream farmers. During the study it was clear that downstream farmers can get water only after the upstream farmers have finished their irrigation (Figure 8). As a result many downstream farmers have been forced to irrigate their crops too lately or insufficiently. For instance, more than one week delay was observed in number 11. Table 3 below shows interview results from some farmers according to their perception i.e., here irrigation delay refers the time from which farmers want to irrigate yet they could not able to irrigate because of water shortages in the area.

Table 3. Farmers claim of irrigation delayed due to water distribution in Tuweir minor

Farmers	Farm Location	Irrigation delay (days)	Date of interview
1	Number 11	4	06 Sep-10
2	Number 14	7	06-Sep-10
3	Number 10	5	26 Sep-10
4	Number 11	16	24-Sep-10

not serious like number 11 (downstream farmers). At least there was water in number three Abu XX up to the tail, while number 11 Abu XX dried completely after the middle. In number 11 it was observed that, starting from 12 September 2010, water flow to its Abu XX was limited and many farmers were complaining about it frequently, because their irrigation was delayed from a few days to more than 15 days as the above Table shows.

The reason for this difference might be socioeconomic or power. Most owners were working at the head while, the number of sharecroppers is more significant in downstream. On the other hand head- tail issues of water distribution are significant. Obviously, at the head farmer can capture the amount of water available regardless of power /socioeconomic factor. Here, with different scales there is a difference in accessing irrigation water at each level of the number between upstream and downstream hawashas.

This is because, as one can imagine that as there is no plan for irrigation scheduling between farmers to irrigate turn by turn, the head farmer might even be irrigating twice before the tail farmer does not irrigate even once. There are no working rules to govern each farmer to irrigate fairly. The problem is more severe for downstream farmers than upstream farmers within the minor. Thus the effect clearly results unequal water distribution between farmers.

Impacts of Water Distribution Pattern

Yield reduction

Though it is difficult to justify yield reduction due to water distribution (since, other factors like agronomic management may also affect it), many farmers in Tuweir canal claim that the yield reduction from time to time is mainly because of poor water distribution between upstream and downstream at each level of the minor. So, even if it is not easy to quantify the reduction without detailed research, Table 4 provides insights pg! zjfme! sfevdujpo! x i jdi ! x bt! efevdufe! gspn ! gbsn fst ! joufswjfx t! jo! ui f! bsfb/! N ptu farmers stated that, last year most of them did not get yield at all in the area. Indeed,

without farmers claim, from the above observed water distribution difference between users, yield reduction is expected. Omer Elwaded (1986, who sited Hamid Fakki et al, 1984) stated that clear yield reduction originates from inequitable water distribution for cotton plants within the scheme depending upon the location and the level of major, minor and Abu XX field channel.

Table 4. Yield difference between the past and last year (2009/2010)

Farmer	**Farmers location in the minor**	**Crop type**	**Previous seasons Average Yield**		**Average Current yield/2009**		**Average Yield Reduction**	
			Suck/ feddan	Kg/ ha	suck/ feddan	Kg/ ha	suck/ feddan	Kg/ ha
1	FOP 9&10	Sorghum	13	3095	4	952	9	2143
2		Sorghum	10	2381	2	476	8	1905
3	FOP7	Sorghum	13	3095	2	476	10	2381
4		Sorghum	10	2381	2	476	7	1667
	Average		**11**	**2619**	**3**	**714**	**9**	**2143**
5	FOP 1	Groundnut	27	6429	18	4286	20	4762
6	FOP 10	Groundnut	20	4762	8	1905	13	3095
7	FOP 2	Groundnut	30	7143	25	5952	5	1190
	Average		**26**	**6190**	**13**	**3095**	**9**	**2143**
9	FOP 2	Wheat	14	3333	4	952	10	2381
10		Wheat	13	3095	1	238	12	2857
	Average		**13**	**3095**	**3**	**714**	**11**	**2619**
1 feddan=0.42 hectare			1 suck=100 kg					

Source: Interviews with farmers

Conflict between farmers

Unequal water distribution creates frictions between upstream and downstream farmers in a minor or number. Some farmers argued that they have found their Abu VI closed. Otherwise they should watch their Abu VI in the evening or they should look for other options, like pumping. In addition conflict is obvious between who are using nakoosi and other practices like creating a head/close NSWs and the impacted downstream users by these practices. It was realised that usually at the tail end of the minor, most of the farmers are sharecroppers while at the head end of the minor, most of them are owners. This exposes that tail end farmers not to equally negotiate on water right or other management claims like maintenance as the head end farmers (owners).

Unequal water distribution has also forced farmers to spent additional costs such as for pumping and labour. Farmers in Tuweir minor said, downstream farmers always use

pumps particularly for the winter season crops. This costs them a lot of money, renting a pump is about 42 US $ at last year currency per one and half days pumping. In addition when the amount of water decreases in the Abu XX farmers need a longer time to irrigate than with a normal flow. In this way they incur additional labour costs.

Conclusion and Recommendations

The past relatively formal and restricted water indenting according to the crops need and the canal capacity estimation has become a theory rather than a practice. Nowadays, water is released to each level jus as a habit, no scientific approach crop water calculation over canal capacity balance at all. As a consequence of unequal, unreliable and unscheduled water distribution to users has become a practice.

Factors such as operation of the FOPs by every farmers and their irrigation perceptions, lack of concern /sense of ownership while managing the system and their different practices to cope up water distribution changes; mismanagements of the system by officials like poor operation and maintenance; and absences of working water management rules for users are aggravating the situation of unequal water distribution within a major/minor/number.

In Tuweir minor, there are water distribution differences between numbers. Usually upstream farmers get relatively good amount of water than downstream farmers. Such variation was also observed within a number (between farms). The way of excavation has also impact on water distribution. After the minor excavation the downstream farmers got relatively good amount of water. However, some upstream numbers get limited amount since the water level in the minor drops down when the sediment removed.

The impacts of unequal, unreliable, or unscheduled water distribution have long term and short term effects on users. In a short term effects it can clearly reduce yields; arise conflicts between farmers or expose farmers to additional costs, like renting/buying pump to get irrigation water, then finally deterioration of the irrigation infrastructures as

a whole. Further more in a long term effects of water distribution changes, farmers have been leaving their villages to seek a job outside the scheme; the remaining farmers are changing their cropping patterns- focusing on less risk bearing crops (sorghum).

The existing water distribution should be improved. Irrigation scheduling among users based on the growing crop is necessary. This can be achieved if hydraulic property is created by each farmer. This can be achieved through farmers training and participation how to manage their irrigation system.

Lessons learned

Some lessons that can be drawn from the paradox of water distribution in the Tuweir minor are:

- From the past well organized system: water distribution based on the crops need and the canal capacity balance, as well as; the experience of crop rotation and uniformity throughout a tertiary unit are very important to equal water distribution among users.
- We have seen how sever silt load and poor maintenance can deteriorate even if a well established large scale schemes like Gezira. So that, continues follow up of a system; employ soil conservation measures on upstream parts; and continuous maintenance of irrigation canals as well as, creation of hydraulic property concept to farmers (through full participation and cost recovery) are important lessons that need actions on the existing and future schemes that we are going to develop in our country.

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