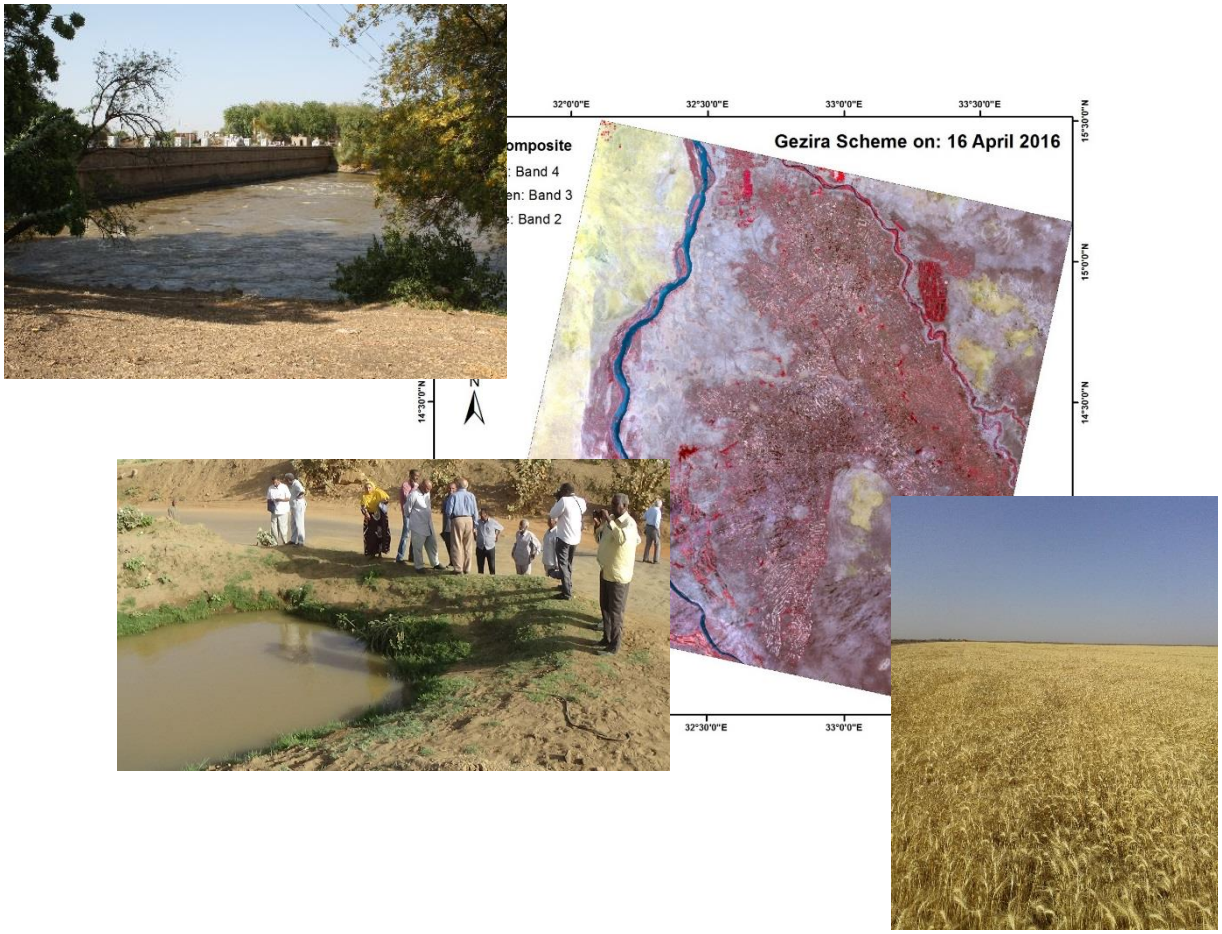
DRAFT WORKPLAN AND BUDGET FOR UPGRADING OF GEZIRA SCHEME, SUDAN



Result of the Expert Consultation Workshop: Upgrading the Gezira Scheme in Sudan

HRC-Wad Medani
21 – 26 February, 2016

PREFACE

An expert consultation workshop was held from February 21 - 26, 2016 at the Hydraulic Research Centre (HRC) in Wad Medani. This one week workshop focused on identifying the major problems in the Gezira Scheme and on formulation of key requirements to upgrade the Scheme and to keep it in a good condition. Almost 40 participants, all with a rich experience in the Scheme, and four experts with a large international experience contributed to the Workshop.

At close to 2.2 million feddan (one million ha), the Gezira Scheme shoulders the giant pillars for sustainable food security and inclusive economic growth in Sudan and in the region. It is believed that the struggle for the revival of the Scheme can be won with good vision, planning and commitment.

Diverse topics were covered including design, operation and maintenance, sediment management as well as organization, financing mechanisms, cropping pattern, crop water requirement and on-farm water management.

Based on these topics the workshop aimed at making a solid start with the upgrading of the Gezira Scheme. As a concrete output a draft work plan and budget have been prepared to guide the upgrading endeavour and the inherent operation and maintenance to keep the irrigation and drainage systems in a good condition. In addition indicative recommendations for modernization of the Scheme at a later stage have been provided. The draft work plan and budget for the upgrading will be further detailed in the weeks after the workshop.

All the relevant information is presented in this Report of the Workshop. I sincerely hope that the results will indeed create a solid basis for the start of the upgrading works in the Gezira Scheme to the benefit of the farmers in the Scheme, the improvement of the agriculture production and last but not least to the benefit of Sudan.

I take this opportunity to thank the foreign expatriates contributed to the workshop: Prof. Bart Schultz; Dr. Frank van Steenbergen; Dr. Rama Raju, and Dr. Abrahim Mehari Halie. I also thank my colleauges at HRC, Researcher Mutaz Abdel Kareem, and Associate Professor Abu Obieda Babiker as well as other other HRC staff for organizing this workshop.

Prof. Yasir A. Mohamed
Director
Hydraulic Research Centre (HRC)

EXECUTIVE SUMMARY

The responsibility for irrigation in the Gezira Scheme has recently been transferred from the Ministry of Agriculture to the Ministry of Water Resources, Irrigation and Electricity (MoWRIE) up to and including the field outlet pipes (FOP). It will require a major effort of MoWRIE and the other stakeholders to upgrade the irrigation and drainage systems to an acceptable level and to establish adequate operation and maintenance services. When these activities have been implemented successfully, the step to modernize the irrigation system and its water management can be taken.

From February 21 to 26, 2016, an expert consultation workshop was held at the Hydraulic Research Centre (HRC) in Wad Medani. This one week workshop focused on identifying the major problems in the Gezira Scheme and on formulation of key requirements to upgrade the irrigation and drainage systems. About 40 participants, all with a rich experience in the Scheme, and four experts with a large international experience contributed to the workshop.

During the workshop, the improvement of Gezira Scheme was proposed to be implemented in two stages:

- *Stage 1.* Upgrading the existing irrigation and drainage systems with the most urgently needed interventions (three years);
- *Stage 2.* Modernization of the irrigation system by changing/replacing water control structures, water management practices and water charging systems.

Concentrating on stage 1, the participants of the workshop:

- identified the major technical, agronomic, organizational and financial problems, and the human resource needs;
- recommended a set of possible solutions;
- developed a draft workplan and budget for five priority interventions;
- suggested critical operation and maintenance requirements to keep the upgraded irrigation and drainage systems in a good condition.

The main outcomes are presented in this summary. Further details are given in the main text of the report, its annexes and a CD-ROM attached to the report.

The start: problem identification

Taking stock of their vast knowledge and experiences as well as drawing from international and regional lessons, the workshop participants detailed the following major problems.

Technical aspects of irrigation

- a large number of minor canals are either silted or over dug; many of the structures (off takes, intermediate and field outlet pipes (FOP) are at best only partially operational;
- Abu Ishreens are oversized due to unauthorized widening of sections by farmers; they are heavily infested with weeds as they are rarely, routinely maintained;
- poor water distribution is visible in the Scheme, while some areas are excessively irrigated, some other regions are deprived of water due to the poor technical status of the minor canals and FOPs;
- there is over supply in the main and major canal systems. This has created turbulent flow and erosion of canal embankments, contributed to sedimentation and drainage problems, and exposes the Gezira Scheme and some villages to flood damage risk, particularly during the wet season;

- the drainage infrastructure is in demand of major repair and in some instances reconstruction: three of the five escape drains are non-functional, the majority of the drainage pumps are non-operational, the protective and collective drains along with their crossings and other structures have aged - they were also not designed for the current much higher drainage requirements.

Agronomic:

- farmers have complete freedom to grow whatever crop they want whenever they so desire. This makes it impossible to plan and implement any irrigation schedule.

Organisation:

- while by the Constitutional Decree 32 the MoWRIE has solidified its responsibility up to and including the FOPs, a clear operational organization structure and decision-making system are not yet in place;
- at Abu Ishreen and field system level, there are many unknowns: who has overall responsibility? who decides on the cropping pattern, submission of indents, repair and maintenance works? how is the use of pumps justified and their use controlled and managed?

Financial aspects:

- the irrigation fee in Gezira Scheme ranges from 100 to 150 SGD (15 to 25 US$) per feddan, which is lower as compared to similar schemes such as in the Niger where the fees vary from 25 to 35 US$ per feddan, though in Pakistan it is around 5 to 10 US$;
- authorities are usually less motivated to invest into the collection of low irrigation fees.

Human resources and services:

- the Gezira Scheme is currently suffering from acute staff shortage: i) the minimum estimated requirement is 125 engineers whereas only 60 are in place; ii) at least 350 new recruits are needed to manage the 30,000 FOPs along the 1750 minor canals; iii) several hundreds of unskilled labourers should also be hired to provide various supportive services;
- there are no well-planned sets of on-job training and capacity building programmes for the staff of Gezira Scheme;
- field houses, transportation and communication facilities are inadequate.

The follow-up: recommending solutions

The solutions proposed by the workshop participants to address the identified problems are as summarized below. These are supposed to be upgrading solutions (Stage 1), i.e., to improve the irrigation and drainage systems to an acceptable level. Next, would be modernization of the irrigation system to be implemented in Stage 2.

Technical aspects of irrigation:

- bring back the minor canals and Abu Ishreens to their 2008 design through sediment and weed removal, cross-sectional modifications or both;
- sediment and weed removal has to be done following surveying before and after the irrigation season. An engineer should supervise the desilting process. This minimizes the risk of oversizing or deepening of the canals;
- a mechanical approach should be used for weed removal as this has been successful in the past (DEMAS in the 1980's). Alternative chemical and biological mechanisms could be tested at pilot scale;

- the night storage method is preferred to the continuous method at the minor canals. This will, however, require strict implementation of the opening and closing schedules of the FOPs. Shifting to a continuous method will result in major costly infrastructural modifications and replacements;
- maintain the current irrigation schedule of 7 to 14 days - do not shift to a complete on-demand method, i.e. providing water to the farmer whenever he requests. This is not of urgent need and its implementation would require full automation;
- formulate the water levels in the main, branch and major canals related to the required levels in the minors. Maintain Lacey's non-silting and non-scouring velocities;
- drainage investment should only be considered after proper water management has been put in place. There is a need for major repair work of the escape, collective and protective drains along with their structures, including crossings and bridges;
- determine the requirements for staff gauges, flow measurements and other information for upgrading purposes;
- the removed sediments can be used for brick production. This is a successful business in India, and can be tested in Gezira;
- explore the possibilities for reducing inflow during the high sediment load period (15 July to 15 August), to at least the actual demand by the crops. One option that was discussed is to adjust the cropping calendar in such a way that crops with the least irrigation demand are grown in the specified time. With respect to this it may be interesting that in New Halfa, groundnuts are sown during May.

Agronomic:

- restrict crop choice in a Nimra to one crop or similar crops that have the same irrigation requirement and schedule;
- cropping of 50% of the area is to be fulfilled as a design constraint;
- canal closure from March 31 to May 22: i) complete closure from March 31 to April 7; ii) partial closure to supply drinking water through specified canals from April 8 to May 22;
- provision of indents at FOPs by the block inspectors (Department of Agriculture) to MoWRIE;
- annual determination of crop type and cropped area and schedule by the block inspectors in consultation with MoWRIE is a must. Approval by the 'Higher Committee for the use of the Blue Nile Waters' meeting;
- the block inspectors (Department of Agriculture), should develop suitable mechanisms that promote effective follow-up of the Higher Committee with respect to crop planning.

Organization:

- the block inspectors (Department of Agriculture) are responsible together with farmers for upgrading, operation and maintenance and all other activities at Abu Ishreen and field level;
- the Gezira Scheme management should have a simple organizational structure with the minimum possible hierarchical levels to facilitate timely decision making. It is important to have four committees in place each responsible for: i) the whole Scheme; ii) major and main canals; iii) minor canal including FOPs; iv) Abu Isheeen and field systems;
- MoWRIE needs to take care for timely warning of stakeholders when the closure of canals after March 31 will be re-introduced;
- the Ministry of Roads and Bridges should get license or approval from the MoWRIE for building roads, crossings and bridges that have an effect on the irrigation and drainage systems of the Gezira Scheme.

Financial aspects:

- the irrigation fees are low and need to be revised - a committee comprising of representatives from the Ministry of Finance, the MoWRIE, the Department of Agriculture and the farmers should determine the irrigation fee that should be paid by the farmers. This fee would have to be determined based on international and regional experiences and on the basis of the actual upgrading and operation and maintenance costs;
- generate additional income by promoting the multiple use of the Gezira Scheme such as fisheries, tourism, tree plantation, brick industry, industries and livestock.

Human resources:

- the minimum required technical staff, 70 additional engineers and 350 FOP operators should be in place as soon as possible;
- services including (field) houses, transportation and communication facilities should be improved;
- regular training and capacity building programmes should be organized.

Guiding implementation: preparing a draft workplan and budget

In four groups, the participants translated their set of recommendations into a draft workplan and budget focusing on five major priorities. Table I gives the details.

Keeping the irrigation and drainage systems in a good condition: recommendations with respect to operation and maintenance

The following recommendations for operation and maintenance (O&M) were formulated.

Technical aspects of irrigation:

- strict opening and closing of FOPs by MoWRIE will be very important;
- a special irrigation schedule needs to be agreed upon among MoWRIE, the Department of Agriculture and the farmers in times of heavy rainfall or any other special condition;
- in future, indiscriminate increase in the size of Abu Ishreens should be prevented;
- mechanical methods for weed control are recommended. Information manuals for weed control would have to be provided - focus has to be on good management of water and regular maintenance to reduce occurrence of weeds;
- promote brick production to benefit from the heaps of sediment removed from the canals;
- periodically determine to what extent over supply can be reduced to prevent damage in drains, canals, farms, roads, houses and wastage of water as much as possible;
- regular maintenance of all drains to keep them in an operable condition;
- after an excessive wet period, drainage has to be organized in such a way that normal irrigation schedules can be applied afterwards.

Cropping pattern:

- farmers need to abide by agreed cropping schedules with the block inspector and after consultation with MoWRIE.

Table 1. Tentative work plan and budget for the five priority areas

Priority interventions	Estimated cost in SDG/feddan	Estimated total cost in SDG for the total area (2.2 million feddan)	Annual budget and time frame								
			2016 budget	% of work accomplished in 2016		2017 budget	% of work accomplished in 2017		2018 budget	% of work allocated for 2018	
				I	II		I	II		I	II
1. Upgrading the minor canals and structures including: • 25% of total no. of offtakes (1500); • 60% of total no. of intermediate structures (3473); • 80% of total no. of FOPs (30000).	217	478 280 000	239 140 000	20	30	143 484 000	20	10	95 656 000	15	5
2. Human resources and services: • new recruitments include 70 engineers, 350 gate operators; 700 to 1000 unskilled labourers; • organizing at least one training programme annually; • improved housing ,offices equipment , communication facilities.	390	856 900 000	514 140 000	40	20	299 915 000	20	15	42 845 000	5	
3. Sediment and weed removal • first two reaches of minor canals covering 50% of the total 7 to 10 km length • 50% of Abu Ishreens	67.5	148 390 000	103 873 000	50	20	29 678 000	10	10	14 839 000	5	5
4. Upgrading main canal: • gantry crane gates at km 57, 77, 99, 108	34	74 800 000	7 480 000		10	26 1 80 000	25	1o	41 140 000	35	20
5. Start the complete upgrading of all protective and collective drainage systems - 25% of work is to be accomplished. Having a proper water management system in place is a precondition	8.5	18 700 000				3 740 000		20	14 960 000	30	50
Total budget	717	1 577 070 000	864 633 000			502 997 000			209 440 000		

Organization:

- the responsibility for O&M works needs to be in line with the responsibilities for upgrading;
- prevent that irrigation canals are running at their capacity when wet periods are being expected;
- MoWRIE is responsible for the maintenance of the protective drains in the Scheme and the villages within the Scheme. This responsibility has to be properly implemented;
- the State Government is responsible for the funding of drainage in other villages.

Financial aspects:

- farmers should pay the agreed irrigation fees. These agreed fees need to be sufficient to keep the irrigation and drainage systems in a good condition and that they are at a reasonable share of farmers in O&M costs. International experience is that the irrigation fees have to be capped at 5 to 10% of the gross income of farmers;
- the fees for O&M have to be set at such a level that a certain reservation is made to fund calamity repair and maintenance work;
- the best criterion agreed upon is a fixed amount of irrigation fee per feddan, dependent on the crop (to be annually revised as necessary);
- a certain budget has to be set aside to fund replacement of structures and equipment;
- more involvement of private sector would be good, but requires a very competent procurement authority.

Human resources: as outlined in the above.

مـلـخص

تم مؤخرا نقل مسؤولية الري في مشروع الجزيرة من وزارة الزراعة إلى وزارة الموارد المائية والري والكهرباء, لتتضمن مسؤلية الري حتي بوابات أبوعشرين, وتتطلب هذه المسؤولية جهودا جبارة من الوزارة وجميع الجهات المعنية لترقية نظام الري بالمشروع ليصل إلي مستوي مقبول, وللوصول إلي خدمة تشغيل وصيانة مناسبة.

تم عقد ورشة عمل بمركز البحوث الهيدروليكية في الفترة من 2/21 الى 2016/2/26 وذلك للتركيز علي تحديد المشاكل الرئيسية في مشروع الجزيرة, و صياغة المتطلبات الرئيسية لترقية نظام الري. وشارك في هذه الورشة حوالي 40 مهندس من مختلف التخصصات (مدنية- ميكانيكا- كهرباء- مساحة) وبخبرات عملية طويلة في المشروع, بالإضافة إلي اربعة خبراء أجانب ذوي خبرات عالمية في مجال الري. خلال هذه الورشة تم إقتراح بعض التحسينات لمشروع الجزيرة والتي يمكن تنفيذها في مرحلتين:

المرحلة الأولي: تحسين النظام الحالي بما يخدم المرحلة الحالية وذلك لتشغيل المشروع بصورة مقبولة (ثلاث سنوات).

المرحلة الثانية : تحديث نظام الري بالمشروع وذلك بتغيير أو إضافة منشاءات تحكم جديدة, نظام إدارة المياه, نظام التحصيل.

بالتركيز علي المرحلة الأولي, تم التوصل إلي الاتي:

- تحديد المشاكل الرئيسية المتعلقة بالنواحي الفنية, المحصولية, التنظيمية, المالية والموارد البشرية.
- وضع توصيات بمجموعة من الحلول الممكنة.
- تحديد مسودة عمل وميزانية لأهم خمسة تغييرات مقترحة.
- إقتراح إحتياجات تشغيل وصيانة مهمة لضمان بقاء منظومة الري بحالة جيدة.

المخرجات الاساسية لهذه الورشة قد تم صياغتها في هذا الملخص, ومزيدا من التفاصيل تم عرضها في تقرير الورشة وملحقاته.

<u>البداية:تحديد المشكلة:-</u>

من واقع الخبرة الطويلة للمشاركين وبتوجيه من الخبرات العالمية والاقليمية, قام المشاركون بتفصيل المشاكل التالية:

النواحي الفنية للري:

- هنالك مجموعة كبيرة من المآخذ والمنظمات الوسيطة فى الترع الفرعية ة وايضا أبوعشرينات إما تعرضت للدفن أو للحفر الزائد, وكذلك أبوعشرين علي أحسن الفروض تعمل بنصف كفاءتها التشغيلية.
- أبوعشرينات تعرضت للحفر الزائد المخالف للمواصفات التصميمية بواسطة المزارعين, وأيضا مغطاة بالحشائش وذلك نتيجة لإهمال إجراء الصيانة الدورية لها بواسطة المزارعين.
- التوزيع السيئ للمياه داخل المشروع, حيث يلاحظ أن بعض المناطق تتعرض للغرق المستمر في حين أن هنالك مناطق أخري لا تصلها المياه وذلك نتيجة للوضع الهندسي السيئ للترع وبوابات أبوعشرين.
- هنالك زيادة في إمداد المياه عن السعة التصميمية للقنوات الرتيسية مم أدي إلي حدوث إضطرابات في السريان والتي بدورها أدت ألي حدوث نحر في جوانب الترع الرئيسية وأسهم ذلك في حدوث مشاكل في المصارف. وأدت جميع هذه الاسباب إلي تعريض بعض القري لمخاطر الغرق وخاصة خلال موسم الامطار.

- البنية التحتية للمصارف بحاجة إلي صيانة عامة وفي بعض الحالات تحتاج لإعادة إنشاء, حيث أن ثلاثة من مصارف التنفيس لا تعمل ومعظم طلمبات التصريف أيضا لا تعمل, المصارف الجامعة والمصارف الواقية والمنشاءات الموجودة عليها جميعها أصبحت بالية وسعتها التصميمية لا تتوافق مع إحتياجات التصريف الحالية.

النواحي المحصولية:

- ❖ حرية إختيار المزارع لنوعية المحصول وزمن زراعته, تجعل من المستحيل إجراء عمليات ري منتظمة.

النواحي التنظيمية:

- ✓ علي الرغم من ان المرسوم الدستوري (رقم 32) أمن علي مسؤولية وزارة الموارد المائية والري والكهرباء في إدارة مياه الري بمشروع الجزيرة حتي بوابة أبوعشرين, لمن من الملاحظ أنه ليس هنالك هيكل تنظيمي وتشغيلي ونظام إتخاذ قرار واضح بعد.
- ✓ علي مستوي أبوعشرين ومستوي الحقل, هنالك العديد من التساؤلات عن المسؤولية العامة, من الذي يحدد التركيبة المحصولية, ومن يحدد طلبيات المياه, ومن هو المسؤول عن عمليات صيانة أبوعشرينات, وكيف يتم التحكم في الطلمبات الموجودة حاليا وكيف تتم إدارتها.

النواحي المالية:

- رسوم المياه في مشروع الجزيرة تتراوح بين 100-150 جنيه سوداني للفدان, وهي تعتبر قيمة منخفضة مقارنة مع المشاريع المشابهة حول العالم, مثلاً في النيجر تتراوح رسوم المياه بين 25-35 دولار واما في باكستان تتراوح من 5-10 دولار.
- المؤسسات عادة لا تتحمس للإستثمار في تحصيل رسوم الري القليلة جداً.

الموارد البشرية والخدمات:

- ➢ مشروع الجزيرة حاليا يعاني من نقص حاد في عدد الموظفين:
  - اقل إحتياج من المهندسين هو 125 والمتواجدين حالياً 60.
  - علي الاقل هنالك حوجة لتعيين 350 عامل لإدارة 30000 أبوعشرين علي طول 1750 ترعة بالمشروع.
  - المئات من العمالة الغير ماهرة يجب تعيينهم للقيام بالاعمال المساعدة.
- ➢ ليس هنالك خطة تدريب وبناء قدرات في مواقع العمل بالنسبة للموظفين في المشروع.
- ➢ المنازل والمواصلات والاتصالات في الحقل غير كافية او غير متوفرة.

<u>المتابعة-التوصيات المقترحة:</u>

الحلول المقترحة بواسطة مشاركي الورشة لمجابهة المشاكل التي تم تحديدها سابقاً قد تم تلخيصها في النقاط اللاحقة, وهذه تعتبر هي الحلول اللازمة للتحسين (المرحلة الأولي), وهي لتحسين نظام الري حتي يصل لمستوي مقبول, وتتبعها مرحلة تحديث نظام الري والتي ستتم في (المرحلة الثانية).

النواحي الفنية للري

- ✓ إعادة الترع وأبوعشرينات إلي القطاع التصميمي للعام 2008, عن طريق إزالة الطمي والحشائش أو تعديل القطاع أو الاثنين معاً.
- ✓ إزالة الطمي والحشائش يجب أن يصاحبها عمل مساحي قبل وبعد الموسم الزراعي, ويجب أن تتم هذه العملية تحت إشراف أحد المهندسين وذلك لتجنب الزيادة المفرطة في القطاع والعمق.
- ✓ يفضل إستخدام الطرق الميكانيكية لإزالة الحشائش وذلك لأنها أثبتت فعاليتها سابقاً (DEMAS in the 1980's) أيضا يمكن إختبار البدائل الكيميائية والأحيائية في إزالة الحشائش وذلك بإختبارها في منطقة صغيرة.
- ✓ نظام التخزين الليلي في الترع مفضل علي الري المتواصل, وبالتالي يحتاج إلي التنفيذ الصارم لتعليمات ومواعيدالفتح والقفل لأبوعشرينات. التغيير لنظام الري المتواصل يتطلب تعديلات وتغييرات مكلفة للبنية التحتية الرئيسية للمشروع.
- ✓ المخافظة علي الجدولة الحالية للري (7-14 يوم) ولا يتم التغيير إلي نظام الري حسب الطلب (توفير المياه للمزارع متى ما طلبها), هذه النقطة ليست بالضرورية في الوقت الحالي وتنفيذها يتطلب التشغيل الالي لكل المشروع.
- ✓ تحديد المناسيب في الترعتين والفروع والترع الرئيسية والتي تتوافق مع المناسيب في الترع الفرعية, المحافظة علي سرعة المياه المتوسطة (Lacey's) وذلك لتفادي النحر والترسيب.
- ✓ صيانة المصارف يجب أخذها في الإعتبار ولكن يتم ذلك بعد إتباع إدارة محكمة لمياه الري في المشروع, حيث أنه هنالك حوجة لصيانة أساسية لمصارف التنفيس والمصارف الواقية والجامعة وأيضاً صيانة للمنشاءات المقامة علي هذه المصارف من معابر وكباري.
- ✓ تحديد إحتياجات موظفي البوابات من أجهزة قياس تصريف والمعلومات الاخري المطلوبة لأغراض التحسين.
- ✓ الإستفادة من الطمي المزال في صناعة الطوب حيث أنها تعتبر إستثمار جيد في الهند ويمكن تجربتها في الجزيرة.
- ✓ دراسة إمكانية تقليل سريان المياه للمشروع خلال فترة التركيز العالي للطمي (7/15- 8/15) لتكون كمية المياه الداخلة علي قدر إحتياج المحصول فقط, أحد الخيارات التي تم مناقشتها هي تحديد وضبط مواعيد الزراعة لتكون المحاصيل التي تحتاج إلي ري أقل تتم زراعتها في فترة محددة (في حلفا الجديدة تتم زراعة الفول السوداني في شهر مايو).

النواحي المحصولية:

- ✓ تحديد خيارات المحاصيل في النمرة الواحدة إلي محصول واحد فقط أو محاصيل مشابهة لها نفس إحتياجات الري.
- ✓ المساحة المحصولية يجب ألا تتعدي 50% وهي المساحة التصميمية للقنوات.
- ✓ قفل القنوات من 31 مارس وحتي 22 مايو.
  - قفل كلي للقنوات من 31 مارس وحتي 7 أبريل.
  - قفل جزئي لتوفير مياه الشرب في بعض القنوات في الفترة من 8 ابريل وحتي 22 مايو.
- ✓ إشتراط تحديد طلبيات المياه بواسطة مفتش القسم (قسم الزراعة).

- ✓ التحديد السنوي للمساحات المزروعة والتركيبة المحصولية ومواعيد الزراعة بواسطة مفتش القسم ويجب ان يتم ذلك بالتشاور مع وزارة الموارد المائية والري والكهرباء (موافقة اللجنة العليا لإستخدام مياه النيل الأزرق).
- ✓ يجب علي مفتش القسم أن يطور آلية مناسبة لتحسين طرق المتابعة مع اللجنة العليا فيما يختص بالخطة المحصولية.

النواحي التنظيمية:

- ✓ مفتش القسم (قسم الزراعة) وبالتعاون مع المزارعين مسؤول عن كل النشاطات المتعلقة بتحسين وصيانة أبوعشرين والحواشات.
- ✓ إدارة مشروع الجزيرة يجب أن يكون لديها مخطط تنظيمي مبسط وذلك لتسهيل إتخاذ القرار فى عملية الرى ومن الضروري أن يكون هنالك أربعة لجان مسؤولة عن:
  - كل المشروع.
  - الترعتين والترع الرئيسية.
  - الترع الفرعية وبوابات أبوعشرينات.
  - أبوعشريانات والحواشات.
- ✓ يجب علي وزارة الموارد المائية والري والكهرباء الاخذ في الأعتبار عملية الإنذار المبكر للمستفيدين عند البدء في عمليات إغلاق القنوات في 31 مارس.
- ✓ يجب علي وزارة الطرق والجسور ان تتحصل علي ترخيص وموافقة من وزارة الموارد المائية والري والكهرباء عند قيامها بإنشاء أي طرق أو معابر أو كباري ذات تأثير علي نظام الري والصرف بمشروع الجزيرة.

الناحية المالية:

- ✓ رسوم المياه قليلة وتحتاج للمراجعة. يجب أن يتم تشكيل لجنة من ممثلي وزارة المالية ووزارة الموارد المائية ووزارة الزراعة والمزارعين لتحديد رسوم الري والتي تدفع بواسطة المزارعين وذلك بالرجوع إلي التجارب الإقليمية والعالمية بناء علي تكلفة التشغيل والتحسين والصيانة.
- ✓ إستحداث مصادر دخل إضافية للإستخدام المتعدد للمشروع مثل الاسماك, السياحة, زراعة الأشجار, صناعة الطوب, الصناعات الأخري والإنتاج الحيواني.

الموارد البشرية:

- ✓ الحد الأدني المطلوب من الموظفين هو زيادة عدد 70 مهندس إضافي و350 مشغل لبوابات أبو عشرين يتم تعيينهم بأسرع ما يمكن.
- ✓ تحسين الخدمات والتي تتضمن المنازل والمواصلات والإتصالات.
- ✓ يجب تنظيم برامج التدريب الدوري وبرامج بناء القدرات.

لتنفيذ التوجيهات:إعداد خطة العمل وميزانية:

تم تقسيم المشاركين إلي أربعة مجموعات حيث قاموا بترجمة هذه التوصيات إلي مسودة خطة عمل وميزانية بالتركيز علي الأولويات الرئيسية, الجدول التالي يوضح التفاصيل:

خطة عمل تجريبية وميزانية أولية لاولي خمسة تعديلات مطلوبة:

اولوية التعديل	التكلفة المقدرة بالجنيه للفدان	التكلفة المقدرة بالجنيه للمساحة الكلية(2.2 مليون فدان)	الميزانية السنوية والإطار الزمني							
			ميزانية 2016	نسبة العمل المنجز في 2016		ميزانية 2017	نسبة العمل المنجز في 2017		ميزانية 2018	نسبة العمل المنجز في 2018	
				1	2		1	2		1	2
1. تطوير الترع الرئيسية والمنشاءات ويتضمن: • 25% من العدد الكلي للمآخذ(1500) . • 60% من المنشءات الوسيطة (3473). • 80% من العدد الكلي لابوعشرينات (30000).	217	478,280,000	239,140,000	20	30	143,484,000	20	10	95,656,000	15	5
2. الموارد البشرية والخدمات: • تعيينات جديدة ل70 مهندس و 350 مشغل بوابات ومن 700 الي 1000 عمالة غير ماهرة. • علي الأقل تنظيم برنامج تدريبي واحد خلال العام. • تحسين السكن والمكاتب ووسائل الإتصال.	390	856,900,000	514,140,000	40	20	299,915,000	20	15	42,845,000	5	

3. إزالة الطمي و الحشائش: • أول مقطعين للترع والتي تغطي 50% من طول 7 الي 10 كيلومتر طولي. • 50% من أبوعشرينات	67.5	148,390,000	103,873,000	50	20	29,678,000	10	10	14,839,000	5	5
4. تحسين الترعة الرئيسية: • رافعات للبوابات في كيلو 57 و 77 و 99 و108	34	74,800,000	7,480,000		10	26,180,000	10	25	41,140,000	20	35
5. بداية العمل في التحسين الكلي لنظام المصارف الواقية ومصارف التجميع: • 25% من العمل يمكن أنجازه عن طريق الإدارة الجيدة للمياه.	8.5	18,700,000				3,740,000	20		14,960,000	50	30
الميزانية الكلية	**717**	**1,577,070,000**	**864,633,000**			**502,997,000**			**209,440,000**		

تم صياغة التوصيات التالية للتشغيل والصيانة للحفاظ علي نظام الري في حالة جيدة:

النواحي الفنية للري:

- أهمية التشدد في فتح وقفل بوابة أبوعشرين بواسطة وزارة الموارد المائية والري والكهرباء.
- الجدولة الاستثنائية للري في حالة هطول أمطار غزيرة او اي حالة إستثنائية أخري يجب الموافقة عليها بواسطة وزارة الموارد المائية وقسم الزراعة والمزارعين.
- مستقبلاً يجب منع أي زيادة في حجم أبوعشرين.
- يوصي بإستخدام الطرق الميكانيكية لإزالة الحشائش, يتم عمل كتيبات لطرق التحكم في نمو الحشائش مثل الادارة الجيدة للمياه والصيانة الدورية.
- تطوير صناعة الطوب للاستفادة من كمية الطمي المزالة من المشروع.
- يتم بصورة دورية تحديد الي اي مدي يمكن تقليل الامداد وذلك لمنع تدهور الترع والمصارف ,الحواشات, الطرق, المنازل ومنع إهدار المياه.
- الصيانة الدورية للمصارف لجعلها تعمل بصورة جيدة.
- يجب تنظيم المصارف بصورة تسمح بتطبيق جدولة الري بعد فترة هطول الامطار.

التركيبة المحصولية:

- يجب علي المزارعين الإلتزام بالتركيبة المحصولية ومواعيد الزراعة مع مفتش القسم وذلك بعد المشاورة مع وزارة الموارد المائية والكهرباء.

النواحي التنظيمية:

- مسؤولية التشغيل والصيانة يجب أن تكون متزامنة مع مسؤولية التحسين.
- يجب منع تشغيل الترع بسعتها الكلية في حالة توقع هطول الأمطار.
- وزارة الموارد المائية هي المسؤولة عن اعمال صيانة المصارف الواقية داخل المشروع والقري الواقعة داخل المشروع, هذه المسؤولية يجب ان يتم تنفيذها بصورة جيدة.
- حكومة الولاية هي المسؤولة عن تمويل صيانة المصارف في القري الأخري.

النواحي المالية:

- يجب علي المزارعين دفع رسوم الري المتفق عليها, وهذه الرسوم يجب ان تكون كافية للمحافظة علي نظام الري بصورة مقبولة وتكون مساهمة معقولة من المزارعين في تكلفة أعمال التشغيل والصيانة. الخبرات العالمية في رسوم الري اقترحت 5% إلي 10% من العائد الكلي للمزارع.
- يجب أن يتم وضع رسوم الري بحيث تضع إعتبار لتمويل أعمال التشغيل والصيانة خلال فترة الكوارث.
- افضل معيار تم الموافقة عليه هو قيمة ثابتة لرسوم الري للفدان وذلك بالإعتماد علي نوع المحصول (ويجب مراجعتها سنوياً علي حسب الضرورة).

الموارد البشرية:

- كما تم توضيحها سابقاً.

TABLE OF CONTENTS

CD-ROM with the PowerPoint presentations and other relevant supporting materials

1. INTRODUCTION

The responsibility for irrigation in the Gezira Scheme has recently been transferred from the Ministry of Agriculture to the Ministry of Water Resources, Irrigation and Electricity (MoWRIE) up to and including the field outlet pipes (FOP). It will require a major effort of MoWRIE and the other stakeholders to upgrade the irrigation and drainage systems to an acceptable level and to establish an adequate operation and maintenance at all levels of the Scheme. When these activities have been implemented successfully the step to modernize the irrigation system can be taken.

From February 21 - 26, 2016 an expert consultation workshop was held at the Hydraulic Research Centre (HRC) in Wad Medani. This one week consultation workshop focused on identifying the major problems in the Gezira Scheme and on formulation of key requirements to upgrade the Scheme and to keep it in good condition. Almost 40 participants, all with a rich experience in the Scheme, and four experts with a large international experience contributed to the workshop. During the workshop there were presentations, discussions and draft workplans and budgets were prepared by the participants in four groups.

Photos 1 and 2: The consultative workshop and field visit to the Gezira Scheme February 2016

This report presents the relevant issues and items of the workshop. The report starts with a brief background and description of the Gezira Scheme. This will be followed by an overview of the observations by the participants with respect to the conditions in the Scheme. Based on the observations

during the fieldtrip, the presentations, discussions and analysis of the various relevant aspects recommendations for upgrading of the Scheme have been formulated. Among others this has resulted in a draft workplan and budget for the upgrading stage and indications for the modernization stage that would have to be implemented when the upgrading stage will have been completed. Details of the workshop are presented in the Annexes. The PowerPoint presentations and other relevant supporting materials are included in the CD-ROM that has already been made available to the participants and is inserted with this report

2. BACKGROUND

Sudan belongs to the group of least developed countries in the world. At present the population of the country is about 40 million. The population growth is relatively rapid, with especially a strong growth in the urban areas (Figure 2.1).

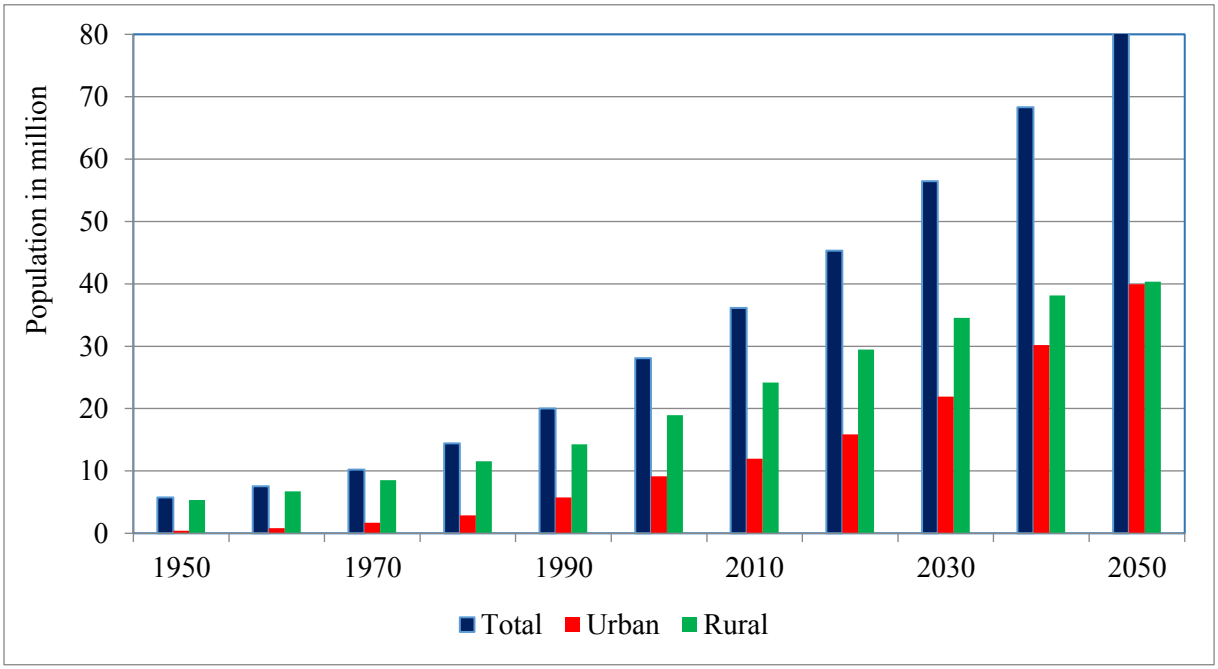


Figure 2.1. Population and population growth in Sudan over the period 1950 - 2050, ditinguished in the rural and urban population (data United Nations, Department of Economic and Social Affairs, Population Division. 2015)

At present Sudan is not food self sufficient and imports about 25% of the cereal consumption of its population. Undernourishment occurs at a relatively large-scale. The Government policy has a strong focus to improve the situation. The Gezira Scheme is one of the largest schemes for irrigated agriculture in the World covering close to 2.2 million feddan (one million ha). The Scheme could therefore provide a significant share in the food production of Sudan, and more in general to the agricultural production. However, at present the Scheme is not in a good condition and performs significant below the potential production level. Therefore the responsibility for irrigation in the Gezira Scheme has recently been transferred from the Ministry of Agriculture to the Ministry of Water Resources, Irrigation and Electricity (MoWRIE) up to and including the field outlet pipes (FOP). It will require a major effort of the MoWRIE and the other stakeholders to upgrade the irrigation and drainage systems to an acceptable level and to establish adequate operation and maintenance services. When these activities have been implemented successfully, the step to modernize the irrigation system and its water management can be taken.

3. THE GEZIRA SCHEME

The Gezira Scheme is located between the Blue Nile and White Nile rivers. The Scheme area covers more than 300 km from South to North and 150 km from East to West. The initial area was designed to serve about 300,000 feddan. An extension to the Scheme was executed in the late 1920s and early 1930s. In the early 1950s another extension was implemented to increase its size to one million feddan. Moreover, in 1957 a start was made with the Managil extension of about 800,000 feddan that was completed in the mid 1960s. It was designed to be irrigated by gravity from Sennar Dam on the Blue Nile, about 110 km south of Wad Medani.

The water quality for irrigation from the Blue Nile is excellent. There is no effect of salinity on the Scheme area except in the south of Khartoum. After the rainy season, sediment is the main problem in the minor canals, which need to be removed annually.

The Gezira Scheme lies within the dry zone, which is characterized by low average annual rainfall of about 200 to 300 mm and clear fluctuation in the distribution and intensity of rainfall from year to year.

The soil has a high clay content with no deep drainage. The Gezira clay soil is heavy - cracking clay soil (Vertisol), it swells and shrinks upon wetting and drying respectively. The Vertisols are deep, dark coloured, low in organic matter very slowly permeable when wet and deeply cracked when dry. The clay content ranges between 50 and 60%, in the top 60 cm.

The Irrigation system consists of two main canals running from Sennar Dam south of Gezira State with total capacity of 354 m^3/s. Total length of the network of branch canals and major canals is about 2,300 km. There are about 1500 minor canals with a total length of over 8,119 km (Figure 3.1).

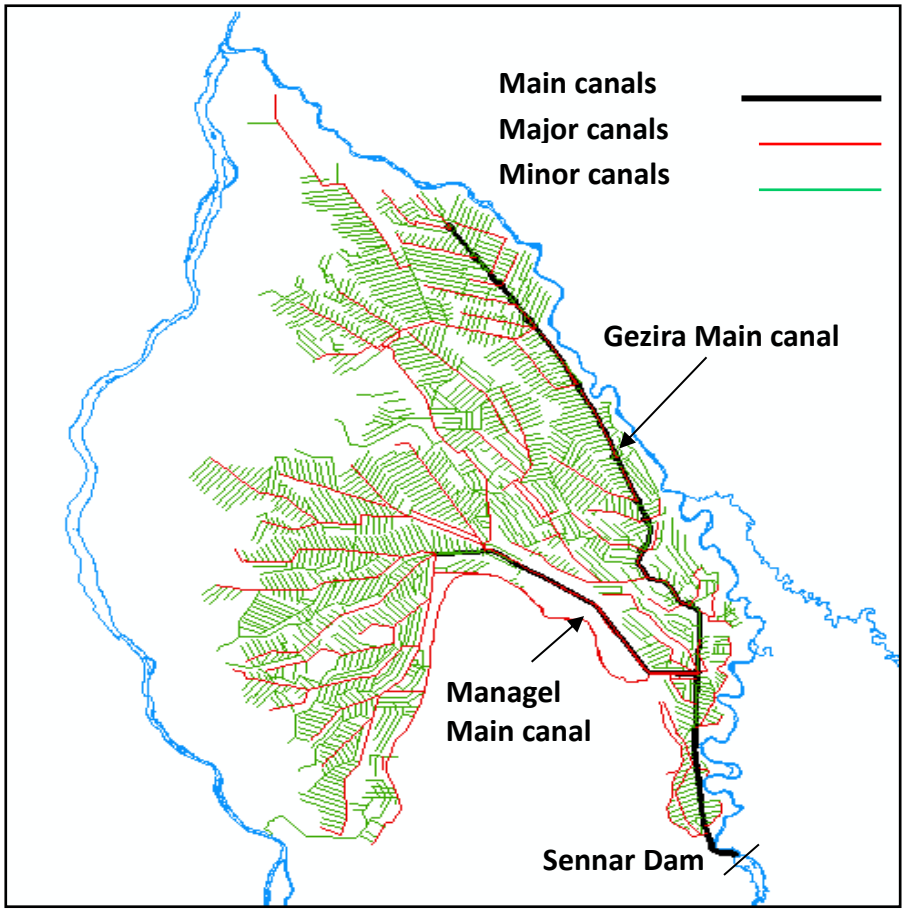


Figure 3.1. Lay out of the main irrigation system of Gezira Scheme

The major and minor canals are designed as distribution system canals. Fields with a gross area of 90 feddan (37.8 ha) are termed a Nimra. In each Nimra there are 18 farmer fields of 5 feddan each, which is referred to as Hawasha (Figure 3.2).

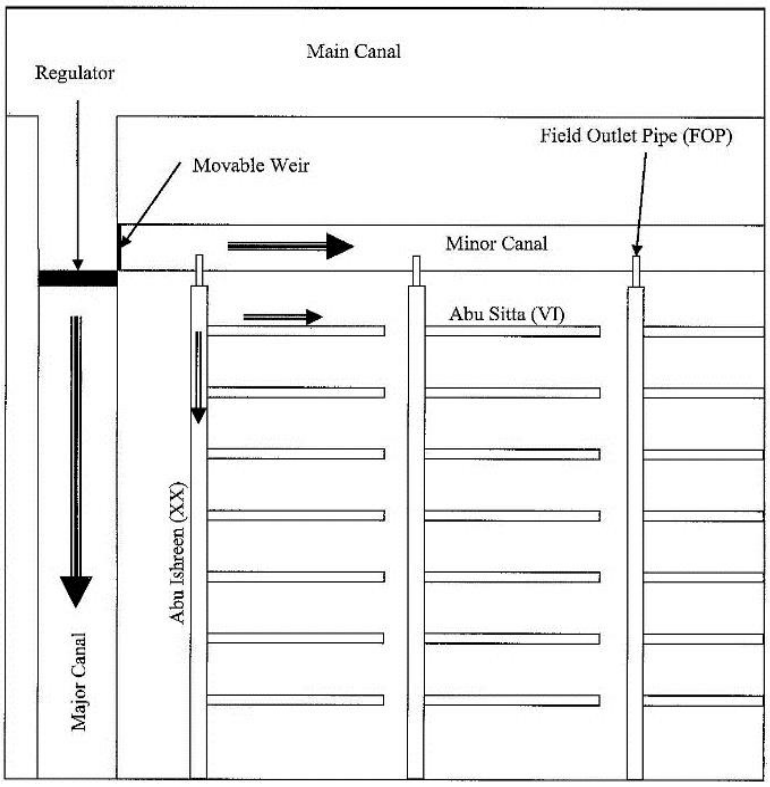


Figure 3.2. Schematic field irrigation system lay out in the Gezira Scheme

Over the past decades the water supply to the Gezira Scheme has significantly increased, while the irrigated area has significantly decreased (Figure 3.3).

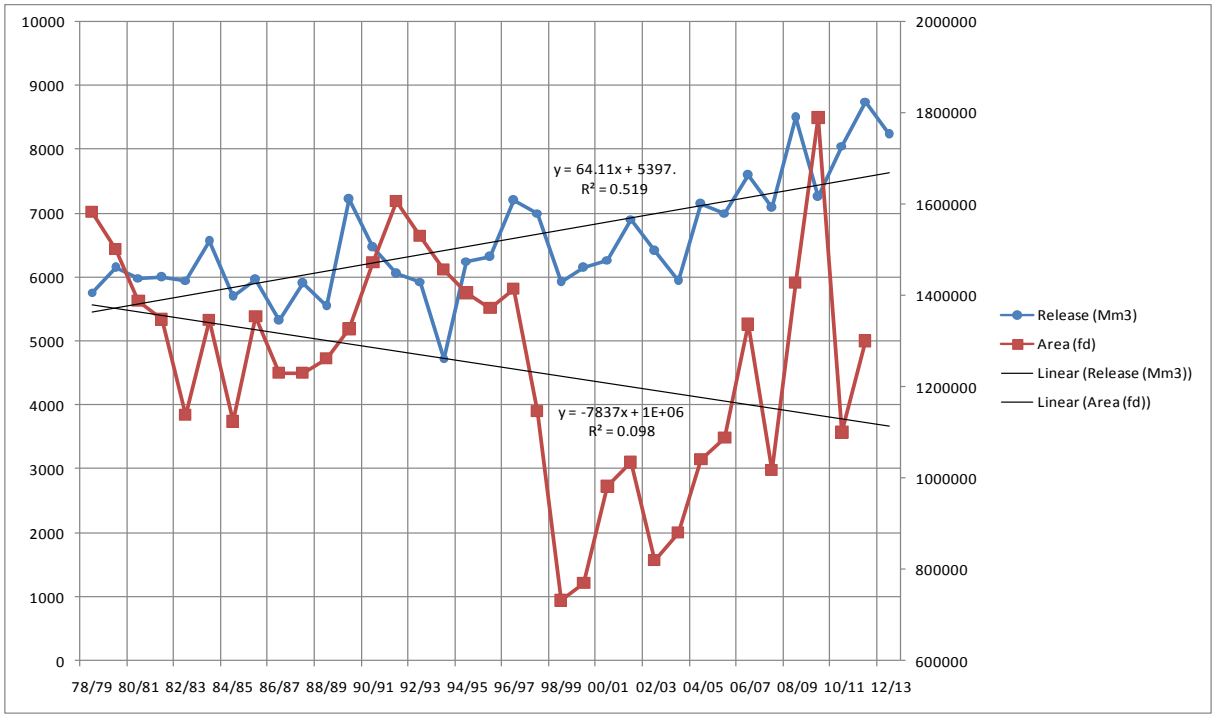


Figure 3.3. Water supply and irrigated area in Gezira Scheme from 1978 - 2013

From Figure 3.3 it can be derived that the water supply has increased from about 970 mm/year to 1,600 mm/year, which implies an increase of more than two-thirds. In fact such an increase will have resulted in significant increase in waterlogging at various places as well as in excessive drainage.

The cropping pattern was changed in Gezira Scheme from four-crops to five-crops as crop rotation in the 1991/1992 crop year after the introduction of livestock and is as follows: Cotton - Sorghum, Groundnut - Wheat (as winter or fallow). Cotton grows as summer crop in designated area.

4. OBSERVATIONS WITH RESPECT TO THE CONDITIONS IN Gezira Scheme

During the workshop, the improvement of Gezira Scheme was proposed to be implemented in two stages:

- *Stage 1.* Upgrading the existing irrigation and drainage systems with most urgently needed interventions (three years);
- *Stage 2.* Modernization of the irrigation system by, among other interventions, changing/replacing water control structures, water management practices and water charging systems.

Concentrating on stage 1, the workshop:

- identified the major technical, agronomic, organizational and financial problems, and the human resources needs;
- recommended a set of possible solutions;
- developed a draft workplan and budget for five priority interventions;
- suggested critical operation and maintenance requirements to keep the upgraded irrigation and drainage systems in a good condition.

Taking stock of their vast knowledge and experiences as well as drawing from international and regional lessons, the workshop participants detailed the following major problems.

Observations with respect to the present state of Gezira Scheme and the need for upgrading

The following observations with respect to the present state of Gezira Scheme and the need for upgrading were agreed upon by the participants in the workshop.

General:

- before upgrading all past assets needs to be returned back to MoWRIE;
- the actual irrigated area differs from the official area – the area to be upgraded should be defined;
- there is damage in the main system, but not that bad relative to the lower system;
- there are no staff gauges and related instruments for data collection and good operation and monitoring.

Photo 3: Intensive weed growth in minor canals in Gezira, February 2016

Technical aspects of irrigation

- deterioration of Gezira Scheme has accumulated over decades: minor canals and Abu Ishreens are the most affected parts of the Scheme:
  - a large number of minor canals are either silted or over dug. Many of the structures (off takes, intermediate and field outlet pipes (FOP) are at best only partially operational;
  - Abu Ishreens are oversized due to unauthorized widening of sections by farmers. They are heavily infested with weeds as they are rarely, routinely maintained. Abu Sitas are a problem as well at several places due to lack of maintenance;

Photo 4: Abu Xx heavily infested with weeds, February 2016

- a decision has to be made whether to apply the continuous, or the night storage irrigation method. With respect to this it has to be taken into account that modification of the irrigation method requires major changes to the design and the structures;
- poor water distribution is visible in the Scheme – while some areas where excessively irrigated, some other regions are deprived of water due to the poor technical status of the minor canals and FOPs;
- there is over supply in the main and major canal systems. This has created turbulent flow and erosion of canal embankments, contributed to sedimentation and drainage problems, and exposes the Gezira Scheme and some villages to flood damage risk, particularly during the wet season;

Photo 5: Bank erosion downstream large cross structures, February 2016

- the drainage infrastructure is in demand of major repair and in some instances reconstruction: three of the five escape drains are non-functional, the majority of the drainage pumps are non-operational, the protective and collective drains along with their crossings and other structures have aged - they were also not designed for the current much higher drainage requirements.

Agronomic:

- farmers have complete freedom to grow whatever crop they want whenever they so desire. This makes it impossible to plan and implement any irrigation schedule.

Organisation:

- while by the Constitutional Decree 32, the MoWRIE has solidified its responsibility for up to and including the FOPs, a clear operational organizational structure and decision-making system is not yet in place. Although the responsibilities don't seem to be defined fully clear considering it is of importance: i) that the Government responsibility in the Gezira Scheme is with the Gezira Board; ii) the Department of Agriculture (block inspectors) is in charge to reach agreement with the farmers on the cropping pattern, submission of the Indent to MoWRIE and for upgrading of the Abu Ishreens with involvement of the farmers; iii) upgrading of Abu Sita is the responsibility of the farmers;
- at Abu Ishreen and field system level, there are many unknowns: who has overall responsibility, who decides on the cropping pattern, submission of indents, repair and maintenance works, how is the use of pumps justified and their use controlled and managed?

Financial aspects:

- the irrigation fee in Gezira Scheme ranges from 100 to 150 SGD (15 to 25 US$) per feddan; which is lower as compared to similar Schemes such as in the Niger where the fees vary from 25 to 35 US$ per feddan, though in Pakistan it is around 5 to 10 US$ per feddan;
- Authorities are usually less motivated to invest into the collection of low irrigation fees;
- funding of upgrading of the main system is by the Ministry of Finance, based on fees by the farmers. Based on Governments recent assignment the fees will be collected by MoWRIE;
- upgrading of Abu Ishreens is an as important as necessary requirement for upgrading of the main irrigation system.

Human resources and services:

- the Gezira Scheme is currently suffering from acute staff shortage: i) the minimum estimated requirement is 125 engineers whereas only 60 are in place; ii) at least 350 new recruits are needed to manage the 30,000 FOPs along the 1750 minor canals; iii) several hundreds of unskilled labourers should also be hired to provide various supportive services;
- there are no well-planned sets of on-job training and capacity building programmes for the staff of the Gezira Scheme;
- field houses, transportation and communication facilities are inadequate.

Other points:

- depressions are a source of conflicts, while everyone is competing to use them. However, if the water management would be good, depressions will not exist. There are negative environmental implications, like water borne diseases, have to be prevented;
- there is no Sudanese legislation with respect to the environmental aspects of upgrading projects;
- up to now Sudan did not use its quota of Nile Water therefore there is no restriction with respect

to this item. An important reduction that may be expected with respect to the sediment in the water of the Blue Nile is caused by the dam construction in Ethiopia;
- there are no clear files or data base programmes with respect to: i) data with specifications of irrigation canals, drains and structures; ii) annual operation and maintenance planning; iii) annual replacement planning; iv) annual budgeting of the above works.

Observations with respect to operation and maintenance of the canals, drains and structures

The following observations with respect to operation and maintenance were agreed upon by the participants in the workshop.

general.
- effective operation and maintenance is an absolute requirement to keep the irrigation and drainage systems in a good condition;
- water management of the Scheme is a key issue and not that much a technical aspect.

Technical aspects of irrigation:
- most of the sediment settles in the first reach of the minors. Proper operation can reduce settling of silt in canals;
- most of the Abu Ishreens were maintained by excavators without any supervision by technical staff and are therefore oversized;
- there are two sources of water supply to some Abu Ishreen – this has led to excessive irrigation;
- maintenance of drainage systems is almost absent.

Other points:
- in preparing the works for upgrading, as well as during the operation and maintenance phase the following agronomic items will have to be taken into account: i) cropping schedule period; ii) cropped area; iii) crop factor(s); iv) crop water requirement(s);
- at Ministry level the Red certificate is the document based on which payment in projects can be arranged.

5. RECOMMENDATIONS TO ACHIEVE ADEQUATE WATER AND SEDIMENT MANAGEMENT IN GEZIRA SCHEME

The solutions proposed by the workshop participants to address the identified problems are as shown below. These are supposed to be upgrading solutions (Stage 1), i.e., to improve the irrigation and drainage systems to an acceptable level. Next would be modernization of the irrigation system to be implemented in Stage 2.

General:

- determine the actually irrigated area that has to be taken into account for upgrading;
- *Stage 1.* For upgrading focus on the latest design based (licensed) irrigated area;
- *Stage 2.* After completion of stage 1 additional actually irrigated areas could be considered;
- determine the requirements for staff gauges, flow measurement and other information for upgrading and operation and monitoring.

Technical aspects of irrigation:

- maintain the role of MoWRIE to operate the FOPs (Constitutional decree 32) based on demand by the block inspectors;
- 50% irrigated and 50% not irrigated/fallow. Rotation to be based on the Nimra scale;
- start with upgrading of the minor canals (desilting and/or better management of minor canals) and make contact with the Department of Agriculture to fix the problems at Abu Ishreen level. With respect to this it is important to bring back the minor canals and Abu Ishreens to their 2008 design profiles through sediment and weed removal, cross-sectional modifications or both. The sediment and weed removal has to be done following surveying before and after the irrigation season, and an engineer should supervise the desilting process. This minimizes the risk of oversizing or deepening of the canals;
- upgrading of some of the structures is crucial:
    - some inventory has been done, this inventory has to be updated. Based on the result priorities have to be set and implemented;
    - apply silt escapes, by-passes and may be silt ejectors;
    - within the main system, urgent interventions are: i) formulate the required water levels in the main, branch and major canals related to the required levels in the minors and maintain as much as possible Lacey's non-silting and non-scouring velocities; ii) formulate the requirements to reduce negative effects of turbulent flow;
    - take care that there is space for working along the canals and structures where required
- sediment management: determine the required changes in operation for optimal sediment management. Surveying before and after the irrigation season. Schedule of sediment and weed removal. Supervision of bulldozers and desilting operations; explore the possibilities for reducing the inflow during the high sediment load period (15 July to 15 August), to at least actual demand by the crops. One option discussed is to adjust the cropping calendar so that crops with the least irrigation demand are grown in the specified time. In New Halfa, for example, groundnuts are sown during May;
- determine the possible impact of the Ethiopian Dam on sediment in the Blue Nile;
- the removed sediments can be used for brick production. This is a successful business in India, and can be tested in Gezira;

- a mechanical approach would have to be used for weed removal as this has been successful in the past (DEMAS in the 1980's). Alternative chemical and biological mechanisms could be tested at pilot scale;
- Night storage is preferred to the continuous method at the minor canals. This will, however, require strict implementation of the opening and closing schedules of the FOPs. Shifting to a continuous method will result in major and costly infrastructural modifications and replacements;
- maintain the current irrigation schedule of 7 to 14 days. Do not shift to complete on-demand method, i.e. providing water to the farmer whenever he requests it. This is not of urgent need and its implementation would require full automation. Over the past twenty years water use per unit area has doubled. It is therefore very important to reduce over supply and excessive irrigation;
- drainage investment should only be considered after proper water management has been put in place. There is a need here for major repair work of the escape, collective and protective drains along with their structures, including crossings and bridges;
- stoplogs should only be used in times of emergency. While there are not many, keep them in stage 1 and replace them in stage 2;
- two types of drainage can be distinguished: i) protective: *escape drainage and preventive drainage*; ii) collective: *drainage of depressions*;
    - determine what is the requirement for escape drainage under improved irrigation;
    - recommend options and conditions for use of drainage water;
    - determine the requirements for upgrading of the protective drainage systems;
    - determine drainage requirements of depressions in light of better management of surrounding irrigation system(s) and implement the findings in one pilot with different options for land use: rice – fishponds;
    - determine requirement for preventive drainage of water coming from higher surrounding areas

Agronomic:

- the cropping pattern can be 4 or 5 crops, but at 50% of the irrigated area is to be fulfilled as a design constraint;
- restrict crop choice in a Nimra to one crop or similar crops that have the same irrigation requirement and schedule;
- canal closure from March 31 to May 22: i) complete closure from March 31 to April 7; ii) partial closure to supply drinking water through specified canals in the period April 8 to May 22;
- provision of indents at FOPs by the block inspectors (Department of Agriculture) to MoWRIE;
- annual determination of crop type and cropped area and schedule by the block inspectors in consultation with MoWRIE is a must. Approval by the 'Higher Committee for the use of the Blue Nile Waters' meeting;
- the block inspectors (Department of Agriculture), should develop suitable mechanisms that promote effective follow-up of the Higher Committee with respect to crop planning.
- the possibilities to reduce inflow during the high sediment load (15 July to 15 August) period in light of the ARC results could be considered when annual cropped area and schedule have been set. They will require further study.

Organization:

- the block inspectors (Department of Agriculture) are responsible together with farmers for upgrading, operation and maintenance and all other activities at Abu Ishreen and field level. Because of this there is a need for agreement with the Department of Agriculture and

representatives of the farmers concerning the share and impact of upgrading of the Abu Ishreens;

- the Gezira Scheme management should have a simple organizational structure with the minimum possible hierarchical levels to facilitate timely decision making. It is important to have four committees in place each responsible for: i) the whole Scheme; ii) major and main canals; iii) minor canal including FOPs; iv) Abu Ishreen and field system;
- MoWRIE needs to take care for timely warning of stakeholders when the closure of canals after March 31 will be re-introduced;
- a fast track has to be created for upgrading of the protective and collective drainage systems;
- also involved are: the Ministry of Finance for Government for subsidies and, loans, as well as the Ministry of Roads and bridges for the road crossings with irrigation canals and drains. The Ministry of Roads and Bridges should get license or approval from the MoWRIE for building roads, crossings and bridges that have an effect on the irrigation and drainage systems of the Gezira Scheme. These parties would have to cooperate as partners.

Financial aspects:

- determine the budget needed by the MoWRIE to upgrade and to operate and maintain Gezira Scheme;
- the irrigation fees are low and need to be revised - a committee comprising of representatives from the Ministry of Finance, the MoWRIE and the Department of Agriculture and farmers should determine the irrigation fee that should be paid by the farmers drawing from international and regional experiences and on the basis of the actual upgrading and operation and maintenance costs. in the determination of the irrigation fee the International experience that the fee can be in the order of magnitude of 5 to 10% of the gross value of the yield could be taken into account;
- funding of the upgrading up to the Abu Ishreen level to be agreed upon by the Department of Agriculture and the farmers;
- generate additional income by promoting the multiple use of the Gezira Scheme such as fisheries, tourism, tree plantation, brick industry, industries and livestock.

Human resources:

- the gaps in staff structure need to be filled. Determine the requirements for gate operators, or more in general the staff requirements. Capacity building at different levels is required. The minimum required technical staff of 70 additional engineers and 350 FOP operators should be in place as soon as possible;
- services including (field) houses, transportation & communication facilities should be improved;
- regular training and capacity building programmes should be organized.

Other points:

- determine the requirements for data collection, storage and retrieval;
- regular testing of improvement options at pilot scale;
- it is recommend that an environmental impact assessment will be made as in any new project;
- at National level agreement between sectors, especially hydropower and MoWRIE, is of importance;
- at transboundary level aspects of upgrading are not an issue.

Keeping the irrigation and drainage systems in a good condition: recommendations with respect to operation and maintenance

The following recommendations for operation and maintenance (O&M) were formulated.

General:

- farmers need to abide by agreed cropping schedules with the Department of Agriculture after consultation with MoWRIE;
- farmers and the Department of Agriculture need to implement their responsibility in maintaining the Abu Ishreen and the field system;
- MoWRIE needs to operate and maintain the irrigation system in such a way that at the FOPs the service to the farmers will be provided that they may expect.

Technical aspects of irrigation:

- strict opening and closing of FOPs by MoWRIE will be very important. In addition special attention will have to be given to prevent excess supply by MoWRIE (main system) and excess irrigation at field level by the farmers. A special irrigation schedule needs to be agreed upon among MoWRIE, the Department of Agriculture and the farmers in times of heavy rainfall or any other special condition;
- a more strict implementation of the maintenance of the minor canals by MoWRIE and of Abu Ishreens by the farmers and the Department of Agricultre will be required. This may also include (provisional) repair of damaged structures and damaged canal banks. Focus has to be on good management of water and regular maintenance to reduce occurrence of weeds. Mechanical methods for weed control are recommended. Information manuals for weed control would have to be provided. Investigate what is the cheapest way of canal maintenance. For example sugar factories have their own machines for maintenance. Experiences so far with chemical and biological methods for weed control have not been successful. However, such methods could be further investigated in further research and studies on various methods for weed control (reducing weed growth and removal);
- promote brick production to benefit from the heaps of sediment removed from the Scheme;
- investigate potential measures for (provisional) bank protection at risky spots;
- in future, indiscriminate increase in the size of Abu Ishreens should be prevented;
- periodically determine to what extent over supply can be reduced to prevent damage in drains, canals, farms, roads, houses and wastage of water as much as possible. In line with this it is also important to prevent that irrigation canals are running at their capacity when wet periods are being expected;
- investigate which maintenance would be required to enable the drainage systems to fulfil their function and implement the recommendations. With respect to this it is also important to determine to what extent over supply can be reduced to prevent damage in protective drains, canals, farms, roads, houses and wastage of water as much as possible. Regular maintenance of protective drains to keep them in an operable condition. After an excessive wet period, drainage has to be organized in such a way that normal irrigation schedules can be applied afterwards;
- determine the feasibility and impacts of different systems for the operation of structures, for example automation, at pilot scale before decisions on modernisation (stage 2) will be taken.

Cropping pattern:

- farmers need to abide by agreed cropping schedules with the block inspector (Department of Agriculture) and after consultation with MoWRIE;
- be a bit more scientific, for instance application of AquaCrop or other simple programmes;
- efficiency(ies) need(s) to be elaborated.

Organization:

- the responsibility for O&M works needs to be in line with the responsibilities for upgrading;
- MoWRIE is responsible for the maintenance of the protective drains in the Scheme and the villages within the Scheme. This responsibility has to be properly implemented;
- the State Government is responsible for the funding of drainage in other villages.

Financial aspects:

- farmers should pay the agreed irrigation fees. These agreed fees need to be sufficient to keep the irrigation system in a good condition and that they are at a reasonable share of farmers in O&M costs. International experience is that the irrigation fees have to be capped at 5 to 10% of the gross income of farmers. For stage 1 the best criterion agreed upon is a fixed amount of irrigation fee per feddan, dependent on the crop (to be annually revised as necessary). In addition stage 1 can be used to try out other methods at pilot scale. The most successful method can be implemented in stage 2;
- the fees for O&M also have to be set at such a level that a certain reservation is made to fund calamity repair and maintenance work. In addition a certain budget has to be set aside to fund replacement of structures and equipment;
- more involvement of private sector would be good, but requires a very competent procurement authority;

Human resources:

- as outlined under the recommendations for upgrading.

Other points:

- National policies, as well as the 1990 Irrigation and Drainage Act and any other existing regulation or law that applies to O&M will have to be abided. Proper consideration has to be given now or in future for water quality, health issues and other environmental issues. There are no special requirements with respect to international aspects;
- more consideration has to be given to the implementation of Scheme level rules and regulations;
- better supervision and monitoring will be required to reduce/prevent illegal construction and other activities. Illegal structures would have to be removed and construction of new illegal structures would have to be prevented;
- consideration has to be given for periodic water quality monitoring in light of national standards.

6. DRAFT WORKPLAN AND BUDGET

Guiding implementation: preparing a draft workplan and budget

In four groups, the participants translated their set of recommendations into a draft workplan and budget focusing on five major priorities. Table I gives the result. The contributions of each group are shown in Annex IV.

Table I. Tentative Workplan and preliminary budget for five priority interventions

Priority interventions	Estimated cost in SDG/feddan	Estimated total cost in SDG for the total area (2.2 million feddan)	Annual budget and time frame								
			2016 budget	% of work accomplished in 2016		2017 budget	% of work accomplished in 2017		2018 budget	% of work allocated for 2018	
				I	II		I	II		I	II
6. Upgrading the minor canals and structures including: • 25% of total no. of offtakes (1500); • 60% of total no. of intermediate structures (3473); • 80% of total no. of FOPs (30000).	217	478 280 000	239 140 000	20	30	143 484 000	20	10	95 656 000	15	5
7. Human resources and services: • new recruitments include 70 engineers, 350 gate operators; 700 to 1000 unskilled labourers; • organizing at least one training programme annually; • improved housing ,offices equipment , communication facilities.	390	856 900 000	514 140 000	40	20	299 915 000	20	15	42 845 000	5	
8. Sediment and weed removal • first two reaches of minor canals covering 50% of the total 7 to 10 km length • 50% of Abu Ishreens	67.5	148 390 000	103 873 000	50	20	29 678 000	10	10	14 839 000	5	5
9. Upgrading main canal: • gantry crane gates at km 57, 77, 99, 108	34	74 800 000	7 480 000		10	26 1 80 000	25	1o	41 140 000	35	20
10. Start the complete upgrading of all protective and collective drainage systems - 25% of work is to be accomplished. Having a proper water management system in place is a precondition	8.5	18 700 000				3 740 000		20	14 960 000	30	50
Total budget	717	1 577 070 000	86 4633 000			502 997 000			209 440 000		

7. CONCLUDING REMARKS

During the Workshop there have been discussions to the power point presentations, a field visit to relevant sites and in depth discussions on the observations, experiences and recommendations. This has resulted in a clear set of recommendations as presented in this report. Further work will have to be done to work out the details and to implement the recommendations. In addition meetings with the partner organisations and the farmers will be required to have the picture, responsibilities and tasks clear for all the stakeholders.

The workshop has resulted in a solid start. It is sincerely hoped that the follow-up will be implemented in the same spirit. In this way the further development of the Gezira Scheme can be successful, which will benefit both its inhabitants and the Sudanese society as a whole.

8. REFERENCES

Abdelrazig E. Mohamed, Adam E. Ahmed and Allam Ahmed. 2008. Food Security in Sudan: Policies and Strategies. SPRU – Science & Technology Policy Research. Brighton, UK. ISBN (Print): 0–907776–36–1; ISBN (Online): 0–907776–37–X.

Constitutional Decree 32

Farbrother, 1977, "Indenting in the Gezira", a handbook giving tables of crop water requirements for Gezira crops

United Nations, Department of Economic and Social Affairs, Population Division. 2015. World Population Prospects, medium prognosis. The 2015 revision. Department of Economic and Social Affairs. New York, USA

ANNEX I. Programme of the workshop

Day 1, 21 February	***Topic***	***Presenter/responsible***	***Chair/moderator***	***Reporter(s)***
8:30 to 10:30	***Opening and introduction***			
8:30 - 9:00	Arrival of participants, registration, distribution of workshop materials	Mutaz		Mutaz
9:00 - 9:30	Opening session		Prof. Yasir A. Mohamed	
9:30 - 9:45	Introduction to the programme	Prof. Yasir		
9:45 - 10:30	Participants introduce themselves, outline their expectations	Participants		
10:30- 11:00	*Coffee Break*			
11:0 to 17:30	***Presentation by experts from Sudan (participants) on major problems in Gezira Scheme and proposed solutions***			
11:00 -11:30	Cropping pattern and crop water requirements	Eng. Ahmed H. Mohamed, Hassan O. B. Hardalow	Assoc. Prof. Abu Obeida	Mutaz/Dr. Abraham
11:30 -12:00	On-farm water management	Eng. El Amin Ali Mohamed		
12:00 -12:30	Design of irrigation diversion and distribution and drainage systems	Eng. Mohamed Sharafeldin Mohamed		
13:00 -13:30	Operation and maintenance, including organization and financing mechanisms	Eng. Abdel Rahim Ahmed Hussein		
13:30 - 14:30	*Lunch Break*			
14:30 -15:30	Discussion	Participants	Abu Obeida	
15:30-16:00	*Coffee Break*			
16:00 - 17:30	Main outcome of the day: summary of draft major problems and proposed solutions.	Mutaz/Abraham		
Day 2, 22 Feb.	***Topic: Field trip to Gezira Irrigation Scheme***	***Presenter/Responsible***	***Chair/Facilitator***	***Reporters***
09:00 -13:00	Visit to relevant/representative sites in Gezira Scheme and to some major problem sites (discussed on day 1) at selected main, secondary, tertiary and field systems	Abu Obeida		Abubaker/Mutaz
13:00 - 14:00	*Lunch Break*			
14:00 - 15:30	Discussion and evaluations of the observation during the field trip	Participants	Abu Obeida	
15:30 - 16:00	*Coffee Break*			
16:00 - 17:30	Main outcome of the day: Photo (and perhaps video clip) illustrated description of major problems and *in situ* proposed solutions.	Abubaker/Mutaz	Abu Obeida	

Day 3, 23 Feb	***Topic: International and regional experiences***	***Presenter/Responsible***	***Chair/Facilitator***	***Reporters***
9:00 -10:00	Major challenges in large irrigation schemes and possible solutions - lessons for Gezira Scheme from across Africa and beyond (Note: covers all topics presented in day 1)	Prof. em. Bart Schultz	Yasir A. Mohamed	Abubaker/Abraham
10:00 - 10:30	Discussion			
10:30 -11:00	*Coffee Break*			
11:00 - 12:00	Key design features which directly influence operation and maintenance - lessons from India and Asia: What will be required to upgrade the system?	Dr. P. Rama Raju		
12:00 - 12:30	Discussion	Participants		
12:30 - 14:00	*Lunch break*			
14:00 to 17:30	▪ Formulation of requirements to upgrade Gezira Scheme and to keep it in a good condition ▪ Main outcome of the days: Revised summary of major problems and proposed solutions	▪ Participants ▪ Bart Schultz/ Rama Raju	Yasir A. Mohamed	
Day 4: 24 Feb	***Topic: International and regional experience***	***Presenter/Responsible***	***Chair/Facilitator***	***Reporters***
09:00 -10:00	Impact of improved operation and maintenance on cohesive sediment transport in Gezira Scheme, Sudan	Ishraga Osman	Adu Obeida	
10:00 to 10:30	Discussion			
10:30 - 11:00	*Coffee Break*			
11:00 -12:00	Drainage requirements in large scale irrigation schemes - lessons for Gezira Scheme	Bart Schultz		
12:00 -12:30	Discussion			
12:30 - 14:00	*Lunch Break*			
14:00 - 14:30	Towards automation in irrigation	▪		
14:30 - 17:30	▪ Formulation of requirements to upgrade Gezira Scheme and to keep it in a good condition (continued) ▪ Main outcome of the days: Final draft of the major problems and proposed technical and organizational solutions	▪ Participants ▪ Bart Schultz/ Rama Raju	Yasir A. Mohamed	Mutaz/Abraham

Day 5, 25 Feb	***Topic: Group work - formulation of a draft workplan and budget***	***Presenter/Responsible***	***Chair/Facilitator***	***Reporters***
9:00 -13:00	▪ Formulation of requirements to upgrade Gezira Scheme and to keep it in a good condition (continued) ▪ Participants in four groups prepare a draft workplan and budget - one facilitator for each group	▪ Participants ▪ Bart Schultz/ Rama Raju	Yasir/Bart Schultz/ Abu Obeida/Abraham	Bart Schultz/Abu Obeida/Abraham
13:00 -14:00	*Lunch Break*			
14:00 17:30	▪ Continue preparation of a draft workplan and budget ▪ Main outcome of the day: Draft workplan and budget by the groups	Participants	Yasir/Bart Schultz/ Abu Obeida/Abraham	Bart Schultz/Abu Obeida/Abraham
Day 6, 26 February	***Topic: Enriching the draft workplan and budget with international experience - wrapping up***	***Presenter/Responsible***	***Chair/Facilitator***	***Reporters***
9:00 -10:00	Water governance and financing operation and maintenance in mega irrigation systems - lessons for Gezira Scheme	Dr. Frank Van Steenbegen	Bart Schultz	Abdu/Abraham
10:00 - 10:30	Discussion			
10:30 - 11:00	*Coffee Break*			
11:00 -13:00	The participants working in groups update the draft workplan and budget	Participants	Frank/Bart Schultz	
13:00 -14:30	*Lunch Break*			
14:30 - 15:30	Presentation and discussion of the draft workplans and budgets	Group representatives	Frank	
15:30 - 16:00	Wrap-up	Yasir		

ANNEX II. Participants of the workshop

Name	الإسم	الرق
A.Rahim Ahmed Hussien	عبد الرحيم محمد حسين	1
Adam Abbakr Bashier	آدم ابكر بشير	2
Tagsir Ahmed Mohammed	تاج السر أحمد محمد	3
Elrayah A.Salam Elhaj	الريح عبد السلام	4
Adil Mohamed El Khidir	عادل محمد الخضر	5
Siddig Yousif Idriss	صديق يوسف	6
Mohamed Hamid Mohamed Ahmed	محمد حامد محمد أحمد	7
Osman Sadig Saleem	عثمان صادق سليم	8
El Zain Babiker El Faki	الزين بابكر الفكي	9
Mohamed A.Magid Hamad	محمد عبد الماجد حامد	10
Balal Mohamed Suliman	بلال محمد سليمان	11
Salih Yassin Mohamed	صالح يسن محمد	12
Hassan Abu El Bashar Ali	حسن ابو البشر علي	13
Mohamed Sharaf El din Mohamed	محمد شرف الدين	14
A.Salaam Mohamed Salih	عبد السلام محمد صالح	15
Gismalla Khalaf Alla Gismalla	قسم الله خلف الله	16
Ahmed Mohamed Ali Abu Sin	أحمد محمد علي أبوسن	17
Hassan Omer Balla Al Hardalow	حسن عمر بلة الحاردلو	18
Mohamed Ali Abd El Hadi	محمد علي عبد الهادي	19
Mohamed Bushara Mohamed	محمد بشارة محمد	20
Haroun Ibraheem El Haj	هارون إبراهيم	21
Saied Suliman Khamees	سيد سليمان خميس	22
Ahmed Adam Ibrahim Kabo	أحمد آدم إبراهيم كابو	23
Mohamed El Khidir Ali Suliman	محمد الخضر علي	24
Saied Adam Suliman	سيد آدم سليمان	25
Mohammed Hassan Elfaki	محمد حسن الفكي	26

Mohamed Zein elabein Magzoub	محمد زين العابدين	27
Salih Abdallah Mohammed	صالح عبد الله محمد	28
Ahmed Babiker Hamid	أحمد بابكر حامد	29
Mufadal El Tayeb Mohamed	مفضل الطيب محمد	30
El Ameen Ali Mohamed	الامين علي محمد	31
Musa Ali Mohammed	موسي علي	32
Ishraqa Sukrab	إشراقة سوكراب	33
Najlaa Eltayeb Elzain.	نجلاء الطيب الزين	34
Anwar Dafaallah	أنور دفع الله	35
Farouk Mahmoud.	فاروق محمود	36
Limya Mahgoub Mohammed	ليمياء محجوب محمد	37
Yasir Abbas Mohammed	ياسر عباس محمد	38
Abu Obeida Babiker Ahmed	أبوعبيدة بابكر أحمد	39
Abraham Mehari Haile	ابراهام مهاري هايلي	40
Almutaz Abdelkarim	المعتز عبد الكريم	41
Julia Awadelkareem	جوليا عوض الكريم	42

ANNEX III. Workshop Topics

Preceding to the Workshop several participants had prepared documents on certain topics for information. These documents are presented in this Annex.

III.1. Crop water requirements and indenting (cwr. and i.) past and present in Gezira Scheme

Eng. Ahmed H. Mohamed, Hassan O.B. Hardalow

Definition (general)

Crops need water to satisfy the transpiration and evaporation. Transpiration is the escape of water vapour through the plants leaves and stem to the atmosphere. Evaporation is the escape of water from the soil surface and plant leave. Therefore the water need of the crop is also called evapotranspiration, and is expressed in mm/day. The crop water requirements depends on the climate, the crop type and the growth stage.

Water requirements - the traditional method

When the canalization system was first constructed, there had been no reliable information about the canals capacity except for the past experience of the British Engineers in Egypt, which allowed 400 cubic meters (10 cm. water depth), every two weeks for the cotton. An experiment was conducted to determine the maximum CWR of the ELS cotton (extra long staple cotton), since the Scheme was designed to grow cotton only as a cash crop and to supply Lankester factories in U.K. It was found that 30 m^3 / day /feddan is quite enough. It was found also from field observations of the cotton crop and the cracking pattern of the soil, that the crop needs irrigation every 14 days. Thus the figures of the experiment held in Tayba near Wad Medani coincide with those applied in Egypt (400/14 ≈30).

Factors and water duty

The duty is the relationship between the volume of water and the area of crop, it is given in cubic meter per feddan per day. In Sudan and according to the design sheet of the projects directory of the M.O.I, the rate of flow duty is called Factor. Here are some definitions which used in the design of the canals of the Scheme:

Gross factor = Water consumption per day in cubic meters per feddan of gross area. = Crop factor * % of Gross area under crop.

Crop factor = Water consumption per day in cubic meters per feddan of crop area.

Gross area = Total area of cultivable land = total of numbers

Crop area = Gross area – fallow, and the duty may be at the level of: field, minor canal head, major head and Main canal head. Table III.1.1 shows the peak factors for the Gezira Scheme.

Table III.1.1. Peak factors for the Gezira Scheme

Level	Minors	Majors	Branches	Main canal
Crop factor	34	32	30	28
Gross F. 50% C.	17	16	15	14
Gross F. 66% C.	22.5	21	20	18.7

The irrigation system was designed in such a way that only 50% of the area should grown in the season. Of this, only 50% of it can be watered at any point of time. This means that 25% of the gross area can be under irrigation at one time. To do this the 25% area has to be irrigated in 7 days, then to move to the other 25% for 7 days also and by this the duration is completed 14 days. The F.O.P serves a number of 90 feddans. For one irrigation we need 400 m^3 , thus the number needs 90*400 = 36000 m^3 and as the number watered in 7 days, the F.O.P discharge is 36000/7 = 5000 m^3/d.

Night storage method

The minor canal is usually divided into reaches by what is known as night storage weirs (NSW). These weirs are used to store water during the night in the minors for irrigation during the day only. The NSW level is 20cm. above the F.S.L. At sunset all the F.O.Ps and NSW gates are closed. The water level rises until the NSW crest is overtopped and the water passes to the second reach. When the farmers come in the morning they find the reaches full and they start irrigating their farms. This method was adopted when it was found that it is difficult to irrigate at night by inexperienced farmers, with possibility of crop damage.

Indenting procedure

The irrigated area is organized as far as irrigation directory into subdivisions. On the agricultural side, it is divided into groups and blocks. The sub division engineer is responsible for water controlling so as to deliver water to the blocks and the sub division below him. The G.I and the B.I are concerned with agricultural works.

1. The first step in water distribution is the indent by the Block. Inspector of the Sudan Gezira Board (SGB) on the Sub-Divisional Engineer of the Ministry of Irrigation (MOI). The indent will be in terms of discharge in cubic meters per day at each of the various control points. These discharges will be based on water factors. Where a minor canal lies in more than one block, indent for the area in the down- stream block should be passed to the upstream B.I and from him to the A.D.E . The upstream B.I should see that the exact supply is passed to the down-stream block;
2. The next step is for the sub divisional engineer to compute these requirements in terms of total discharges at his control points, and so to derive the total requirements of his subdivision. Adding this to the total requirements of the subdivision or subdivisions downstream, he makes up the total indent on the sub divisional Engineer next above him. He must take into account the maximum permissible water factor;
3. The sub divisional Engineer, Wad Elnau, indents upon the R. E.Sennar Dam, and keeps the D.E Wad Medani, informed of all changes of indent on the canal head;
4. Indents by $B.I_s$ on $A.D.E_s$ are rendered weekly on Tuesdays as early in the day as possible. Only under exceptional circumstances should they be sent later than 1 p.m.: if received after 2 p.m., they will not be included in the alteration to be effected before 6 p.m. on canal head, but will be applied there at 6 a.m. on the following morning;
5. Adjustment indents, when required, will be sent in on Saturdays, under the same conditions. It should not involve a change in the total supply to the major canal, but only balance changes of indent on different areas on the same major canal;

6. In the event of heavy rains, the Inspector will inform the sub divisional engineer of the reductions needed, and if possible suggest other channels to which the surplus water may be delivered.

When execution:

- instructions are sent to all regulators;
- the rule of satisfying the tail first is applied.

Advantages:

- it doesn't affected by the climate factors;
- it is not necessary to know the sowing dates of the crops, only the areas are enough;
- easy calculation;
- the water levels don't influenced.

Disadvantages:

- **i**t didn't cater for crop intensification;
- opening of more than 25% of F.O.Ps means lowering the water levels in the minor canals;

The period of intensification and diversification

The Scheme applied the policy of intensification and diversification by introducing new crops such as groundnut and wheat in the Scheme, and it reaches its peak in the mid seventies. It has a great impact on water management and water control. The farmer found himself dealing with four crops, and the night storage method was no longer suitable because farmers irrigate day and night. The number requires more than 7 days to finish its irrigation.

The scientific method: Farbrother method

Due to the above mentioned reasons, it was suggested to introduce the method of crop water requirements to determine the water indents. This method is used to be the base by which the cultivated area in the Scheme is agreed upon with the M.O.I so that the maximum capacity of the supply canal doesn't exceed.

During the period 1967-1977 scientist Farbrother and others used soil moisture measurements to determine ET for the main crops in the Gezira Scheme. The crop coefficients were also determined by recognizing the growing stages in days. The reference evapotranspiration ETo is determined from metrological data of Wad Medani city. They came out with Table III.1.2.

Table III.1.2 was prepared according to crop serials and crop rotations for the main crops in Gezira Scheme. The length of the growing season is taken as 210, 180, 140, 120 and 120 days for the ELS cotton, Acala cotton, ground nuts, sorghum and wheat respectively. The sowing dates are taken as 5th Aug. for ELS, 15th Jul. for Acala, 5th Jul for sorghum, 25th Jun. for groundnuts and 15th Nov. for wheat. ET_0 values for Wad Medani city are used. Crop coefficients established by the ARC in Wad Medani as well are used**.** The equation is **{$CWR = ET_O * K_C$}.** The fig. with * is the 1st water.

Table III.1.2. Crop Water Requirements of the Main Crops in Gezira (m^3/fed./day) (Farbrother, 1977)

Period Sowing Date	ELS 21-31 July	Acala 11-20 July	Groundnut 21-30 June	Sorghum 1-10 July	Wheat 11-20 Nov.	$ET_o m^3 f^{-1} d^{-1}$
21-30 June	-	-	80*	-	-	34

1-10 July	-	-	18	80*	-	30
11-20 July	-	60*	18	17	-	28
21-31 '	40*	15	18	17	-	27
1-10 Aug.	14	15	19	20	-	26
11-20 '	14	16	21	26	-	25
21-31 '	15	19	25	31	-	25
1-10 Sep.	17	24	29	32	-	26
11-20 '	19	29	32	32	-	26
21-30 '	24	33	32	32	-	26
1-10 Oct.	29	34	31	30	-	26
11-20 '	31	33	29	25	-	25
21-31 '	31	33	24	22	-	25
1-10 Nov.	30	31	23	-	-	24
11-20 '	30	28	-	-	60*	24
21-30 '	29	22	-	-	12	24
1-10 Dec.	27	18	-	-	16	23
11-20 '	26	16	-	-	20	22
21-31 '	25	16	-	-	25	21
1-10 Jan.	23	15	-	-	29	22
11-20 '	22	-	-	-	30	24
21-31 '	22	-	-	-	31	25
1-10 Feb.	20	-	-	-	26	26
11-20 '	20	-	-	-	22	27
21-28 '	-	-	-	-	20	28
1-10 Mar.	-	-	-	-	18	30
Total CWR	5000	4500	4000	3500	3000	

With intensification, the summer crops area was increased to more than 1 million feddans. By the end of September and early of October, the CWR of G.N, Sorghum and cotton reached their peak. The total requirements of the whole area reached 32-34 Mm^3/day and this above the capacity of the main canals.

Water indenting:

- the water indent procedure would not have been as in the past, that is F.O.P times 5000;
- every B.I or G.I makes his indent by his own way, some of them indent the maximum of the canal from the beginning of the season and leave it without change;
- some of them look to the level of the canal, if it decreases, they ask for more;
- some farmers used to dig a link ditch between the tail of the minor canal to the collector drain to insure that their canal is flowing all the time and when they need the water they close this link canal to raise the water level.

Advantages:

- it computes the actual water consumption of the different crops at different growing stages. This is important for canal design;
- it enables the irrigation authorities to make sure of the capacity of the supply canals. This is useful in planning of the agricultural season;
- it can be used in the operation of the minor canals, so that the crop mix are planned such that the total CWR doesn't exceed the capacity of the minor;
- it can be useful in the season evaluation by comparing the CWR with the actual released water.

Disadvantages:

- it doesn't cater for canal losses;
- difficulties in following planting dates;
- the calculation of the crop waters is not that easy;
- it affects the water levels and unless the levels raised by 14% it can't applied;
- it needs the canals and the hydraulic structures and the gauges to be in a good condition;
- the operation of the system became complicated because of the interfere of crops together.

III.2. Design and operation requirements

Eng. Mohamed Sharafeldin Mohamed

Introduction:

- Gezira Scheme is considered as the oldest irrigation scheme in Sudan;
- its area is estimated about 2.2 million feddan;
- the annual water consumption in the Scheme varies between 6 to 8 milliard cubic meters;
- the included irrigation network length is 10683 thousand km, the minor canals represent 76% of the length of all the canals in the Scheme;
- it was administratively divided into 23 irrigation divisions;
- it contains more than 500 water controlling points (Barrages).

Table III.2.1. Summary of the canal lengths in Gezira Scheme

Canals	Number	Total length (km)	Discharge (m^3/s)
Main canal	2	261	354
Gezira Main Canal	1	-	168
Managil Main Canal	1	-	186
Branches	11	651	25 - 120
Majors	107	1652	1.5 - 15
Minors	1498	8119	0.5 – 1.5
Abu Ishreen	29000	40000	116 l/s
A/vi	350000	100000	25 – 50 l/s

The irrigation methods in the Scheme:

- the continuous irrigation method has being used since the foundation of the Scheme and continued until the earliest of the 30s of the last century;
- the irrigation method was converted to the night storage method because of the feasible and social difficulties of the night irrigation;
- the night storage method differs from the continuous irrigation method in the type of the controlling structures and the administrative effort.

The night storage method advantages are:

- it contributes in distributing the levels fairly along the canal (If it is applied properly);
- the high lands can be irrigated easily because the level is higher than the designed canal level and level of the continuous irrigation method;
- it helps in controlling wasted water phenomenon*
- it accommodates the farmers' social side and the irrigation water users;
- All these features can be guaranteed according to the efficient and uniform administratively efforts.

The disadvantages of the night storage method are:

- the sedimentation and weeds problems have been worse;
- it requires efficient and uniform administrative efforts.

Technical Considerations

Step 1: Preliminary soil and topographic survey
Step 2: Detailed soil and topographic survey
Step 3: Design the alignment of canals and drains

General principles to be followed:

- canals must be situated in ridges and drains in depression;
- contours at interval of 25 m shall be used in the alignments and to generate longitudinal sections;
- main canals must be situated along the main ridge and branch canals along secondary ridges;
- branch drains to be placed in the depression between branch canals;
- branch drain shall discharge into main drain and Main drain must be situated in the lowest depression.

Step 4: Determine method of irrigation

Step 5: Determine Crop Factor and Crop Water Requirements:

- determine the total area to be irrigated, crop mix in one year from January to December and estimate the crop factor for each crop;
- determine the Potential Evapotranspiration of a reference crop (Eto) from the climate of the area using meteorological data;
- apply the crop factor formula to obtain actual evapotranspiration for each crop:

$$Et_a = Crop\ factor\ x\ Eto$$

- add losses of water in the system. Typical losses are 3% at minor, 5% at major and 5% at main canal.

Step 6: Design of longitudinal sections:

- normally starts with the Longitudinal Section for the Abu Ishreen, then minor canal, major canal and finally the main canals. Start with the Tail and proceed upstream;
- set the Full supply level at the tail equal to 50 cm and proceed upstream to determine the location of the cross structures along the longitudinal profile;
- the profile or longitudinal section for minor canal shall be drawn at scale of maximum 1:20,000 and for major and main canal at scale of 1:50,000;
- proceed to the longitudinal section of major canal and superimpose the locations of the minor canals on the profile and repeat the same procedure.

Step 7: Design of cross-structures

R.S.G Structures

Used to regulate flows on main canals, branches and major canals. As an orifice normally the following basic Formula is used:

$$Q = C_d A\sqrt{H}$$

Where:

Cd = coefficient of discharge , A = area of the gate opening in m

H = head losses through gate in m , Q = Full Supply (F.S.) discharge plus 25%

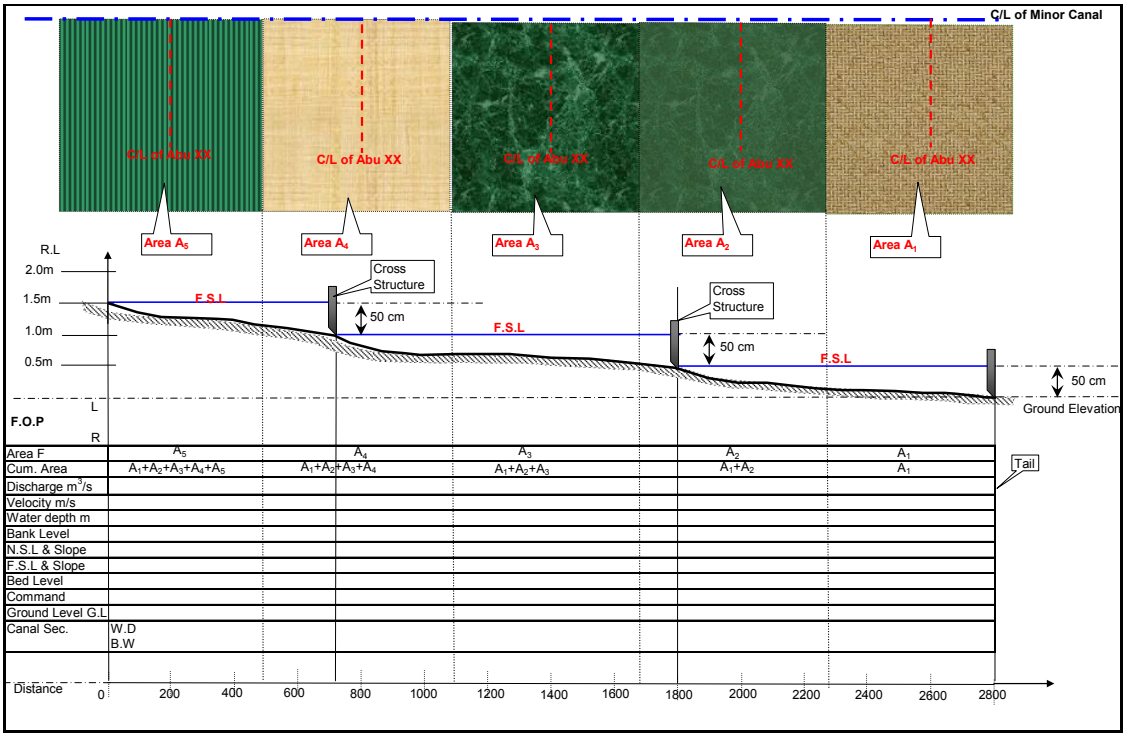


Figure III.2.1. Design Sheet of a Longitudinal Section

The width of the gate is selected to satisfy the following criteria:

- the opening required for maximum discharge should be less than two-third (2/3) of the height of the groove;
- the submergence underside of the gate should be a minimum of 0.6 m below the downstream water level;
- with the gate closed there should be a freeboard of 0.3 m from F.S.L to ???.

Movable weir structures (Butcher's weir):

- these were developed to meet the particular irrigation requirements in the Sudan;
- the weir consists of round-crested movable gate with guiding grooves and a self-sustaining hand gear for raising and lowering it.

Movable weir structures

- two types: Series I (M.W.I) and Series II (M.W.II).They are designed to discharge up to 5.2 m^3/s;
- the regulator structure consists of Reinforced Concrete (R.C.) floor with masonry superstructure and incorporate 6 m bridge;
- the minimum head through the structure is 0.3 m;
- the width of the weir is selected to pass the F.S.L discharge with a maximum head over the weir of 0.7m based on the following formula:

$$Q = 2.3wh^{1.5}$$

Where:
w = weir width in m
h = head over the weir in m
Q = discharge over the weir in m3/s.

Well Head Regulators (W.H.R):

- installed at minor canals and Double Abu Ishreen off-take structures where the required head is above 0.5 m;
- the minimum head loss from F.S.L upstream to F.S.L downstream is 0.3 m.

Pipe diameter (m)	Net cultivable area served in feddans
0.35	0-200
0.50	200-400
0.76	400-900
0.91	900-1890
1.01	1890-2340
1.24	2340-3630
2X0.91	3630-3780
2X1.01	3780-4540

Step 8: Design of canal cross-sections

Manning formula is used and double check by Lacey formula is used for the design of the canal sections.

$$Q = \frac{1}{n} AR^{2/3} \sqrt{S}$$

Where:
n = Manning roughness coefficient
A = cross-sectional area of flow
R = Hydraulic radius (m)
S = Channel bed slope.

Lacey equation is as follows:

$$W_s = 4.83Q^{1/2}$$

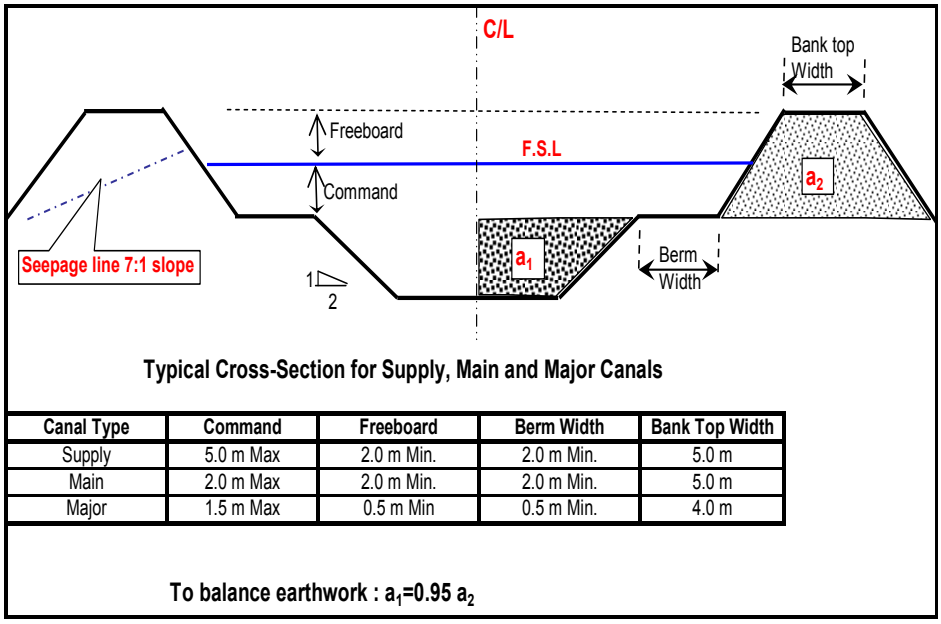
$$b = 0.8W_s$$

$$D_m = 2.46\frac{v}{f}$$

$$S = 0.0003e^{1/3} f^{5/3} EQ^{1/6}$$

Where:

W_s = water surface top width (m)
E = width factor
Q = full supply discharge (m^3/s)
B = bed width (m)
D_m = mean depth = A/W_s (m)
V = mean velocity (m/s);
F = silt factor
E = wetted perimeter /W_s
S = water surface slope



Canal Type	Command	Freeboard	Berm Width	Bank Top Width
Supply	5.0 m Max	2.0 m Min.	2.0 m Min.	5.0 m
Main	2.0 m Max	2.0 m Min.	2.0 m Min.	5.0 m
Major	1.5 m Max	0.5 m Min	0.5 m Min.	4.0 m

Figure III.2.2. Typical canal cross-section

Step 9: Design of the drainage system

According to the layout of canalization the drainage system (surface or sub-surface) is laid out containing the following**:**

- minor drain which drains the field;
- collector drain parallel to major drain which collects all minor drain discharging into a main drain;
- main drain takes the water out from canalized area to natural drainage paths.

Drainage requirements

The current equation to calculate the drainage is:

$$Q = CA^{2/3}$$

Where:
Q = discharge of frequency 1 in 5 wet years (m^3/s)
A = catchment area in feddan
C = runoff coefficient (factor)

- the above equation drains the area in 5 days and is based on the M.O.I experience to drain basin irrigation in Gezira canalization system;
- the formula is not applicable to furrow irrigation;
- a revised method based on field storage of 48 hrs and constant surface could be used. The design discharge is given by the simple balance equation:

  $$Q = RF - SMD - Et$$

  Where:
  Q = design flow
  RF = rainfall of frequency 1 in 5 wet year
  SMD = soil moisture deficit
  ET = evapotranspiration

- the 1 in 5 year 'wet' rainfall for each hydro-metrological region is predicted from the relationship:

  $$RF = V + aY$$

  Where:
  V = mode of the two days annual maximum rainfall given by:

  $$V = X - 0.5772a$$

  Where:
  X = mean of two days annual maximum rainfall

  $$a = \frac{\sigma 6^{1/2}}{\pi}$$

  Where:
  a = scale factor given by:
  σ = standard deviation of two days annual maximum rainfall
  Y = Probability of occurrence of 1 in 5 years wet rainfall.

Step 10: Project costing and bill of quantities

*Step 11: Prepare setting out sheets for excavating the canals and various s****

The administrative concepts

This concept depends on the night storage network according to the following concepts:

1. using the minor canals as night storing containers;
2. new intermediates regulators have been established and structured (CNSW) in the branches canals (divided to reaches or boxes);
3. committing that the irrigation is done during daylight;
4. each block (90 feddan) is irrigated in intervals that don't exceed 7 days;
5. the canals were technically designed to provide irrigation of 50% of the canal area at the same time;
6. the water requirements process is done with coordination between the administrative body which follows the Scheme and the administrative body of the irrigation ministry;
7. a network of water observers from irrigation ministry is concerned of supplying the water demand at the majors and canals scale;
8. Gezira Scheme administration is responsible of managing and irrigation water distribution in the branches canals regarding opening and closing Abu Ishreen gates and the other intermediates structures in the branch canals.

The problems of the operation of the irrigation canals:

- as the project is a mega project; there are big numbers of controlling structures and water regulators (that require periodic and continuous maintenance);
- the disruption of the night storage method as a result of the ruining in addition to the irrigation during night;
- there is water wasted in some locations and less in other locations (tail end problems) because there is no committing for the administrative operation regulations;
- the preceded administrative grip put the farmer in the situation of the spectator only;
- the absence of the legislation related to the misusing and wasting the water;
- it wasn't committed by the agricultural cycle and over indenting;
- the sediment deposits and weeds growth in canals;
- the decrease of the technical trained and qualified staff;
- the uncovering of the small canal management in the irrigation system before 2005 law leaded to worsen the canals;
- the weak investments and insufficient capabilities of operation and maintenance (cars, technical equipment …etc.).

The suggested solutions:

1. providing the financial and technical capabilities and intensive efforts for the maintenance of irrigation structures;
2. committing the requirements of the night storage regarding that there is no night irrigation and protecting the intermediate regulators;
3. committing the scientific aspects in what concerning with the water demand and setting and programming the irrigation in the fields;
4. committing the agricultural cycle (crops types, the dates of cultivation and when crops get out and setting of the cultivated area);
5. putting the rules and law that related to penalizing the users who waste water;
6. intensive efforts (technical and financial) that related to removing the sediment and weeds;

7. encouraging the researches in the field of the canals design which can decrease the sediment deposits rates and weeds growth;
8. providing the trained and qualified technical staff.

The experience of operation of Gezira Scheme network since the 20s of the last century summarized that:

1. the design is good standing because it was relied on a long experience and it continued working with high efficiency. However, there were changes due to the long lifetime of the Scheme and others;
2. the administrative changes resulted in appearance of some negative practices of the technical works;
3. the changes that occurred in the last period in the subordination and the management of the irrigation in the Scheme (2005 law, irrigation administration follows the Directorate of the Scheme) showed the importance of rehabilitation and enhancing the network.

بسم الله الرحمن الرحيم

III.3. On-Farm Water Management – Past and Present

إدارة المياه على مستوي الحقل بمشروع الجزيرة
الحاضر والمستقبل

Eng. El Amin Ali Mohamed, et al

Gezira Scheme is irrigated from Sennar Dam by surface irrigation, using two main canals, which deliver the water to majors, branches and finally to minors which feed Abu Ishreen. (Abu Ishreen) has designed to irrigate 90 feddans which called (Nimra).

Advantages of surface irrigation:
1. cost less in establishing and operation;
2. needs less labour;
3. the farmers knowledge and experience which they inherited from elders.

Disadvantages of surface irrigation:
1. inefficiency between 30 - 50%;
2. huge amount of water is wasted.

Irrigation is one of the most essential components in Gezira Scheme that's why its managed through 23 departments with cooperation of 21 agricultural department which includes114 inspection offices.

In the past water request is by increasing the area through the production council in the village which is submitted to the inspection engineer which submits it to the department engineer so he can supply the water request for irrigation. And this is done by irrigation schedule managed by the pass inspector and the production council. The irrigation is done for the first 30 feddan of Alnimra together and then its changed for the second 30 feddan and then for the last 30 feddan by this the cycle of Alnimra is completed in 10 days, the irrigation is done during the day only.

The suitable decisions are done depending on the irrigation schedule by the farmers all the season and with it the farmer knows when to irrigate and the amount of water need it.

Advantages of irrigation schedule:
1. getting the highest return output of the production;
2. codify and rationalize the amount of irrigation water used;
3. improving the efficiency of using water for a long term;
4. avoiding the negative effects which are caused by the non-Wesley irrigation practices for example soil salinization;
5. improving the efficiency of adding the fertilizers and pesticides.

Gezira Scheme management collects the irrigation water fees and this was done until the law of Gezira Scheme in 2005 which changed the responsibility of maintenance and managing the branch canals and field channels (Abu Ishreen and Abu Sita) to the water users associations which is also responsible for collecting the water irrigation fees.

Also the irrigation operation management has been devolution to Gezira Scheme management.

There were negative side effects in the irrigation operation management for changing the channel field management for the branch canal doors to the water users associations as:-

- lack of engineering operations and rehabilitation of the canals in the water users associations because they don't have technical background;
- the farmers are not committed with the irrigation schedule in the agricultural cycle, and opening a number of Abu Ishreens, they are also not committed to the time of growing different type of crops;
- this irrigation defect caused thirst in places and flood in other places which lead some farmers to use pumps to lift the water from the branch canals which has low water level than the field channels which was caused by the non-technical rehabilitation of the branched canals and Abu Ishreens.

Laws and legalizations for improving the surface irrigation in Gezira Scheme

We can summarize the objectives of these laws in the following:

1. improving the efficiency of using the irrigation water to get to the optimal use;
2. applying the wisdom management for the irrigation water and commit to it;
3. developing the population awareness for decreasing the consumption;
4. changing the growing pattern and the types of crops;
5. encourage the farmers to use the developed irrigation;
6. develop technics and methods for water use;
7. developing the capacity building and training through preparing programs for the capacity building and training.

III.4. Drainage System in the Gezira Scheme

Eng. Mufadal E. Ahmed

Summary

The soil of Gezira Scheme is considered from the Sudan central clay plain which considered as impermeable and store large amount of water in addition to its cracks during the dry period and its swelling to seal the cracks when it gets wetting or rain. This character was used in the first design of the drainage system in Gezira Scheme considering the soil is allowed to take certain amounts of the surface run-off after rain which contributed in the no requirements to construct field drains (the designer estimations for the storing significant portion of the rain in half of the quaternary cycle area (fallow land*). Also branches drains have been constructed to drain the drainage water in the main drains then to outside the agricultural area or to the river (according to the drain location – then to the Blue Nile or the White Nile). This system has been used uniformly for long decades with the escapes in the main drain.

After the agricultural intensification in 1970s of the last century; and with time going and deterioration of the structures and the accumulation of the sediment without removing it specially in the branch canals which resulted in appearance of some drainage problems in the Scheme, and it was supposed that the rehabilitation process for the drainage network with the rehabilitation of the Scheme in the earliest of 1980s that funded from the world bank, but the program was not done efficiently and it included the elimination of the accumulated sediment in all sections, constructing new drains and crosses and changing the rainy pumps. Presently the drainage system in the Scheme suffers from total drop represented in:

1. the branch drain have been completely buried and it cannot be found in the drainage system;
2. the major canals efficiency on the limited capacity decreased due to the accumulation of sediment and weeds;
3. the water has been accumulated because the change in the crop cycle (from quaternary to fivefold) with the results of applying 2005 law that texts that there are no available lands to keep the rain water and the excessive water which leaded to water spilling from the major drains sides;
4. this drop has influenced directly the water management in the Scheme so that there are difficulties for the farmers to reach their fields and it contributed in drowning in number of villages in the west of Managil. In addition to the continuous water ponds in the fields roads. The drainage system requires a new evaluation with the other components to find out a clear integrated view that aims to one target which is the efficient water management.

1. Introduction

The Gezira Scheme was the first large-scale irrigated agricultural development in the Sudan. Located within the Sudan Central Clay Plain (SCCP), this Central Clay Plain consists of deep cracking self-mulching clays with high holding capacities, but low permeability when dry, deep cracks permit very rapid intakes of water but the swells on wetting sealing the cracks and becoming almost impermeable.

The topography of the Scheme has gentle slopes towards the rivers (Blue and White Niles) and towards the North (5 - 10 cm/km).

The Gezira Scheme Irrigation System was laid out on a grid system incorporating 90 (feddans) plots (1 feddan = 0.42 ha), depending on the topography of the area. It was designed in the 1920's after prolonged experiments had been carried out on a prototype scale. It was designed with the main objective

of producing cotton, a single cash crop. Originally the irrigation system was laid out to suit the size of tenancy and crop rotation. The basic unit is a group of four adjacent fields of 90 F each called numbers. One crop is grown on each number following the four rotation system.

The irrigation system comprises twin main canals running from head works at Sennar Dam, a network of 2,300 km of branch and major canals; and about 1,500 minors and 29,000 water course (Abu Ishreen). Whereas for drainage system, the original design of the Gezira Irrigation System recognized that because of the nature of the soil and absence of a high water table, there was no need for, and indeed no means of providing sub-surface drainage of the fields. The only need for drainage, therefore, was for dealing with surface runoff from rainfall or excess irrigation.

The system of drains which exists in various areas in the Gezira has been provided with the object of carrying off rainwater from the land as soon as possible after it has fallen.

2. The original drainage system in the Scheme

Basically, the surface runoff drainage system in the Scheme consists of minor surface drains of about 6,000 km length, and collective or major drains of about 1,500 km length (World Bank Technical Paper 120, 1990).

Minor drains run parallel to minor canals discharging into collector drains which generally follow the lines of natural drainage and lead the runoff water to outfalls. However, there are no field drains parallel to the Abu Ishreen to take runoff from the fields.

The collector drains ideally outfall beyond the cultivation boundaries to natural drainage lines (depressions) or thence to the Blue or White Nile. However, several drains terminate in large local depressions usually on land which is unsuitable for agriculture especially in Gezira like: Wad El Shafie K.99, Aseer (k.57-77), Wad Rabiaa, Ambasha, Wad Elsaid, and other places; after that the runoff water is allowed to pond up and then evaporate.

The drainage system design capacities were originally based on empirical formulae derived from experience of basin irrigation according to the relationship: (DSF-design sheet file)

$$\mathbf{Q = CA^{2/3}}$$

Where:

Q = discharge in m^3/day

A = catchment area in feddan

C = runoff factor, a constant depending on intensity of rain, soil permeability, geographical zone and other climatic factors (= 150 for North of the Scheme and 270 for far South of the Scheme).

This relationship is developed for the cultivated area under basin irrigation and assumes considerable storage of potential runoff on the field and some storage in fallow area.

The drainage system was set as complementary to the canal system. Surface runoff from water drains on the fields is led into a minor Drain which is parallel to a minor canal.

Minor drains and collector drains channel sections are designed based upon the Manning Equation.As the discharge from the above relationship was known, and similarly water surface slope in a reach (*based on 0.20 m free board from ground level for various slopes of minor drains and side slope 1:1 -DSF*). The bed width and corresponding water depth are chosen from a number of combinations. The choice is left at the discretion of the Design Engineer.

For escape drains, Gezira Scheme is characterized by a very limited capacity for runoff of surplus water and includes the following escape drains and their authorized capacities Gezira escape drain (sources Gezira Regulation Handbook).

Table III.4.1. Capacities of escape drains

Item	Escape	Authorized capacity (Mm^3/day)
1	K.57 Escape	1.80
2	K.77 - Wad El Nau Escape	0.40
3	K. 108 - Beika Escape	0.80
4	K.169 - Abu Usher Escape	1-20
	Total	4.20

3. The existing drainage system

In the late 1970's, the Sudan Government was very much concerned about the general decline of the irrigated agriculture particularly in the Gezira Scheme. It was agreed to initiate a rehabilitation program (with the World Bank) as a first phase for a period of 4 to 5 years. The rehabilitation project initiated in 1984 concentrated on the restoration of the irrigation system in order to reach the highest possible production level and a package for rehabilitation of the drainage system was included within other components as follows:

> '*To restore the drainage systems to original design standards the project includes removal of an estimated 3.0 million m^3 of silt from major drains, construction of 190 km of new drain and rehabilitation of 4,000 km of silted up minor drains to their design sections. Five new drainage pumping station will replace the old ones which are out of operation. Two new siphons and six hundred road crossings along the major drains are also to be installed*', (World Bank, report 1994, Gezira Scheme)

Unfortunately the two important items (silt clearance of minor drains, and excavation of new minor drains) were not executed, and other items no records are found about their implementation. Accordingly the present drainage running without field and minor drains (the minor drains are completely buried and not exist).

For escape drains, only two are working (Beika and Abu Usher), the other two drains *are not working and a construction of major irrigation canals and Ashalt road have been built parallel to their root*(@K.57 – Hag Abdall New Major, and @ k.77- Elhosh new rood crossing the root).

The working drainage system now is only collector drains with a very limited capacities, the attached table shows the collector drains, their location in the Gezira Scheme and lengths.

4. Effect of the drainage system to the water management

Water management in the Gezira Scheme faces lot of difficulties, not only within farm level, but the wide spread of irrigation water all over the Scheme creates an unsuitable environment for production .Although it is realized that such data and information about the drainage system have to be weighed before drawing firm conclusion, but they clearly reflect the serious deterioration of the Gezira irrigation system, which contributes to mismanagement of water as:

- existence of flooded ponds within the irrigated areas.
- Wide spread of irrigated water to reach field roads and Scheme boundaries by abundant of water (White Nile villages).
- High consumption of water in last recent seasons (more than 7 milliards), even with less irrigated areas.

- Also the change of crops rotation from 4 to 5 course without a deep studies made an extra difficulties to manage water in the Scheme particularly during rainy season, Since at time of heavy showers a large part of the total area is either fallow or has not yet been planted, and the original design accept considerable storage of potential runoff on those areas, even for more than 48 hours.

المصارف الجامعة والواقية بمشروع الجزيرة والمناقلوموقعها بالأقسمام وأطوالها

Table III.4.2. Collector and Protective Drains in Gezira Scheme- Their Locations and lengths

Drain name	الطول-Length-(km)	إسم المصرف	القسمSub-division	القطاع
Wadi Elnil	**17.0**	**مصرف وداي النيل**	**عبد الماجد**	**شمال الجزيرة**
Massad	**30.0**	**مصرف مساعد**		
Abu Guta North	**20.6**	**أبوقوته شمال**		
Noweilla	**19.0**	**مصرف النويله**	**ود البر**	
Wad Rabiaa	**8.0**	**مصرف ود ربيعه**		
Khashim	**4.3**	**مصرف الخشيم**		
Wad Jubara	**3.0**	**مصرف ود جباره**		
Wad Elbur	**3.0**	**مصرف ود البر**		
Zongaha	**4.0**	**مصرف زنقاحة**		
Wad Matar	**50.8**	**مصرف ود مطر**	**طابت**	
Noweila-Wadi elnil	**29.0**	**مصرف النويله وادي النيل**		
Abu Ushar	**3.1**	**مصرف ابو عشر**	**قرشي**	
Elkuo	**8.86**	**مصرف الكوع**		
Eljmeiab	**11.0**	**مصرف الجميعاب**		
Abu jidian	**8.1**	**مصرف أبو جديان**		
Kabaro	**13.1**	**مصرف كبرو**		
Wad Matar	**154.3**	**مصرف ود مطر**	**كاب الجداد**	
West Debiba	**13.0**	**مصرف الدبيبة الغربية**		
Kasambar	**13.7**	**المصرف الجامع للكسمبر**	**الترابي**	
Gononab	**50.0**	**مصرف فرعي للقنوناب**		

Table III.4.3.

Drain Name	المأخذ	الطول-Length-(km)	إسم المصرف	القسمSub-division	القطاع
Managil Mound	**ك 14 فرع المناقل**	**38.0**	**مصرف هضبة المناقل**	**ري المختار**	**شرق المناقل**
Abu jeareen		**26.0**	**أبو جعرين**		
Abd Elghany		**4.5**	**عبد الغني**		
Elnasih		**12.0**	**النصيح**		
Managil lower	**من الفم ك 65**	**44.0**	**مصرف تخفيض المناقل**	**شلعي**	**'**
Mansi- Fakhakhir	**' ' ' '**	**11.0**	**' منسي الفخاخير**		
Huda-mansi	**' ' ' '**	**19.0**	**' الهدي منسي**		
Managil lower	**من ك 44 إلي ك 62**	**18.0**	**مصرف تخفيض المناقل**	**ري سرحان**	**'**
Surhan branch	**من ك 43 إلي ك 55**	**12.0**	**' فرع سرحان**		
Elazazi -W.Balla		**11.0**	**مصرف العزازي ود بله**	**ري المنسي**	**'**
Elareija		**33.0**	**' العريجه**		
Mansi- Fakhakhir2		**14.0**	**' منسي فخاخير**		

Huda-mansi2		**19.0**	**' هدي منسي**		
Tako-Tahameed		**21.0**	**مصرف تكو تحاميد**	**ري التحاميد**	'
Elazazi -W.Balla		**12.0**	**' العزازي ود بله**		
Tahameed		**14.0**	**' تحاميد**		
Hafair north		**15.0**	**مصرف الحفاير الشمالي**	**ري الحفاير**	**غرب المناقل**
Omer		**14.0**	**' ' / عمر**		
Maatoug		**59.0**	**' معتوق / المنقطعة**		
Wad Doora/Munata		**50.0**	**' منقطعه / ود دوره**		
Maatoug-Fakhaghir		**47.0**	**مصرف معتوق / فخاخير**	**ري الفخاخير**	'
Mansi-Fakhakhir		**43.0**	**' منسي / فخاخير**		
Wad Doora/Munata		**33.0**	**مصـــرف منقطعـه/ ود دوره**	**ري الماطوري**	
Wad Doora/Azazab		**48.0**	**' العزازاب / ود دروه**		
Jamousi		**25.6**	**' ' / الجاموسي**		
Kawa		**26.55**	**' الكوه**		
Abu Ouoon		**0.90**	**' أبوعون**		
Jamousi/Azazab		**27**.0	**مصـــرف جـامـوس/ عزازاب**	**ري قبوجه**	
		29.0	**' التخفيض**		
Shawal/managil		**21.8**	**' الشوال المناقل**		
Shawal/managil2		**142.0**	**مصرف الشوال المناقل**	**ري الشوال**	
Kawa Branch		**24.0**	**' فرع الكوه**		
Wagi		**21.0**	**' الواقي**		

Table III.4.4. In addition to the drains in the following divisions

عدد-11	المسلمية	**شمال الجزيرة**
عدد-2	البساتنا	
عدد 6-	ود النو	
عدد-2	حاج عبد الله	
عدد-8	شمالي غرب سنار	
عدد-2	الحرقه نور الدين	

III.5. Operation and Maintenance (O&M) in Gezira Scheme in past and present

Eng. Abdalrahim Ahmed Hussien, Eng. Mohamed Hamad M.Ahmed and Eng. Salih Yassien Mohames

Introduction

The most important entry to the good production in the Scheme is the operation and maintenance to the irrigation system in the Scheme especially to the involved participants.

The participants are the agricultural department and farmers and all who has an active and complete role in the Scheme so it can be effective in the national economic and development, superiority of irrigation levels in the developed countries.

The irrigation system includes the following:

- Sennar Dam;
- The two main canals Gezira and Almanagil with length 261 km;
- Group of 14 branch and 122 major in all the departments of Gezira and Almanagil with length 2072 km;
- Group of 1446 branch canals with length 10507 km;
- Group of 29824 Abu Ishreen;
- Group of 191 drainages with length 2668 km;
- 4 big barrages with onash doors;
- 141 barrages with R.S.G regulator doors;
- 19 barrages with R & W regulator doors (it was more than that these are the remaining);
- 996 barrages with moving regulator MW & MW;
- 3473 barrages with pipe regulator doors W.H.R with diameter range 35 cm up to 124 cm;
- 29824 barrages with F.O.P regulator doors for Abu Ishreen;
- 348 heavy moving bridges;
- 787 light moving bridges;
- 194 small siphons;
- 13 big siphons;
- 13 electric and diesel pump stations in different locations of the Scheme.

Operation and maintenance of the irrigation system in the past

The operation and maintenance for the irrigation system that was mentioned earlier there is special department for Gezira and Almanagil schemes supervised by the general manager. Also there is the follow up of the management which is done by Mr. Undersecretary and Mr. Minister, and every person who has authority. There is mechanic and electric general department in the ministry which has an effective role in operation and maintenance. Operational management for Gezira and Almanagil in Wad Medani with the general manager of engineers and accountants and writers. Also there is mechanic and electric general department in Wad Medani includes several specializations some in operation and maintenance in Gezira Scheme, also there is a director in wad medani with staff of engineers, technicians, accountants and writers. And a director in Almanagil in 24 Qurashy with staff of engineers, technicians, accountants and writers in the out scheme sectors. There was three and later it became four in the Gazira division sectors and two in Almanagil. And every division has engineer with a staff of

chief engineer, technicians, accountants, writers and a mechanic engineer which supervise the warehouse which has the needs for the operation and maintenance. The same in Almanagil. In every sub division sector which is 13 in Gezira and 15 in Almanagil there is an engineer, assistant engineer, mechanic technician, accountant and writer.

In every sub division sectort there is from two to five engineering point. The total of these points in algazira and almanagil are 78 point, every point has an engineer and staff of measuring engineer, observer, measuring technicians, labours, builder, carpenter, weeds labour, water observers, guards and barrage labour. There is a car available for each engineer and a lorry in every department and even the point engineer has a lorry.

The role of the point in operation and maintenance

The point engineer is responsible of a 30,000 feddan area with seven branch canals border. He and his staff are responsible for operating and maintenance of these canals or areas by daily observation for the levels in the mouth of the canal and the situation of the canal and barrage from the mouth barrage and the middle barrages and Abu Ishreen doors and pipes. To do any maintenance work that is need it in the facilities. Knowing that all the needs for maintenance are available in the store which was ordered according to his suggestion. Also the workers and staff are with him so the work doesn't need to be postponed for tomorrow. He is supposed to mend all the cracks in the canal which rarely happens because there is constant observation to the water levels and control regulators. He should also do the cross sections for the canals and determine the canals that need sediment removal by putting the priority first and then the second and submitting it to the sector engineer for approval. After approval he prepares the rehabilitation list and follows up the rehabilitation with the measure engineer and technicians. (Knowing that the sediment removal from the canals is done by the irrigation ministry machines, the work which is done by the electric and mechanic department in the operating and maintenance process in Gezira Scheme) after that he writes a report of the amount of sediment removed compared to the demand and sending it to the sector to be put in the canal file. Also if the work needs cross sections to know the amount of sediment removed so it can match the rehabilitation list, he should do it if the canals are dry. If he had any problem in his sector he should be prepared to solve it immediately. If weeds appeared in the canals which can happen in winter, there are weeds labour which can remove them (they are temporary labours which are employed with daily payment for three months in a year) if a door was broke down or an accident happened to one of the barrages there is the turning worker (which is technically related to the electric and mechanic department) and the builder and labour and the needs in the sector (all the needs for the civil and mechanic maintenance). The point engineer has to know all the designed levels of each canal from the mouth and through all the middle regulators knowing that the operation of the middle regulators is only done by the agricultural department by the canal guard which opens and close the Abu Ishreen doors day and knight so that the irrigation can be during the day only. Also the middle doors for knight storage. The point engineer makes schedule for the mouth canal guard which shows the required door openings verses the amount of water that passes through the opened door, this is to make it easier to communicate with the canal guard in the mouth door of the canal to let the required amount of water pass. The point engineer receives the water request from his canals sectors from the agricultural department inspector and sends it to the sector engineer so he can added to the other requests. After receiving the requests he increases or decreases the water supply from the canal according to the requests that he received from the inspector, knowing that it's according to the capacity design of the canal. The point engineer prepares the budget proposal for his sector and sends it to the sector engineer. Considering the care of the working environment and the means of comfort for the workers in the point by using lands out of the agricultural cycle, workers club, houses, clean drinking water and transportation to the hospitals and schools. The role of the sub division sector in operation

and maintenance is that the sector engineer and his staff follows up the operation and maintenance in there sector knowing that the area of the sector ranges from 150,000 feddan to 60,000 feddan. They should follow up all the maintenance and operation done by point engineer in his sector to ensure it and solve the problems that appear. Ensuring the cross sections in the canals which are done by the point engineer and submitting the cross sections to the majors for the sector engineer to revise and approve it. Revising the main barrages level in the sector daily morning and at the mid-day and at knight. Prepare the budget proposal for the sector from the points adding the proposed head of the sector. In the sector there is a mechanic technicians, turning labour for maintaining the main barrages doors in the sector in the case of simple maintenance otherwise it is requested from the electric and mechanic department which is located in the head of the division sector or from the general electric and mechanic department in wad medani. The sector engineer follows up the incoming water requests from the points and ensures the increase or decrease supply knowing that the point water requests are gathers in the sector and it is sent to the concerned sector after adding the requests of the previous sector if this sector was in the middle. Or sending it to the director of Sennar Dam which is the irrigation department of Wad Alno which gathers all the water requests of Gezira and Almanagil schemes and of course the water requests of wad Alno irrigation department so the director of Sennar Dam can supply all the requests according to the capacity design of the two main canals Gezira and Almanagil. (The water request that is made by wad alno engineer is added to what the sector engineer does its mentioned above) which is also done and followed up by the water observers in the barrages. The water requests are done daily in the flood season and once if there was increase in a week after storage in this time it's done in Tuesday. In 31.03 there will be a complete close from the dam and the main barrages so that the sub division sector engineer can look and observe the rocks and doors in all the main barrages and doing all the simple maintenance and proposing the complicated maintenance that needs more time (because the closing is for seven days after that it opens for the summer canals (summer water)) for preparing the maintenance needs. Also the mechanical department looks at the doors and does the simple maintenance and paints the doors. The working environment is good as been mentioned for the point with a difference.

The role of the division sector head is operation and maintenance, the sector engineer and the mechanic and electric engineers do the field follow up for the operation and maintenance and also from the activity reports in the departments. The engineer approves the major cross sections after revising and supervising and participated in the field work and orders doing the cross sections. The mechanic engineer ensures the main barrages doors are working in the sectors and gets involved in the other barrages doors if asked. Also he follows up the work of the machines in the sediment removal by the field visit or from the incoming reports. That's why the sector engineer follows up the levels in the main barrages morning, mid-day and knight, registers all the remarks and orders in the concerned page in the level measuring book so it can be done by the barrage observer. The engineer and his staff prepares the proposed budget after gathering it from the sub-division sector and adding and discussing it with the department in Wad Medani for Gezira Scheme and in 24 Qurashy for Almanagil. The engineer participates in the coordination meetings with the Scheme Department to determine the location and type of areas that should be planted and the suitable time for planting according to the agricultural research corporation. Also the engineer follows up the implementing of the proposed budget which used to be done perfectly because the needs arrive in time (from the store, errands, mechanic transport, the central purchases from ministry of finance and the purchases from Wad Medami). The work environment as mentioned with difference.

The role of the Gezira Irrigation Department in Wad Medani and 24Qurashy in operation and maintenance is the follow up from each operation director in Gezira and in Almanagil in the operation and maintenance in each sector through the incoming weekly and monthly reports, also through the programmed and non-programmed field visit to see how the operation and maintenance is going and solve any problems if found. Also follow up the main barrages level daily in the morning so find the

solution for a problem if found. Prepare the proposed budget for all the departments and submitting it to the director of Gezira and Almanagil. Participating in the coordinated meetings with the agricultural department to know how the work is going according to the incoming reports every ten days about the peasant or farming process and irrigation and solve the problems if found. The director of Gezira irrigation and his staff puts a programme for the closing of Sennar Dam at 31.03 and a programe for summer water after a week from closing and notice all the involvers and the general manager, the minister and the agricultural department.

The role of irrigation process in Gezira and Almanagil, mechanics and electricity, under-secretary and minister in operation and maintenance.

The follow up of the operation and maintenance from the weekly and monthly incoming reports which is submitted after gathering it from each sector in the Scheme. This is to know how the work is going in the operation and maintenance and to get involved in solving the problems if there were problems mentioned in the report. If there were argent problems that needs a quick solution it needs to be submitted in time. The water supply needed from the Dam it is requested from Wad Alno irrigation engineer if it was according to the design capacity of the two main canals. If for any reason there was increase on the water request it should be approved from the undersecretary or the minister. The undersecretary should be a member of the Gezira Scheme council so he should know all there is to the operation and maintenance in the Scheme also the minister should know that for the council of ministers meetings.

Operation and maintenance of the irrigation system in present

Above was the method used in the past in the operation and maintenance of the irrigation system in Gezira Scheme.

The method now that is mentioned in all the reports and speeches that wants the Gezira Scheme to return to its first way. Knowing that all that is mentioned was used even when they changed the joint account to individual account in the Scheme and the economic liberalization policy which lead to force the farmers to pay water and managing fees. At this time the operation and maintenance started to decline in the Scheme. Because the previous method used to depend on the excellent funding flow from the ministry of finance for all the Scheme agricultural and irrigation departments. Then the problems appeared between the agricultural department and irrigation department, it was all in the operation and maintenance in the embranchment canals. In the previous method the operation of the embranchment canals used to be the responsibility of the agricultural department and the maintenance is the responsibility of the irrigation department. That why a decision was made that the operation and maintenance of the embranchment canals should be the responsibility of the irrigation department which didn't continue for long also the decision of making the irrigation water authority didn't continue for long, because the conflicts were continuing. A committee was made it recommended to disintegrate the irrigation water authority, and the operation and maintenance of the embranchment canals became the responsibility of the agricultural department. This is also didn't continue because the law of the 2005 gave the operation and maintenance to the embranchment canals to what is called water users associations from farmers finally Gezira and Almanagil irrigation process departments were added to the general manager of the Scheme. All of this didn't solve the problems but it increased more. The role of the engineers became to solve the conflicts here and there. The number of workers in the irrigation department became less and most of them moved to other locations to seek their interest. For example the weed labours became partners with the farmers and they lived in the camp, the engineers left to the gulf countries and to other companies in Sudan. And now after presidential decree number 32 which devolved the department of operation and maintenance of the irrigation process of the Scheme to the ministry of water resource irrigation and electricity, by this decision the irrigation undersecretary

received the irrigation buildings and all involved from equipment and accessories. By this the operation and maintenance of the irrigation system is the responsibility of the irrigation undersecretary.

III.6. O&M Financing Modalities

Eng. Ahmed M. A. Abu Sin

Conclusion

Deadly sure that the operation and maintenance with their recent situation depend mainly on water fees.

1. paying for operation and maintenance on the irrigation network is strongly related to the success of the season;
2. the success of the agricultural season for Gezira Scheme depends mainly and highly on the season funding and its sufficiency and time;
3. before the agricultural intensification; the agricultural fund was only provided to Cotton crop while the other crops (Sorghum, beans and vegetables) were on the farmer's own;
4. after the agricultural intensification the beans and wheat have been entered in the agricultural cycle and then the cycle in Gezira Scheme became quaternary and triple cycle in Managil Scheme, while the funds for cotton, beans and wheat became personal;
5. the agricultural intensification and the diversity in crops lead to weeds appearance in the irrigation canals and drains which results in increase in sediments rates in channels; and so on this agricultural intensification added more weigh at budget of operation and maintenance in irrigation network;
6. the addition of rice crop in the agricultural intensification and the crops diversity requires land submergence for a long period which results in weeds growth (Elseid and Elnajel) in the areas where the water management was bad or due to the farmers ignorance and as a consequent the rice has consolidated the irrigated land and the productivity of all crops weakened;
7. the form of the agricultural fund and the success of the season effect the operation and maintenance works in the irrigation networks, so it could be possible to look for the funding methods:
    a) since the agricultural company became the responsible of Gezira Scheme; it participated with the government in providing only the required fund for cotton production;
    b) when the company contract was ended in June 1950; Gezira Scheme Directorate has been keeping get its financial resources from the cotton profits;
    c) in 1968 and according to applying the agricultural intensification and the costs of wheat and beans; the administration had to get debt from Central Bank in addition to the main ratified with 7% interest;
    d) in 1970 the cotton strain marketing was funded to the Cotton Marketing Corporation and the seed should be marketed by the Scheme directorate and the Scheme technical supervision transmitted from the Finance ministry to Agriculture Ministry. During the last half of 1970s the country faced a decrease in getting hard currency due to the less crops productivity and the Scheme requirements from the import production inputs became provided by the foreign loan until 30/06/1989;
    e) In 1988 season the government announced that the corporations and institutions department which follows the Finance Ministry is the responsible of approving the Scheme budget;
8. the dependence on the external loans affected the inputs that became with high prices and low quality, also the funds from Sudan Bank with interest rate (7 - 9%) leaded to rise up the production cost and this affected the productivity;

9. the decrease in productivity resulted in the disability of the farmers to return back the funds and so there was shortage to pay the maintenance and operation costs for the Scheme because there is no profit;
10. the cost of operation and maintenance for the irrigation networks has been paid from the government share which is from the Scheme surplus of the profit that the directorate collected the irrigation fees;
11. when the productivity decreased through season 90/91; the Scheme directorate didn't pay the water fees for the Finance Ministry and then the ministry paid the operation and maintenance costs;
12. the cost of the agricultural funding, the operation and maintenance for the irrigation networks have been paid from the combined account after collecting the irrigation and land fees;
13. this system suffered from several problems and conflicts in the farmers' share which resulted in decreasing the government and the Scheme directorate shares.

Table III.6.1 shows the changes which were occurred in the triple company during the period 1950/1951 – 1980/1981.

Table III.6.1. Changes that occurred in the triple company during the period 1950/1951 – 1980/1981

Season	Government	Farmer	Directorate	Finance Ministry	Social Services	Agricultural Assurance
50/51 – 56/57	40	40	40	-	-	2
56/57 – 59/60	42	42	10	2	2	2
63/64 – 64/65	40	44	10	2	2	2
65/66 – 68/69	36	48	10	2	2	2
69/70 – 80/81	36	47	10	2	3	2

14. the broke up of the triple company system applied the personal account system;
15. the agricultural administration has been keeping collecting the irrigation fees since 80/1981 for the finance ministry which it has been paying the costs of maintenance and operation for the irrigation and water resources ministry;
16. according to the financial blockade and the low productivity in the Scheme plus the delay in funding the operation and maintenance works in irrigation networks which were not efficient; the irrigation network became bad and as consequent the productivity decreased and the irrigation fees collecting from farmers became very difficult knowing that the Scheme directorate has been keeping taking 10% from the directorate share from the irrigation fees and the Scheme profit;
17. the irrigation fees have been estimated according to the number of irrigations that were required for each crop in the agricultural cycle;
18. the irrigation fees categories were defined by specialized committees after the broke up of the triple sharing system;
19. in 1955 the irrigation water corporation was founded to be responsible of water supply and the operation and maintenance of canals; whereas the costs of operation and maintenance from water fees, but the water fees have being collected still by the Scheme directorate that doesn't transform these fees to the finance ministry. The result of this was a great failure in the operation and maintenance works for the irrigation network;
20. after this failure from the committee of the irrigation water administration; a law texts that the operation and maintenance works or the smaller irrigation network should follow Gezira Scheme directorate was issued in 1995;

21. the performance of the small irrigation network weakened and a big problem in the operation and maintenance the small irrigation network was developed;
22. one of the disadvantages of the law of devolution of the small irrigation network to the Scheme directorate ended the engineers' stations systems which were 72 stations in the Scheme that affected negatively the operation and maintenance works and determining of the cultivated areas and so it affected the irrigation fees budget;
23. in 2000 the small irrigation network were returned back while the engineers' station system didn't, and the finance ministry should rehabilitate the irrigation network. The unavailability of the engineers stations in the Scheme resulted in difficulties in rehabilitation of the irrigation network and its operation efficiently, and the rehabilitation was done in a certain and small domain.

In 2005 a law was announced about forming the water users links and the small network should follow the links that provide the funds for the operation and maintenance of the small irrigation networks.

السياسات والتشريعات بمشروع الجزيرة

III.7. Policies and Legislations

Eng. A/Salaam Mohamed Salih

Introduction

The policies and legislations are the regulators of the relation between the different management bodies in the Scheme and the institutional and legislative reform guarantee the implementation of the prepared plans to provide water for irrigation in the defined time and the place to improve and increase the productivity and the national production.

- *the participating bodies in Gezira Scheme:*
  The bodies that play an important role in the irrigation process are:
  1. Irrigation Ministry. 2. Directorate of Agriculture
  3. the farmers 4. the Government
- The responsibilities of these participating bodies in the irrigation process can be summarized as:
  1. *Ministry of Irrigation:*
     - to simplify the irrigation process management; the Scheme was divided to four big irrigation divisions which were divided also into smaller divisions (13 in Gezira and 10 in Managil);
     - an engineer with assistant engineer to supervise each division;
     - the responsibility of the irrigation engineer are:
       a) checking the proposed areas to be cultivated according to the plan;
       b) defining the cultivation and irrigation times and the number of irrigations with the agricultural inspector and checking the canals capacity;
       c) committing the receiving of the agricultural extension officer indents and matching it with the times and water discharges in canals;
       d) operating and maintenance the irrigation network in the certain division;
     - providing security and measuring technicians in the gates and canals to support in water management;
  2. *Department of Agriculture:*
     - whole Scheme area has been divided into administrative divisions and each division further divided into offices or stations (114 offices) and each office has extension engineer with one or two inspector to assist him;
     - the responsibilities of the agricultural extension officer:
       i. determine the proposed cultivated areas (the area, the agricultural cycle, crops….etc.) before the onset of the agricultural season;
       ii. supervise the farmers in preparing the land and provide extension advices;
       iii. provide the water indent to the irrigation engineer and following the supplying this requirements;
  3. *Farmers:*
     - the number of the farmers in Gezira Scheme is estimated about 130,000 farmers;
     - the farmer responsibilities are:
       i. prepare the land that will be cultivated in a way that facilitates the irrigation;
       ii. committing with the cultivation and the irrigation schedule;
       iii. application of irrigation water at field level;

iv. weeding and cleaning the field ditches (Abu Ishreen and A/VI);

4. *The Government:*
   - is the owner of the Scheme and is represented by the governor who is responsible for developing the Scheme and is appointed by the president of the republic.

The legislated changes in Gezira Scheme

1. *The irrigation and drainage Act of 1990:*
   Contains six chapters and 25 articles; and the main objectives of this Act are:
   - maximize the utilization of the water resources and its structures;
   - check the safety of the layout and design of the projects to ensure its objectives;
   - define the responsibilities of the administration, operation and maintenance to apply it as required;
   - the ability of the continuous raising the operation efficiency and the productivity;
   - protecting the work environment;
   - protecting the elements of the projects from violations and harmful uses;
   - also it is included in the Act some subjects related to the infractions which are committed without obeying the Act rules and penalties that can be signed when someone committed in any of it.

   The law should be renewed to be in the same level with the institutional changes that happened in Gezira Scheme.

2. *Gezira Scheme Act of 2005:*
   This law was preceded by several laws that were objected to improve Gezira Scheme; the first one was the Gezira Scheme lands Act in 1927 followed by Gezira Scheme Act in 1950 and Gezira Scheme Act in 1984. The articles related to irrigation in 2005 Act are:
   i. Article 18(1): The ministry of irrigation is responsible for the maintenance and management of the irrigation channels and the main drains. Also it was stated in this article that the ministry of Finance should fund the maintenance, the rehabilitation and the operation of the irrigation canals from collecting the water rates from farmers;
   ii. Article 18(2): The water users associations are responsible for operation and maintenance of the field canals and drains;
   iii. Article 18(3): The approval of irrigation for any area from the Scheme network is only done after the agreement of the governing board;
   iv. Article 19(a): The water users associations are formed on the Scheme scale under the supervision of the governing board. The self-administration of farmers represents legal personality and receives real tasks in the uses of water management by contract with the Irrigation Ministry in the field of water supply and technical consulting;
   v. Article 19(b): the irrigation ministry should form a special directorate for the irrigation of Gezira Scheme.

   - ❖ 2005 Act caused negative impacts on the Scheme due to the inappropriate application;
   - ❖ there are no regulations for the act except the water users associations regulation and it was defective;
   - ❖ it resulted in transferring the irrigation management from its legal and institutional position in the ministry of irrigation and water resources to the ministry of agriculture;

- ❖ all workers services in the Scheme were ended in one day which hasn't ever happened before;
- ❖ the administrational hierarchy has not been done for the water users associations in the Scheme level;
- ❖ there was no any maintenance for the irrigation canals and structures as the act provided.

3. *Gezira Scheme Act of 2015 with 2014 changes:*

To improve the incapability that caused from 2005 Act; some amendments have been made which are:

- ❖ dissolving the water users associations expressions and replace it by farmers regulations;
- ❖ providing two explanations for the field canals and irrigation canals expressions;
- ❖ cancelling the article (18) and replacing it with:
  - i. the irrigation department (following ministry of agriculture in the past) and currently the ministry of irrigation, water resources and electricity is the responsible of maintenance and managing the irrigation canals, main drains and pumps in the Scheme to provide the sufficient water to farmers regulations at the off take of the field canals, whereas the ministry of finance concerned by the funds of rehabilitation and operation of the irrigation canals as return from collecting the water rates which contribute in applying these services;
  - ii. the Scheme administration and farmers organizations are responsible of the operation and maintenance of the field canals and drains;
  - iii. the ratifications are only done by the irrigation administration and after the governor confirmation;
  - iv. the Ministry of Agriculture and Irrigation (Currently Ministry of Water Resources, Irrigation and Electricity) should establish a special irrigation department for Gezira Scheme irrigation; and this will technically follows the ministry and administratively follows the Scheme administration;
- ❖ the modified law requires a new regulation for it.

4. *Constitutional Decree number (32) of 2015:*

According to the Constitutional Decree (32) all the irrigation responsibilities were transferred to the ministry of water resources, irrigation and electricity.

5. *Organizing the owners of agricultural and livestock production professions Act of 2011:*

The intent of this act is to form farmers' organizations to be an alternative for the farmers unions and the water users associations as the law texted for the regulations to be as follows:

- *Basic organizations.* It is formed by number of farmers and pastorals; the area of the one Basic society should not be less than 1000 feddan and it is possible to form more than one society for the long canals;
- *The specific organizations*. It is formed from number of basic societies;
- *The specialized organizations.* It is formed from number of specific organizations;
- *The general organization*. is the united organization for all the farmers and livestock.
  - ❖ it is common for any project to face this huge and several changes which can affect negatively or positively in the performance of the different project components. For example Gezira Scheme was subjected to changes in the agricultural cycles (Diversity and intensification), the change of sharing pattern, the personal account system, the irrigation methods changes, Economic liberalization policy, Institutional Reform ….etc. So the several legislations changes which affected the project are

related to the total and general policy of the national economy and the social developing strategies in the country;

- ❖ the answer of the following asked questions is remaining under attention of those who are interested in the project future:
  - does the applicable institutional situation in the irrigation administration of Gezira Scheme represent the ideal situation to enhance the project situation?
  - are the current applicable legislations sufficient?
  - does the activation of the acts that were intended to improve performance and the legal frameworks for penalties that related to the infringements of these acts have positive effects in protecting the irrigation structures?
  - is there any other national or regional experiences can be utilized in the legislative institutional part for the irrigation of Gezira Scheme and what are they?
  - what are the motivations and the threats to the success or failure of the irrigation in Gezira Scheme from the institutional and legislative parts?

III.8. Sediment and Weeds Management

Eng. Osman S. Saleem and Mohamed E. Suliman

The sediment removal from channels researches

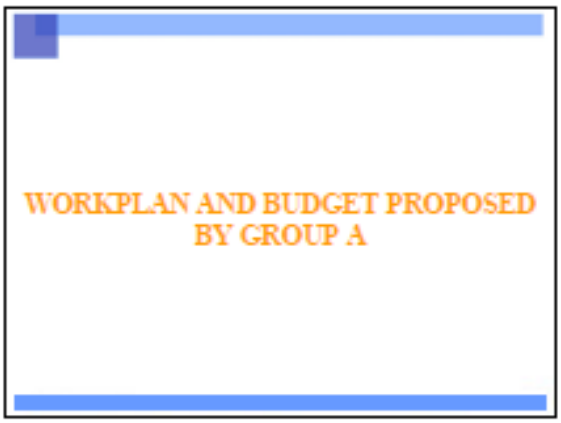
1. The situation of the canals is estimated (usually) from the daily measurements note which all the daily data for all canals are recorded in it. He downstream* level indicates to the availability of some obstacles in the canal which can be deposit sediment or aquatic weeds through the reach;
2. After that visualization and some measurements to check the designed width and depth are done for the canal;
3. According to that the priorities are defined in the planned removal program after the budget estimation;
4. A base line in parallel to the canal is set up with fixing stakes every 200 m (T.B.M) through the canal length;
5. The Reduction and plotting the cross sections profiles in graph papers are done at the office (M.M.P). From the longitudinal profiles of the canal the designed profile is plotted and then the sediment rates can be calculated to be removed;
6. The required removal of the canal is printed in a Table;
7. After the determination of the amount of sediment that should be removed and after completing the work; the cross sections profiles after the removal process are checked again to make sure that the ratified amount of sediment that were estimated to be removed are completed properly.
8. The data is recorded weekly in a Table.

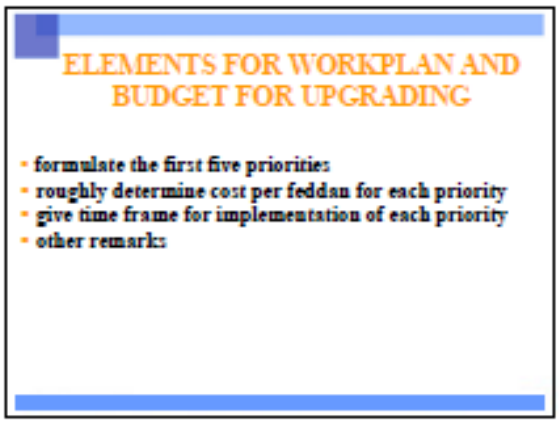
Instructions:

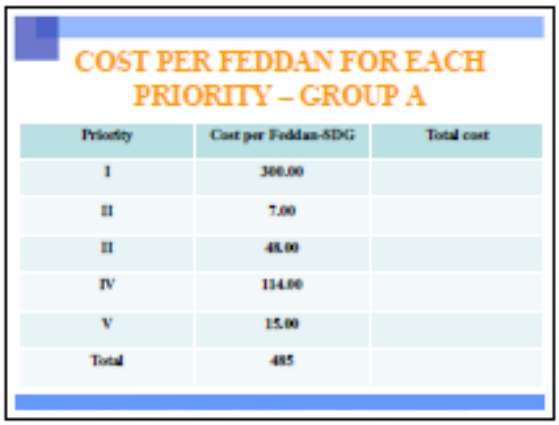
1. the excavator driver and the measurement technician should properly apply the work;
2. the measurement technician must make checks before and after the excavator work to make sure of digging the quite required depths;
3. the excavator driver should fulfil the instructions of the measurement technician;
4. the measurement technician should fix surveying poles at the first and last points of the excavation reach and at the axis;
5. the removed sediment should be put uniformly in both sides without leaving any gaps between two buckets;
6. the measurement technician should be present in the work site with the excavator all the time;
7. the excavator driver should not work in case of the measurement technician absence;
8. the measurement technician should directly report if there is any breakdown in the excavator.

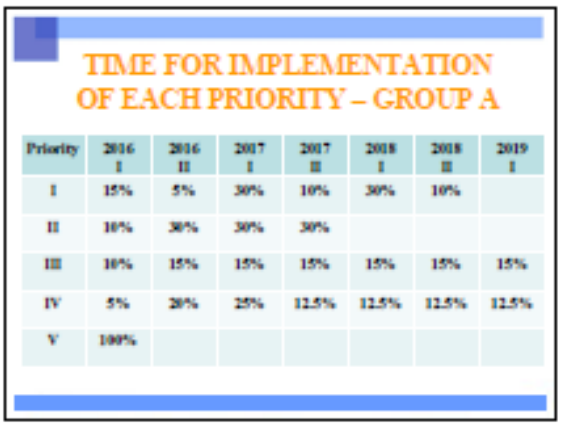
ANNEX IV. Draft Workplans and Budgets as prepared by 4 groups

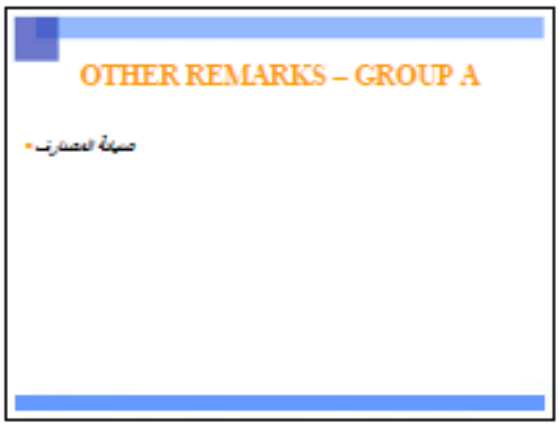
Note: this should indeed be on the CD as well, but I did put it here, while it was prepared by the participants after good discussions











ELEMENTS FOR WORKPLAN AND BUDGET FOR UPGRADING

- formulate the first five priorities
- roughly determine cost per feddan for each priority
- give time frame for implementation of each priority
- other remarks

PROPOSEDWORKPLAN AND BUDGET GROUP B

FIRST FIVE PRIORITIES – GROUP B

- I) Some types of offtakes and intermediate structrures are not functioning properly so needs replacement , silt clearnce is essencial
- II) Became the responsibility of the ministry and all of it are bad an may not exist , so most of it need complete new construction arrangement and errection.
- III) This is a very important part in the main canal and was constructed since the early time of the scheme . The upgrade of this type is very cruisal to water supply downstream.
- IV) There is insufficient number of engineers in the sections and divisoins and skilled staff , need for new staff for the operation of Abuishreen (housing,offices , comunation facilities, trainning and others need to be established). The coordination committees and task missions need to be set up.

FIRST FIVE PRIORITIES – GROUP B

I) **Off-take and intermediate structures to minor canals, silt removal and measuring and data collection utilities.**

II) **Abuishreen out lets pipes and valves (FOP & valves)**

III) **Gantry crane gates in the main canal (k 57,77,99, 108 ..)**

IV) **Human power recruitment and training ,housing ,offices ,equipement , commucination facilities for the sections and formulation of coordination relationship betweetn parties**

V) **Drainage systems upgrading**

%AGE FOR IMPLEMENTATION OF EACH PRIORITY – GROUP B

Priority	2016 I	2016 II	2017 I	2017 II	2018 I	2018 II	2019 I
I	30	10	20	10	15	10	5
II	30	25	25	20	-	-	-
III	..	10	25	10	30	15	10
IV	20	25	25	15	10	5	-
V	20	15	25	20	15	5	-

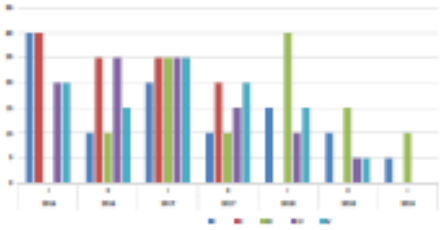
COST PER FEDDAN FOR EACH PRIORITY – GROUP B

Priority	Cost per Feddan	Total cost
I	26.5	5563500
II	40.1	8420000
III	11.9	2500000
IV	441.5	927283000
V	10.8	2272000
Total	530.8	1,114,818,000

BUDGET FOR IMPLEMENTATION OF EACH PRIORITY – GROUP B

Priority	2016 I	2016 II	2017 I	2017 II	2018 I	2018 II	2019 I
I	16684500	8561500	11113000	8561500	8342250	8561500	2780750
II	21050000	21050000	21050000	21050000	-	-	-
III	-	2500000	6250000	2500000	7500000	2750000	2500000
IV	185456600	231821750	231821750	139092450	92728300	46364150	-
V	4564000	340000	5680000	4564000	340000	1136000	-

TIME FOR IMPLEMENTATION OF EACH PRIORITY – GROUP B



PROPOSED WORKPLAN AND BUDGET GROUP C

ELEMENTS FOR WORKPLAN AND BUDGET FOR UPGRADING

- formulate the first five priorities
- roughly determine cost per feddan for each priority
- give time frame for implementation of each priority
- other remarks

FIRST FIVE PRIORITIES – GROUP C

I- Upgrading of structures in lower system (Minor canal & FOPs).(include off takes ,intermediate structures,FOP.s)
- ✓ 25% of total no. Of offtakes (1500)
- ✓ 60% of total no. Of intermediate structures (3473).
- ✓ 80% of total no. Of FOPs (30000).

II – Sediments remaval and improving managment of minor canals :
- ✓ considering firset two reaches for Minor canals (50% of the total length of the minors).

FIRST FIVE PRIORITIES – GROUP C

III – Filling the human resources shortage (engineers, operators, skilled/unskilled labourers and others)
- ✓ Recruitment
- ✓ Training
- ✓ Imporving work environment (transport, houses, ...)

IV- Drainage system
- ✓ Removal of sediment - earth work
- ✓ structural – crossings

V- Upgrading the upper system structures
- ✓ Main control points
- ✓ Offtake of escape drain

COST PER FEDDAN FOR EACH PRIORITY – GROUP C

Priority	Cost per Feddan	Total cost
I	114	
II	16	
III	25	
IV	6	
V	14	
Total		

TIME FOR IMPLEMENTATION OF EACH PRIORITY – GROUP C

Priority	2016 I	2016 II mil. SDG	2017 I mil. SDG	2017 II mil. SDG	2018 I mil. SDG	2018 II mil. SDG	2019 I
I		1.313	5.497	4.427	1.754	1.754	
II		26.68	0	0	0	0	
III		48.607	0	0	0	0	
IV		2.891	2.691	2.291	1.290	1.290	
V		0	6.600	4.400	5.500	6.850	

PREPARATION OF WORKPLAN AND BUDGET

Participants

Responsible

Rama Raju, Bart Schultz, Abu Obeida and Abraham

Facilitators

Bart Schultz, Abu Obeida and Abraham

Reporters

ELEMENTS FOR WORKPLAN AND BUDGET FOR UPGRADING

- formulate the first five priorities
- roughly determine cost per feddan for each priority
- give time frame for implementation of each priority
- other remarks

FIRST FIVE PRIORITIES – GROUP D

I Irrigation Structures and Control Gates in the Distribution system

II Human Resources Needs , and capacity Buildings

III Infra-structure, Services & Working Environment

IV Drainage system full study and implementation

V `Sediment Removal and weeds control

Summery of Priorities cost for Base Year

Item	Description	Total Cost
PI)	Irrigation Structures and Control Gates in Distribution System	191,100,000.0
PII)	Human Resources Needs, & capacity Building	182,710,800.0
PIII)	Infra-structure, Services, and Working Environment	282,349,800.0
PIV)	Drainage System Study and Implementation	36,825,000.0
PV)	Sediment Removal and Weed Control	36,750,000.0
	Gt. Total	896,501,000.0
	cost / Fd	485.67

COST PER FEDDAN FOR EACH PRIORITY – GROUP D

Priority	Cost per Feddan	Total cost
I	382.3	537,480,000
II	357.4	506,149,500
II	524.7	787,048,500
IV	73.1	109,575,000
V	73.5	110,250,000
Total		2,086,503,000

TIME FOR IMPLEMENTATION OF EACH PRIORITY – GROUP D

Priority	2016 I	2016 II	2017 I	2017 II	2018 I	2018 II	2019 I
I	study	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
II		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
III		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
IV		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]