REPUBLIC OF SUDAN - MINISTRY OF AGRICULTURE AND FORESTRY (MOAF)
GASH SUSTAINABLE LIVELIHOODS RESTORATION PROJECT (GSLRP)
PROJECT COORDINATION UNIT (PCU)
KASSALA STATE
TEL: 825662 - 826820
FAX: 826302

جمهورية السودان - وزارة الزراعة والغابات
مشروع تنمية سبل المعيشة المستدامة بحوطة القاش
وحدة تنسيق المشروع
ولاية كسلا
تلفون: ٨٢٥٦٦٢ - ٨٢٦٨٢٠
فاكس: ٨٢٦٣٠٢

التاريخ: ٢٠٠٨/٧/٢٧ النمرة: وزغ/م ت س م م/بعثات/١

السيد/ _____

الموضوع : بعثة المتابعه من إيفاد

١٥/أغسطس الى ١٢/ سبتمبر ٢٠٠٨

كما سبق أن أوضحنا فى إجتماعات سابقه بأنه ستصل بعثة متابعه من إيفاد فى أغسطس ٢٠٠٨ وذلك لمتابعة تكملة تقرير نصف الفترة. نرجو أن نفيدكم بأن البعثه ستبدأ عملها بالخرطوم فى ١٥/أغسطس ٢٠٠٨ وتصل الى كسلا فى ١٩/أغسطس وستبقي بها للاجتماعات والزيارات الميدانية حتي ٣٠/أغسطس ٢٠٠٨ حيث تعود بعدها الى الخرطوم لمواصلة الاجتماعات مع الوزارات المركزية وتعقد اجتماعها الختامي فى يوم ١/سبتمبر/٢٠٠٨ لتتفرغ بعده حتي ١٢ سبتمبر ٢٠٠٨ لاعداد تقريرها النهائي.

تجدون مرفق صلاحيات البعثه والتقرير الذي أعده مهندس الري المستر أيان.

الجدير بالذكر أن البعثه ستقودها رشا عمر وعضوية د. محمد عبدالقادر و د. سيد زكي ومستر أيان ، كما أنها بعثه هامه ستحدد مستقبل الأنشطه فى المشروع وتحتوي المرفقات علي كل المعلومات المطلوب من الوحدات إعدادها.

ولتيسير الأستعدادات نرجو ان يتم عقد اجتماع يوم الثلاثاء الموافق ٢٠٠٨/٧/٢٩ الـ١١:٣٠ـاعه بمكاتب هذه الوحده.

للاهمية نرجو أن يشارك الساده مدراء الوحدات المنفذه وضباط المتابعه والمهنيون بوحدة التنسيق. أرجو أن يعطي الأمر أهمية قصوي.

وشكراً ...

عبده عباس الرفيق

منسق المشروع

مرفقات:

- كأعلاه

معون الى الساده :

- مدير عام وزارة الزراعه والري – كسلا (أرسل لكم المرفق علي العناوين البريدية للساده عبد الحكيم وعبد القادر وعبدالحفيظ).ارجو ان يخطر الساده المدراء به ومناقشته بينكم قبل الأجتماع)
- مدير عام مشروع القاش الزراعي – أروما (أرسل لكم المرفق علي عنوانكم البريدي)
- المدير التنفيذي لوحدة ترويض نهر القاش – كسلا (أرسل لكم المرفق علي عنوانكم البريدي وعنوان السيد/ حاتم)
- مدير عام وزارة الثروة الحيوانية والسمكيه – كسلا (أرسل لكم المرفق علي عنوان السيد/ د.أنور)
- رئيس اللجنه القانونية – كسلا
- مسجل التنظيمات القاعدية (أرسل لكم المرفق علي عنوانكم)
- مدير عام هيئة مياه الشرب - كسلا
- مدير البنك الزراعي السوداني – فرع اروما (أرسل المرفق علي عنوانكم)
- المهنيون – وحدة التنسيق (أرسل لكم المرفق علي عناوينكم البريدية)

صورة الى

- السيد/ وزير الزراعه والري – رئيس المجلس التنفيذي

Feedback requested on the terms of reference for the follow up mission to GSLRP - In... Page 1

Feedback requested on the terms of reference for the follow up mission to GSLRP

Thursday, July 24, 2008 3:53 AM

From: "Omar, Rasha" <r.omar@ifad.org>

To: "gslrpcu - kassala" <gslrpcuk@yahoo.com>

Cc: "Stordeur, Isabelle" <i.stordeur@ifad.org>, "Abdelgadir, Mohamed" <m.abdelgadir@ifad.org>, "Mohamed Abdelgadir" <mohamed.abdelgadir@undp.org>, "Mohamed Hasan Gubara" <hassuni99@yahoo.com>... more

Terms of reference of the follow up mission to GSLRP.doc (107KB), WP on Irrigation Infrastructure Rehabilitation_Ian.doc (2337KB)

Dear Mr. Abdu Abbas,

Kindly find attached the terms of reference for the forthcoming follow up mission to the GSLRP. You will find in the terms of reference the list of preparatory work that is needed from the GSLRP, GAS and GRTU and that requires to be ready prior to the arrival of the mission. I am also sending you an advance copy of Mr. Ian Anderson paper on the rehabilitation of the irrigaton infrastructure, the river control works and the rehabilitation of the water pipeline, for review, verification and feedback. The rest of the report will be sent to you by next wednesday 30th July.

Look forward to your response on the TOR , on the preparatory work required prior to the mission and whether the GSLRP/ GAS and GRTU will be able to have the required feedback available by 15th august, prior to the start of the follow up mission.

Best regards,

rasha

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Terms of Reference for the Follow Up Mission to the GSLRP (SD-630)
DRAFT for REVIEW

I. Introduction to the mission

The GSLRP was appraised in mid-2003 immediately during the devastating floods that struck Kassala city and its surroundings. The loan agreement was signed in January 2004. The start up workshop was held in June 2004 and the loan became effective in August 2004. Loan completion is scheduled on 30th Sep 2012 and loan closing on 31st March 2013.

The project investment period covers 8 years. The total project cost at appraisal amounts to USD 39.0 million, to be financed by the Government (USD 8.9 million), IFAD (USD 24.9 million), the participating financial institutions (USD 0.5 million), and beneficiaries (USD 4.7 million). The project's economic internal rate of return (EIRR) over 20 years is estimated as 12.7% when considering the costs of river control and the costs related to institutional support to MOIWR. When dropping these costs, EIRR is estimated at 15.4%.

The **overall objective of the project** is to regenerate the livelihoods of the maximum number of poor people in and around the Gash delta, compatible with the efficient and sustainable use of its land and water resources and based upon a shared vision of development and stability of the related institutional arrangements. The purpose of the project is to ensure an efficient, equitable and sustainable operation of the Gash Agricultural Scheme and its integration into the local economy. The project target group is composed of 67 000 households out of a total rural population of 75 000 households. Beneficiary households include both farmers who are tenants in the Gash flood irrigation scheme and non tenants who are either landless or who have an agro-pastoral livelihood.

The specific **outputs of the project** are:

(I) the elaboration and maintenance of a shared vision of development;
(II) establishment of institutional arrangements appropriate to the shared vision;
(iii) rehabilitated water and other social infrastructure and water harvesting devices;
(iv) improved crop and livestock husbandry practices;
(v) access of tenants and non-tenants to formal financial services; and
(vi) strengthened State planning capacity.

The Project has the 5 following components:

(a) **Irrigation Infrastructure Rehabilitation** that will enhance the capture of flood waters through river control and stream regulation, reconstruct the water reticulation network canals and access roads, and improve field layouts.
(b) **Animal Production and Rangeland Management** that will improve animal health services, restock men and women with improved animal breeds, and develop a sound land use policy through the rehabilitation community stock water facilities, construction of water containment and spreading structures, and control of mesquite invasion.
(c) **Community Development, Capacity Building and Empowerment** that will increase drinking water supply and quality by refurbishing existing facilities, build the capacity and empower communities through training both men and women, group formation, and provision of community initiative grants – on a matching basis - for social services support.
(d) **Financial Services and Marketing** that will allow the target group the resources to increase their productivity through the provision of credit lines for

crop inputs, the acquisition of agricultural machinery and livestock, food processing and other off-farm enterprise, and pre-financing to enhance the opportunities for marketing produce.

(e) **Institutional Support** that will encompass land tenancy reform, the formation and empowerment of Water Users' Associations, support to the Gash Agricultural Scheme, State Line Ministries and agencies, and the Project Coordination Unit to assure that the Project parties can achieve the objectives. Payment of water fees is considered an important financing contribution by the community of farmers to the sustainability of irrigation benefits.

The GSLRP **implementation approach** relies on using investments to support reforms in the governance of land and water resources that are expected to have a higher impact on livelihoods and sustainability of the flood irrigation scheme. The reform package proposed for land and water governance includes re-allocation of land to eligible tenant farmers based on a set of poverty criteria, shifting the rotation from 3 years to 2 years, formation of WUAs that would be responsible for land and water management at masga and block levels, and co-management of the flood irrigation scheme between the Gash Agriculture Development Corporation responsible for scheme management and the WUAs.

The Project Coordination Unit based in Kassala coordinates the implementation of the project activities. The Project Implementation Partners include the Gash Agriculture Development Corporation, the State Ministry of Agriculture and the 3 localities located in the project area. The sub-component of river control is directly implemented by the Gash River Training Unit (GRTU) of the federal Ministry of Irrigation and Water Resources and the GRTU is also based in Kassala.

The project has undergone a **mid term review** in May/June 2008. The mid-term review assessed the performance of the project as moderately unsatisfactory.

The GSLRP had positive impacts on the following:

- improved household nutrition through the remarkable increase in cultivable land, from an average of 49,000 feddan in 1990-2003 to an average of 76,000 in 2004-2007). This has been associated with remarkable increase in the annual total production of sorghum (dura, local variety: Aklamoe), the staple food, from an estimated 150 to 750 tonnes/year. Increased production of animal feeds has also reflected positively on improved health conditions through improved production of milk.
- Malnutrition rates are on the decrease and asset holding is on the increase.
- Community organization such as WUAs,Village Development Committees, Range Users Associations and CBOs and the associated wide range of training, capacity building, awareness raising, illiteracy classes, and extension works have resulted in visible social transformation reflected in the increased participation of women, registration of tenancies under the names of women and the emergence of appreciated number of informal community structures, especially among women, centred around income generation activities (IGAs).
- Population stabilization as exemplified by the case of Tambay village where approximately 400 households have been attracted back to the village, through improvements in domestic water supply, after being displaced to other areas for more than 20 years by the severe drought of the early 1980s.
- The assessment of the project performance denotes important physical progress in the river control works and rehabilitation of the GAS scheme.

Despite the above mentioned positive results, the MTR mission raised concerns regarding the

project efficiency, effectiveness and sustainability due to the following:

- The works of the river control and rehabilitation of GAS have been undertaken without sufficient attention to long term financing arrangements, management arrangements and capacity building of the state and users' organizations.
- The screening process for eligible tenants was not rigorous enough to rule out elite capture and accumulation of land holdings: although the average cultivated area has increase to approx 1.5 to 2 fed/tenant from0.5 fed/tenant priori to the project, it still falls short of the targeted 3 fed/ tenant/ year.
- Inappropriate capacities of the WUAs to undertake and sustain the future reform process. This is the result of insufficient and largely irrelevant training and the failure to implement the envisaged complementary extension/ financing and marketing services intended to support the farmers (introductionof cash crops, improved crop inputs, acquisition of farm machinery, and marketing associations)

The MTR has recommended the continuation of the project subject to critical adjustments in the technical specifications of the rehabilitation/ O&M of the spate irrigation scheme as well as improved on-masga water management, the identification of tenants in order to contain elite capture, the clarification of the WUA roles and strengthening of their capacity through appropriate training, the capacity building and organizational development of the Gash Agricultural Scheme, the supervision of the rehabilitation of the water pipelines, and re-design of the rural financial services. The proposed follow up missions will assist the Government and the PCU in validating and operationalizing these recommendations and calculating their financial implications on the IFAD loan and Government financing.

Since sharing the findings of the MTR, the **Ministry of Agriculture and Forestry has taken pro-active steps** to institutionalize the charter of the GAS and the new management system of the spate irrigation scheme co-shared with the WUAs, as well as established a committee to look into the issue of tenant identification. However, new developments in the institutional context of the project warrant an active dialogue with the Government on the options of the next phase of the project: the GAS director has resigned, opposition is gathering to block the identification of farmers, extreme pressure is put on the PCU for the project not to proceed with the proposed institutional changes.

II. Objectives of the follow-up mission

The follow-up mission aims to: (i) review and validate the priority recommendations developed by the MTR ;(ii) develop agreement and ownership for the main recommendations stemming from the MTR and the Government remedial measures particularly with state authorities including the parliamentary authorities, the SMAARI, the GAS management, the GRTU management, MOFNE and MOAF as the lead project agency; (iii) develop a work plan and budget for the implementation of the main MTR and Government recommendations; (iv) agree with the Government on the monitoring of the project performance; (v) agree with the Government on the amendments required to the loan agreement.

III. Organization of the assignment

The MTR synthesis report and working papers will be transmitted to the Government on or about 31st July 2008. On or about 15th August, a power point presentatiou of the main findings and priority recommendations will be made to the federal Government particularly MoIWR, MOFNE and MOAF, the GAS/ GRTU/ SMAARI representatives. The recommendations will be validated during the session. On or about 18th August and until 30th August, focus will be geared on operationalizing the main recommendations and preparing a multi-year work plan and budget to cover the remainder of the project period. A wrap up is scheduled at the end of

this mission to present and finalize the multi-year annual work plan and budget, financing plan and set of loan amendments.

The main operational issues to be addressed are likely to include but are not limited to:

- The technical specifications for irrigation and drainage as well as on-masga water management that are required to improve the rate of cultivated areas. The objective is to secure enough water to allow farmers to cultivate close to 3 fed/ year.
- The clarification of WUA responsibilities, capacity building requirements, internal organization, as well as supervision and audit arrangements. WUA were initially thought at appraisal to be able to maintain O&M costs at affordable level and to control elite capture of land. This assumption has proved partially correct.
- The clarification of GAS responsibilities, internal organization, supervision and audit arrangements. The GAS charter will be reviewed to assess the extent it creates an enabling environment for the co-management of the scheme between WUAs and GAS.
- The options for identification of eligible tenants and the management of the resistance to such a process, as well as incentive package to make the proposed identification process acceptable.
- What role for the LCLR?
- The re-design of the community development and rural finance components;
- The supervision of the potable water works;
- The implementation of the exit strategy of the project and the ensuing loan amendment.

IV. Scope of work of the team members

The follow-up mission will be composed of Mr. Sayed Zaki, institutional specialist and team leader and Mr.Ian McAnderson, civil engineer and water specialist. Ms. Rasha Omar, Country Program Manager, and Mr.Mohamed Abdelgadir, Country Presence Officer will participate fully in the mission. The mission will be led by Ms. Omar.

The detailed scope of work of the mission members are described herebelow.

Mr. Sayed Zaki, institutional development specialist, will be responsible for guiding the PCU on matters related to countering benefit leakages and elite capture, revising the implementation approach of the rural finance component, planning the sustainability strategy of the project. More specifically he will be responsible for the following:

- Present the findings of the MTR and validate these with the stakeholders of the project;
- Demonstrate the risks to the project and their social and economic costs as well as discuss the options for the mitigation of these risks with the stakeholders. The main risks are related to weak targeting and benefit leakage/ elite capture as well as to weak institutional and physical sustainability of the project;
- Clarify the institutional reforms required and negotiate with the key stakeholders (Farmers Union, Chairman of the Parliament, GAS, EOD, civil servants of GAS and selected WUAs) the incentives and disincentives for these institutional reforms;
- Review the recommendations pertaining to the rural finance component with the project and assist the PCU/ABS in developing a work plan and budget for the recommendations. The work plan would include a description of main activities, timeframe, division of responsibilities and costs;
- Assist the PCU in operationalizing the recommendations pertaining to the exit strategy of the project: staffing requirements and deployment; training and capacity

building; change in the project governance with the merger of the GSLRP PEB and the GAS BOD (if validated), evolution of the role of certain institutions such as the LCLR;

- Provide input on the GAS charter;
- Assist the PCU in developing milestones to track the progress of the sustainability strategy;
- Supervise that the PCU submits a multi-year work plan with the above;
- Contribute to the write-up of the mission aide-mémoire.

Contractual period for Mr. Sayed Zaki:

- 15th and 16th August, preparation of a power point presentation on MTR findings;
- 17th August, presentation of the MTR recommendations and their validation with stakeholders;
- 18th August, Follow-up discussions with the MOFNE, MOAF and MOIWR.
- 19th August, departure to Kassala;
- 20th to 30th August, fieldwork in Kassala;
- 31st August, departure to Khartoum;
- 1st September, wrap up meeting with the MOFNE, MOAF and MOIWR;
- 2nd to 12th September, review finalization of work plans submitted by the project and its key implementing agencies, finalization of the MTR report based on agreements reached with the Gvt and requested loan amendments.

Mr. Ian McAnderson, water specialist, will be responsible for operationalizing the recommendations related to the technical specifications for the rehabilitation of the spate irrigation scheme, the capacity building requirements of GAS and WUAs, the planning and financing of river control and the supervision of the water pipeline works:

- Examine MIWR designers in Wad Medani and Kassala the designs used for the rehabilitation of the Gash irrigation systems with a view to identifying improvements and additional works to be completed;
- Examine with MIWR/GAS the current condition and requirements for improvements for all structures in the GAS systems following the discussions in Wad Medani above.
- Assist the GAS and the MIWR with the estimation of O&M, on-misga water management in order to guarantee higher rates of cultivated areas;
- Work with GRTU to agree on the future work for the Flood mitigation strategy, communications and additional flow measurement equipment needed for GRTU to improve its flood warning capability and future funding needed to complete their long term river training programme;
- Assist the GRTU in preparing and submitting their work plan in such a way as funds are available for works in October;
- Examine with GRTU and GAS proposals for improvement of access between Aroma and the offtake sites and associated costs;
- Develop the roles, responsibilities, institutional linkages between the GAS/ WUA/ GRTU in line with the efficient and effective water management. In this regard develop a proposal for the internal organization of the GAS and a plan for capacity building;
- Assist GRTU and GAS to prepare annual requirements for O&M together with a clear plan for future O&M needs and for GAS, the proportions of the costs that could be met by the beneficiaries, the determination of the costs and the build up that would be possible considering returns to farmers.
- Carry out a quality audit of the supervision of the water pipeline and determine compliance of the works with the technical specifications;

- Assist the PCU with the identification of appropriate monitoring indicators;
- Supervise that the PCU/GAS/GRTU submit the multi-year work plan and budget with the above;
- Contribute to the mission aide-mémoire.
- Update the working paper submitted for the MTR based on the mission findings and conclusions.

Contractual period for Mr.McAnderson:

- 17th August, arrival of Mr.Mc Anderson in Khartoum;
- 18th August, meetings in Khartoum;
- 19th August, departure to Kassala;
- 20th to 30th August, fieldwork in Kassala;
- 31st August, departure to Khartoum;
- 1st September, wrap up meeting with the MCFNE, MOAF and MOIWR;
- 2nd September, Departure of Mr.McAnderson;
- 3rd to 8th September, report writing to update working paper, from home base.

Mr. Mohamed Abdelgadir, Country Presence Officer, will be responsible for the following:

- Assist the SMAARI in the development of its services to the farmers/ herders in the spate irrigation scheme and in the rainfed areas;
- Assist the PCU with the update of the M&E plan in order to incorporate the milestones for the project sustainability and new performance indicators developed as output of this mission.
- Assist the PCU with adjusting the M&E implementation arrangements;
- Assist the PCU in costing the M&E for the remaining period of the project;
- Supervise that the PCU submits a work plan with the above;
- Contribute to the write up of the aide-mémoire.

Ms. Rasha Omar, Country Programme Manager, will be responsible for the following:

- Lead the negotiation and agreement on the enabling environment for the continuation of the project activities;
- Validate with the Government the activities that will be maintained in the remaining phase of the project;
- Assist the PCU in adjusting the implementation approach for the community development and women empowerment activities;
- Monitor the development of the work plan and budget for the remaining period of the project;
- Lead the write-up of the aide-mémoire;
- Finalize the MTR report based on the conclusions of the mission.

Deliverables

- Aide memoire of the follow-up mission discussed and finalized based on the wrap up meeting with the Government.
- Multi-year programme and budget for the remaining period of the project.
- The MTR report finalized.

Itinerary of the mission

- 31st July, transmission of draft MTR report;

- 17th August, presentation of the MTR recommendations and their validation with stakeholders;
- 18th August, Follow-up discussions with the MOFNE, MOAF and MOIWR.;
- 19th August, departure to Kassala;
- 20th to 30th August, fieldwork in Kassala;
- 31st August, departure to Khartoum;
- 1st September, wrap up meeting with the MOFNE, MOAF and MOIWR;
- 2nd to 12th September, review finalization of work plans submitted by the project and its key implementing agencies, finalization of the MTR report based on agreements reached with the Gvt and requested loan amendments.

Annex 1: Preparatory activities required for the mission

PCU needs to work with GAS, GRTU and MIWR to ensure the following are available before the mission arrives:

I. Main Irrigation Systems

a) The details of the main canal and branch canals as well as river offtakes in the WP on irrigation rehabilitation and river control, are checked and finalised together with command areas and annual target areas.

b) MIWR need to prepare all details of designs and design report so that the mission can have concentrated and useful discussions on where to go and the way forward.

c) GAS Engineering staff and MIWR need to prepare an inventory of all structures showing those that have been rehabilitated, those that need improvements and those that are OK.

d) Details on the amount of the silt cleared from the canals by canals as far back as records go should be prepared.

e) Electronic copies of all signed and priced contracts for civil works for both GAS and GRTU are available (CCU did not have complete copies, but promised them);

II. GAS Equipment

f) A complete list of all equipment owned and operated by GAS including those not supplied by IFAD and the current condition and what they are used for.

g) Proposals for maintaining and using the equipment need to be prepared together with any requirements for improving the existing workshop facilities at GAS.

III. Misga Level Developments

h) Details of all of the Misga canals contained in the WP on rehabilitation of Gash spate irrigation and the river control, and should be checked and corrected if necessary.

i) Information on works carried out for Misga areas relating to bunding and mesquite clearance are up to date and show clearly those that are still outstanding. (GAS should develop a clear programme showing current Misga level activities, where they are being undertaken, where capital works for Misga improvement are being carried out, where maintenance of Misga bunds is being undertaken, where Misga canals need to be extended or where problems exist).

j) A clear and scheduled mesquite control programme related to the land development works should be drawn up so that it is clear which Misgas have received support and have been cleared, those that need maintaining, those still to be included and those that have parts of the Misgas with severe mesquite infestation.

k) The proposals set out in the working paper for Water Charges should be examined so that these proposals can be developed to form the basis for future sustainable funding of the systems. This needs to be linked with the training of the WUA members.

l) Details on the large number of casual labourers employed by GAS to support the irrigation process need to be prepared in tabular form so that the roles and costs of these staff can be examined to determine whether the full costs can and should be passed onto WUAs.

m) GAS should document the approach, experiences gained and findings relating to Misga level improvements so that a better understanding is gained for upscaling of the activities.

III. Water Supply

n) For the Water Supply, PCU will need to prepare an up-to-date and complete programme for the works showing both contractors work together, the results of the pumping tests and rationale for the selection of pumps, the permits for the contractor to cross the roads, railway line and private land.

o) Details of all variation orders and changes to contract quantities and specifications should be available for review by the mission with translations if required.

p) The reasons and details of any subcontracting arrangements connected with the water supply component should be prepared.

q) A Simpler TORs for resistivity and groundwater surveys should be prepared for examination of the GAS area to identify potential alternative groundwater sources. The work should comprise three stages. It should start with a brief literature survey and examination of satellite imagery to identify possible water bearing strata. This should be followed by overall resistivity surveys covering the GAS and surrounds area from the West to the East. Once areas of potential have been identified, more detailed resistivity surveys should be undertaken. Recommendations should then be prepared on areas with potential that could be examined using test drilling.

r) The progress of the work under the Kassala Water Corporation to survey sources in Kassala should be determined so that ways in which it can be incorporated into the planned resistivity surveys can be reviewed and how advantage could be made of the drilling rigs that they use with UNICEF.

WORKING PAPER ON

IRRIGATION INFRASTRUCTURE REHABILITATION

AND

WATER DEVELOPMENT SUB-COMPONENT

Table of Contents

Tables

Figures

Abbreviations and Acronyms

ABS	Agricultural Bank of Sudan
AR	Appraisal Report
ACORD	Agency for cooperative – Recherché & Development
ARC	Agricultural Research Corporation
AWPB	Annual Work Plans and Budget
BET	Block Extension Team
BOD	Board of Directors
CCU	Central Coordination Unit
CDA	Community Development Advisor
CDO	Community Development Officer
CFCI	Child Friendly Community Initiative
FU	Farmers Union
GAS	Gash Agricultural Scheme (synonymous with Gash Development Authority)
GOS	Government of Sudan
GRTU	Gash River Training Unit
GSLRP	Gash Sustainable Livelihoods Regeneration Project
HTC	Higher Technical Committee
ICB	International Competitive Bid
IFAD	International Fund for Agricultural Development
KSDC	Kassala State Drinking Water Corporation
LCB	Local Competitive Bid
LCLR	Legal Committee for Land Reform
LET	Locality Extension Team
MAAWI	Ministry of Agriculture Animal Wealth and Irrigation (Kassala State)
MIWR	Federal Ministry of Irrigation and Water Resources
MOAF	Federal Ministry of Agriculture and Forestry
MOH	Ministry of Health (Kassala State)
MOFNE	Federal Ministry of Finance and National Economy
MOM	Management Operation and Maintenance
NGO	Non-Governmental Organization
PCU	Project Coordination Unit
PEB	Project Executive Board
PFI	Participating Financial Institution
PIA	Project Implementing Agency
SA	Special Account
SDD	Sudanese Dinar (precursor to Sudanese Pound)
SDG	Sudanese Pound
SDR	Special Drawing Rights
SE	Socio-Economist
SM	Supervision Mission
TOR	Term of Reference
WA	Withdrawal Application
WUA	Water Users' Association

Currency Equivalents

Currency		Equivalent
US$ 1.00	=	SDD 240
US$ 1.00	=	SDG 2.00

Government of the Republic of the Sudan

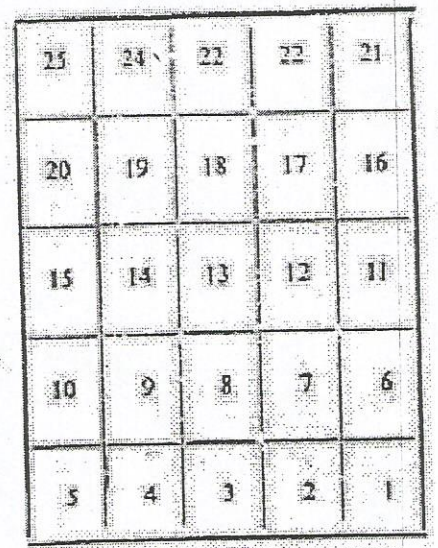
Fiscal Year:	1 January - 31 December
Agricultural Year:	1 July – 30 June
Gash Flood Season	July to September

Definitions

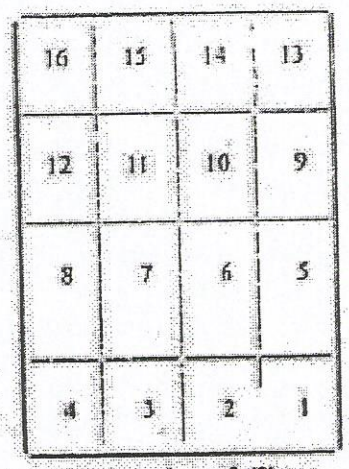
Angareeb	A Beja word now common to the whole Sudan. Means a bed made of a wooden frame strung with natural rope.
Badobe	A cracking clay soil.
Balag	Beja for the phenomenon of sheet flow. A normal *Balag* consists of a wide area of sheet flow. In some parts of the flow may be quite swift and a number of small channels may be formed, although the water surface is continuous. In other parts, the float may be slow and almost stagnate. When a *Balag* has been established for a season or two, a dense growth of bush appears followed in course by Forest. The *Balag* forms thus unaffected silt trap. These areas of sheet flow provide a very useful spill area that is a common feature of the Gash Delta. Also to describe the land where trees grow within the irrigation scheme at either the top or bottom of a *Misga*.
Bash Khafir	Head Water master
Beja	The Beja speak Beja or To Bedawie. The Beja people are an ethnic group dwelling on parts of North-Eastern and Eastern Africa including the Horn of Africa. They are found mostly in Sudan but also in parts of Eritrea and Egypt. They formerly were classified as belonging to the Hamitic race.
Dawran	Arabic word used in the Gash to denote the rounded "nose" or pitching on the downstream side of the entrance to an irrigation offtake. It also has many other uses but that given is the only sense in which this word is used in this report.
Feddan	Unit of measure. 1.038 acres or 0.420 hectares. Conveniently regarded as approximately one acre.
Gitta	Arabic. Used in a specialized sense in the Gash for the basic unit of land allotment. Contains 10 feddans exactly.
Haboob	Arabic term for a dust storm to which the Gash area is particularly prone.
Haffir	Arabic for an excavated pond for storing water over into the dry season.
Hod	Arabic for a basin. Also used in the Gash in the specialized sense of an area of land allotment. It contains 25 *Marabbas* of 16 *Gittas*, i.e. a total of 4,000 feddans.
Jebel	Arabic for a hill or mountain.
Kantar	Arabic for a variable quantity but in the Gash it signifies 312 lb of unginned cotton.
Khafir	Water Master.
Khor	Arabic for a watercourse that normally only carries water during the rainy season or sometimes only after individual storms.
Kurmut	A round leafed shrub (Cadaba rotundifolia Forsk).
Lebad	The alluvial Gash silt.
Libash	Traditional downstream protection for an offtake or drop structure. Normally forms the shape of an "onion".
Marabba	Arabic for a square. In the Gash used in the specialized sense of a unit of land allotment, being the smallest permanently demarcated area and consisting of 16 *Gittas* i.e. 160 feddans.
Mesquite	Thorny tree (*Accacia proposis*) that was first introduced to control sand dune migration and now infests irrigated lands, irrigation canals and river plain and *Balag* areas.
Misga	Arabic for a secondary distribution channel or the area watered by such a channel. This is again a specialized meaning.
Nefir	Common Works (labour contributed free by communities).
Rabt	Traditional Land Entitlement
Sagia	Arabic for the Persian water-wheel and, near Kassala, the land that was traditionally watered by it.
Shaiyote	An area of land watered by a cut from the Gash or a *Balag* area as distinct from cultivation served by the modern irrigation scheme.
Sudd	Arabic. An earthen dam in a water channel.
Tundub	A leafless shrub of the semi-desert areas (Capparis decidua Pax).
Turfa	The common tamarisk tree of the Gash (Tamarix articulata Vahl).

Terminology

The Gash Delta was demarcated by the Sudan Survey Department in around 1940's using lines in two directions at right angles. These lines divide the area into large squares, [Hod - literally a basin – in this case a square of land containing exactly 4000 feddans. Its side is 4,098.78 metres long]. Each Hod is sub-divided into twenty five squares [Marabba - literally a square – in this case a square of land containing exactly 160 feddans. Its side is 819.76 metres long. Twenty five Marabbas make one Hod. Numbered iron beacons mark the corners of Marabbas.]. The Marabbas, for the convenience of land allotment, are divided by chainmen into sixteen number ten feddan plots [Gitta - literally a piece – in this case a square of land containing exactly 10 feddans. Its side is 204.94 metres long and its corners are marked temporarily immediately prior to the watering of an area when land is to be flooded (see Figure ___). Sixteen Gittas make one Marabba]. The numbering of all units begins at the south east corner running from right to left as shown in the Figure above.

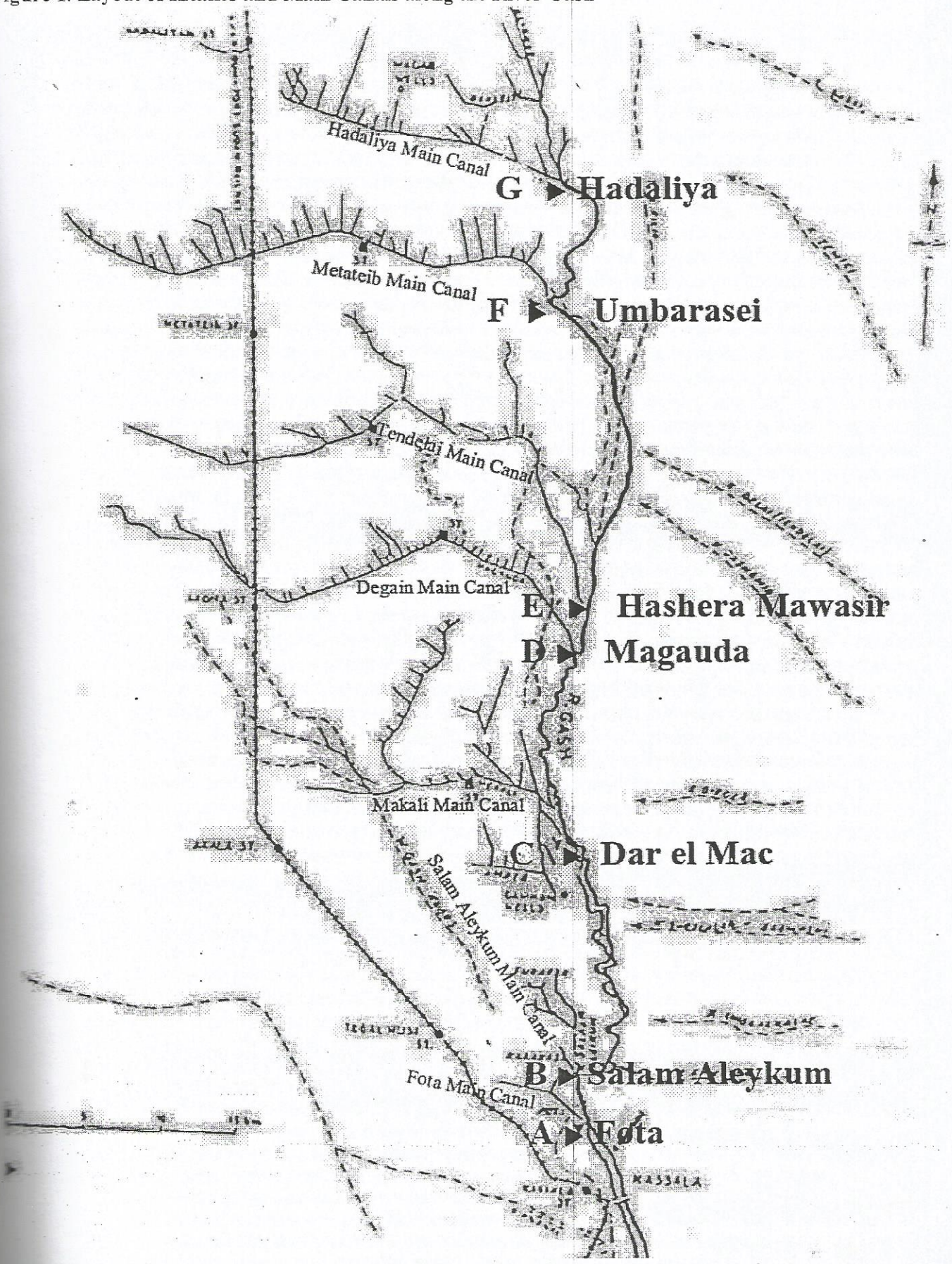


Numbering of Marabbas in one Hod.



Numbering of Gittas in one Marabba.

Figure 1. Layout of Intakes and Main Canals along the River Gash



1. Introduction

The Gash River has been known in the past to be fearsome with sharp uncontrollable floods. Historically the river flowed further to the west with the original Delta area close to what is now the New Halfa irrigation scheme. It rises in Eritrea, some 15 miles south of Asmara, and as the river Mareb, it flows through a relatively narrow valley until it reaches Haykota, where it gradually widens into a sandy-clayey plain, the Tesseney-Omhajer plain[1]. From there it flows in a westerly direction to Tesseney where the river turns northwards into Sudan. The Gash/Mareb is dry for much of the year, but is subject to sudden floods during the rainy season (July to September). The river transports considerable amounts of sediment (fine sand and silt) and has been estimated to transport about 5.5 millions tons of sediment annually at Kassala Bridge. This derives mainly from the Eritrean highlands. In its course through the lower parts of Eritrea, the river slope is relatively steep and as the river crosses a number of rock intrusions that act as a series of control sections, the river continual deposits and picks up material from the river bed and the neighbouring banks to stay in regime. When the river crosses the border, its slope reduces remarkably[2] and the river gradually deposits the sediment load in its course and the lower Delta[3]. This gives rise to a very unstable river that that has changed direction many times and that undergoes continuous morphological changes. These sediment deposits have led to a gradual build up in river channel level (sometimes 1-2 m), especially where irrigation offtakes are located. In Kassala City, the existing river bed is now some two meters above much of the ground level in the City and thus when breaches occur, considerable flood damage results.

The Gash Delta, with its apex at Kassala, stretches as an alluvial fan in a north westerly direction with sides of roughly one hundred kilometres in length. It slopes steeply to the north, and also, but less so, to the west. Its limits on its west and north sides are not sharply demarcated, but its area, in the widest sense, is assessed at 700,000 feddans of which about 400,000 feddans could be irrigated. The area commanded by the present canalisation is roughly 250,000 feddans. In the past, considerable areas were irrigated annually using the flood flows and around 300,000 Feddans[4] were reported to benefit with around one third being irrigated annually (3-year rotation). Since 1980, irrigated agriculture has been on the decline due to both changes in river course and in the viability of crops grown[5]. These changes often isolate offtake structures of irrigation canals from the river channel precluding irrigation of the areas under their command until unless expensive and major realignment work is carried out. During the months before the flood season, water sources for both livestock and humans become critical. At this time, most rely upon sources close to or within the Gash River bed and this creates considerable animal pressure and over grazing of the rangeland resources and often impinges on the seasonally irrigated areas of the Gash Agricultural Scheme.

1.1 Gash River Flows

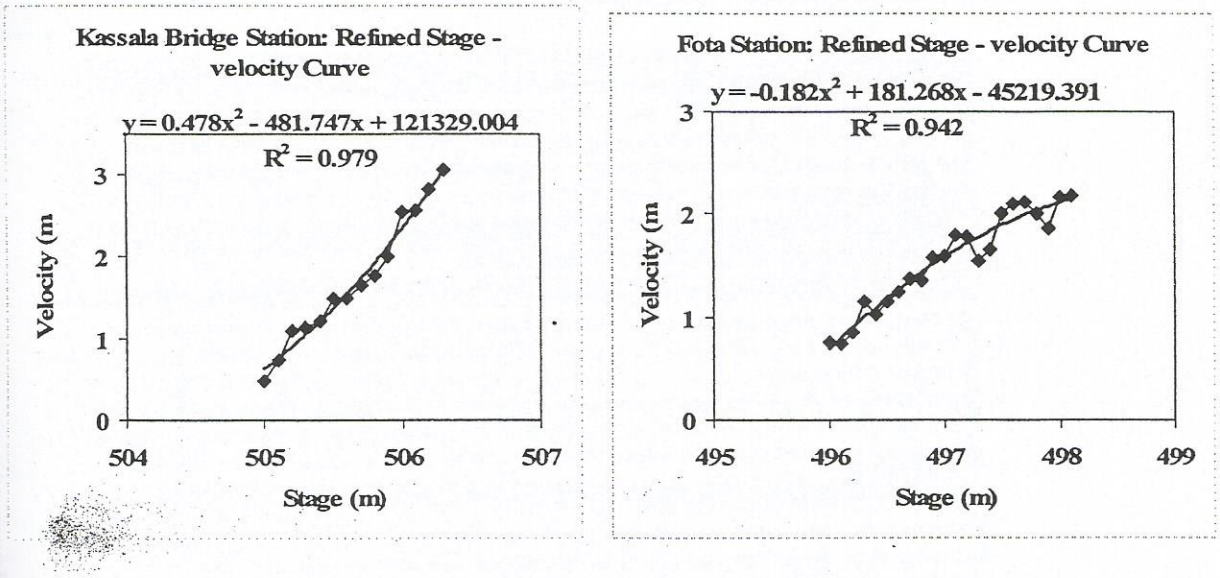
The Gash River extends some 121 Km from the border with Eritrea down to the Gash die Delta, some 91 km north of Kassala town. Most flows occur between July and September and comprise a series of flood flows that are often superimposed to give very high floods that have been estimated at around 1,000 m^3/sec at Kassala Bridge[6]. The average annual yield has been computed at 1,000 million m^3 and

[1] This plain is dotted with isolated granite and metamorphic hills and slopes gently from the mountain ridge westwards into Sudan, while basaltic hills rise at the southern side of the plain.
[2] Where it enters Sudan the slope is 1.30 m/km and this gradually decreases with distance northwards.
[3] The Gash die, a water drainage/spreading area at the downstream limits of the Gash River.
[4] The Gash agricultural scheme represents 80% of this area.
[5] The lack of effective flood control and the collapse of the cotton marketing system led to abandoning of the cash crop, cotton and most farmers resorted to growing sorghum for their subsistence.
[6] Recent measurements by GRTU at flood flows indicate that the past flows using float methods may have over estimated the peak flows by 5-10%. At peak flow, the average velocity reaches 5 m/s at Kassala Bridge.

this is the main source of water for irrigated agriculture and domestic use (through recharge of the alluvial river bed deposits). The river has caused much damage during times of excessive floods and the staff of GRTU have noted that the frequency of occurrence of high floods has increased noticeably since 1983. Flood disasters have become a major thread to human life and property in Kassala City and villages neighbouring the water course[7].

Traditionally, as no established gauging stations existed, flow records have been kept using staff gauges with calibration measurements made using the float method to assess discharge from the surface flow velocity. These have been recorded at Kassala Bridge and four other measuring sites. Following the supervision mission in 2005 after which flow measurement and sediment sampling equipment were purchased, records of flows were checked using both float and current meter measurements. Due to the turbulent nature of spate flows, this was not easy and the only site where this was possible was Kassala Bridge. Even this was not ideal due to the adverse flow conditions created by the proximity of two bridges with soffits at different levels and the turbulence around the bridge piers and the bridge and high flows made accurate flow measurement difficult[8]. Some flow measurements were successful and it was considered that the flow method was probably overestimating the actual flow by between 5 to 10%. The figures below relate flow velocity to river stage after adjustment.

Figure 2. Stage Velocity Curves for Kassala Bridge and Fota Gauging Stations



1.2 Flood Protection Works

Kassala City is divided into two by the Gash River in the Kassala reach where the city is protected against floods by a system of historic[9] and new[10] spurs and dyke system. In spite of very serious efforts in the past to control the river changes and to minimise the impact of annual floods, significant damage occurs each year to the protection systems. Although the spurs prevent meandering, direct flows to the centre of river channel, increase the velocity of flow and reduce sediment deposition in the main course, deposition is still occurring during the recession limbs of the floods.

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[7] The 2003 flood resulted in huge damage (91 casualties and US$ 168 million loss in property).

[8] Many difficulties were encountered during measurements: (a) The 50 kg weight provided with the equipment was insufficient for high stages; (b) depth sounding by steel rods was dangerous for spate flows; (c) echo-sounder gave faulty results when sediment concentrations exceeded 33000 ppm.

[9] Started in early 1930s, it consists of 32 spurs and two earth embankment alongside the river Course. The length of spurs ranges 180m to 670m with an average distance of 500m between spurs. The width of river channel between spurs heads is 120 m.

[10] Supported under the IFAD GSLRP programme through complementary GOS funding.

After the flood disaster of July 2003, responsibility for the river training works was transferred to MIWR[11] who established the Gash River Training Unit (GRTU) in early January 2004. The GRTU was made responsible for the implementation of river training works (through force account and contractors), river monitoring works and preparing related studies and designs. The importance of the river training works in guaranteeing stable and sustainable river water to the Gash Agricultural Scheme (GAS) resulted in a change in some of the activities[12] and a reallocation of budgets.

Comment [r1]: It already existed by fell under the state ministry of agriculture, animal resources and irrigation

1.3 Early Warning System

In 2003, a high level commission was established - the Higher Technical Committee (HTC) - formed after the serious floods of the same year, proposed that an Early Warning System be established during the flood season. Flood flows take about 3 hours to reach Kassala town from Gira and information on flood levels at this site are conveyed by mobile phone to GRTU management in Kassala. However, no clear data on time lag to each offtake for such floods and information on the possible severity of downstream flood events from Kassala Bridge to Hadaliya exist. This is hampered by a lack in communications between the offtake sites, GRTU headquarters and GAS headquarters in Aroma, as the mobile phone network does not cover most of the offtake sites.

2. River Control and Stream Regulation

The aim of the **Irrigation Infrastructure Rehabilitation** component is to enhance the capture of flood waters through better control of river flow, reconstruction of the six main canal systems, improvement of access roads and changes in field layouts. The works were divided into those associated with the main Gash River (discussed in this chapter) and those associated with the infrastructure of the Gash Agricultural Scheme (GAS) discussed in the next chapter.

2.1 Gash River Control and Management

Flood flows from the River Gash have been increasing annually probably due to the lack of adequate catchment protection in Eritrea. There is no firm hydrological evidence of this as most flow measurements and records are based on the float method that determines surface velocity and relates this to discharge. However, the level of floods at the Kassala bridge are a good indicator and observations over the last 10-20 years have confirmed that floods of around 1,000 m3/sec. have been occurring every 3-5 years. GRTU have been attempting to utilise these data to calibrate the flood flows and thereby predict long-term flows and determine safe levels for flood protection.

Following the excessive flood of 2003, the HTC looked at ways of reducing the damage caused by these peak floods and also to examine the approach adopted by the Gash River Training Unit (GRTU). In addition to the repair and reinforcement of the existing spurs and tie banks, one of the recommendations was to increase the speed of velocity in the river section upstream and downstream from the Kassala road bridge so that the design flow velocity is achieved with material deposition avoided. This was considered necessary to ensure that flood flows do not reach to the bottom of the bridge decks. GRTU is thus engaged in removing material downstream from the bridge to a depth of about 2-3 m to ensure that the first floods have sufficient velocity to scour the material deposited from the last floods from last season. It is uncertain whether this will be successful as, if the first floods are not large then it is quite likely that the area excavated will fill up with sediment with the first flows.

The main features of the Gash River can be summarised as follows:

- Seasonal ephemeral river characterised by sever floods of relatively short duration;
- Braided and meandering river course in Sudan;

[11] By Presidential Decree.
[12] Appraisal mission July-August 2003.

- Relatively steep longitudinal slope of around 1.0 to 1.5 m/km;
- Rapidly declining river slope from the border with Eritrea that gives rise to meandering and considerable silt deposition;
- High average sediment load of about 5.5 kg/m^3;
- Severe sedimentation in both the Gash river course and the irrigation conveyance system;
- Limited duration of river flows (about three months normally from mid July to mid October);
- High variation in flood flows during flow season with consecutive flood events that often combine to give very large and damaging floods and at other times dwindle to negligible and unusable flows for irrigation;
- Total annual flow volumes that range from 0.6 - 1.4 milliard cubic meters;
- Very high flood flow velocity (average peak flow ~ 5m/sec.);
- Considerable annual damage to infrastructure due to the unpredictable flow characteristics which in the past have caused frequent changes in river course.

2.2 Works Upstream of Kassala Town.

Most of the planned works upstream from Kassala town will be completed by the time the flood flows arrive this year. This includes the cutting through of the large river meander at Gira near to the Eritrean border, the placement of additional spurs and bank protection in various places. Each year damage and loss of land occurs due to stream bank erosion during flood events. However, with the main works completed, it is anticipated that these can be undertaken as part of the annual operation and maintenance works by GRTU using force account, unless another exceptional flood occurs.

2.3 Works in Kassala Town Reach

The planned programme of new spur construction for the protection of Kassala town has been completed increasing the number of spurs from 28 to 43 required. The works included the repair of the existing spurs and associated tie banks as well as the recent raising of the banks by one metre in 2008 to address the backwater effects from caused by the two bridges. In the appraisal document it was proposed that the old bridge to Kassala from the Port Sudan road should be demolished or raised as it was throttling the flow of the water due to progressive siltation. It was also suggested that the river bed be excavated.

Past records of river stage at Kassala Bridge indicate that the current combination of two bridges with the bottom of the downstream bridge deck nearly one metre lower than the upstream bridge is not only providing a constraint to the peak floods, it is also creating adverse hydraulic conditions and wave action due to the transition from free flow to orifice flow conditions under the bridges. This caused a surcharge of about one metre at the upstream bridge and the turbulent flow caused erosion of the flood banks close to the bridge.

Both bridges remain unchanged and the flood of 2007 showed that with the rising peak floods and river bed levels, it is now causing a major problem and was probably one of the causes of flood damage in Kassala town in 2007. Cleaning of the downstream channel is being carried out at present and is planned annually to increase the velocity through this section and also to provide more clearance under the bridge. The dynamics of flood flows in heavily sedimented rivers would indicate that cleaning is only a temporary measure and whereas it will have an impact on the medium floods, it is unlikely to have significant impacts on high flood flows that are constrained by both bridges. Although this year the flood protection dikes had been raised by over 1 m, there is still a serious danger that breaches will occur if flood levels similar to those recorded in 2007 are repeated. The data from GRTU would indicate that this is likely to occur.

2.4 Works Downstream of Kassala Town.

Downstream from Kassala Bridge, river training works and bank protection are essential for both securing the integrity of the irrigation systems and preventing floods overtopping the banks and flooding Aroma and other towns in the Northern Gash Delta. The meandering of the Gash River and the annual deposition of silt has meant that over the last 40 years, the river bed has risen from 1-3 metres. In certain places the river course is flowing directly towards the left bank and this resulted in flood damage and overtopping. The original plan for the protection of the Gash River included tie banks to connect flood protection works with each intake. Over time these tie banks had been damaged, breached and are now generally lower than needed to prevent overland flood flow into GAS. GRTU have been systematically reinstating these tie banks and raising them by about 1 m. This is an ongoing process from upstream to downstream and is mainly located on the left bank, the direction in which the river is trying to flow.

2.4.1 Tie banks

These were developed to prevent overland flow into the irrigated areas. They take the name form the person responsible for their construction (Morris; Ahmed Nakash; Assayita; etc) and link or *tie in with* the offtake structures to the seven main canals systems of GAS. They are usually built at the western limit of meander belt of the Gash River and thereby form the limit of the flood plain. The Tie banks form an integral part of the flood protection work of the Gash river system and over time have proved to be less effective due to breaches and rising sedimentation in the Gash river course. GRTU has been systematically improving these Tie banks working from upstream to downstream.

2.4.2 Importance of Balags

An important part of the Gash flood protection is the preservation of the flood plain area, known locally as *Balag*, to ensure that if the river overtops its banks, there is adequate place for overland flow to take place without overtopping the Tie banks. Downstream from Fota intake this has been mostly successful except where land concessions for crop cultivation have been given within the flood plain area. Infestations of Mesquite have caused a decline in the tamarisk and other more suitable trees and pilot areas to test the eradication of the mesquite and replacement of more suitable and less evasive trees has been included under GSLRP.

3. Rehabilitation of GAS Infrastructure

The irrigation system in the Gash Agricultural Scheme (GAS) command area comprises main, link and some branch canals fed from the Gash River by means of gravity offtakes fitted with stop logs. The flows in these gravity canals are divided into a number of *Misga* or distributary canals that directly supply the agricultural land through breaches in the canal banks. Unit flows are high and these flow across the *Misga* blocks (of about 3000 feddans) as a wetting front following the line of least resistance and guided by *Misga* water workers who are instructed by the *Sheikh al Misga* or water master[13]. The design of these systems was first developed in the 1930s and improved upon in the late 1950s. They were originally developed for the cultivation of cotton using flush irrigation[14] [illegible] *River Gash in Sudan*. The considerable amount of sediment that is transported by this river[15] is deposited within the canal systems and gives rise to increased annual maintenance costs necessary to provide the design slopes and flows within each of the six blocks that utilise the river water.

[13] The main factors affecting its progress are slope, nature/texture of soil, surface characteristics & its covering.
[14] This is a variation on spate irrigation that utilise fluctuating run-off in the seasonal Gash River.
[15] 5% by Volume.

Table 1. Details of Offtakes, Main Canals and Command Areas for Gash Agricultural Scheme

k	Offtake	Canal	Length	Discharge	Bed Width	Water Depth	Canal Slope	No of Mesgas /10.	C H Swan	Design Area /2	WUA Areas /1	GAS Manager 26 June /3	Q/500 [in any one season] /4	Assumed single season Target Area	Design Duty /5.		Remarks
			(m)	(m^3/sec)	(m)	(m)	(m/km)		(Feddans)						(l/s/fd)	(l/s/ha)	
ssala	Fota	Fota main canal	1,150	18	6	1.90	0.85	0	11,000	16,000	18,700	18,500	4,500	5,000	4.1	9.9	Design Discharge increased as lobat exits.
	Fota Main Canal	Fota branch canal	6,750		6	1.5	0.96	4									
	Fota Main Canal	Rabakasa Main canal	4,800	10	4	1.55	0.62	4									
ssala	Salam Aleykum	Salam Aleykum Main Canal	3,150	20	10	1.5	0.75	0					5,000	5,000			As above
	Salam Aleykum Main Can	Tograr Main Canal	14,500		12	1.5	0.97	19									
	Salam Aleykum Main Can	Gammam Well Canal			10	1.5	1.00	0									
	Gammam Well Canal	Amber Link Canal	2,200	16	5	1.46	0.93	0									
	Amber Link Canal	Adareif Main Canal	8,450	8	3	1.48	0.85	9									
	Amber Link Canal	Aldrip Makali Canal	5,100	8	4	1.2	0.78	0									
Makali	Dar el Mac	Dar el Mak	4,040	32	10	1.17	0.8	0	12000	14,000		21,000	8,000	10,000	3.0	7.3	Design Discharge increased as lobat exits. Actual offtake discharge seems to be low.
	Dar el Mac	Makali Main Canal	21,490	32	8	1.19	0.60	18									
	Makali Main Canal	Helaibet Canal	8,500	32	8	1.19	0.58	4									
	Makali Main Canal	Akla Canal	8,400	10	3	1.48	0.85	6									
	Makali Main Canal	Aras Stream	6,000		3	1.25	0.6	0									
egain	Magauda	Degain Main Canal	32,900	38	10	2.68	0.5	44	11000	19,000	19,300	19,500	19,000	19,500	3.9	9.4	Design discharge has been adjusted down as data provided (58 m^3/sec) seemed to be incorrect.
ndelai	Hashera Mawasir	Tendelai Main Canal	21,500	48	10	2.18	0.57	8	16000	28,000	28,500	27,000	24,000	22,000	3.6	8.5	
	Tendelai Main canal	Tendeli West Canal	22,000	48	10	1.71	0.41	16									
	Tendelai Main canal	Tendeli North Canal	8,100	14.4	8	1.32	0.50	8									
etateib	Umbarasei	Metateib Main Canal	12,748	26	10	2.2	0.43	26	14000	8,000		21,000	13,000	14,000	2.5	5.9	Design capacity seems low
adaliya	Hadiliya	Hadaliya main Canal	20,200	32	6	2.18	0.64	17	14000	5,000		125,000	16,000	16,000	0.5	1.2	Area seems overestimated
	Hadiliya	Awadai Canal	3,200	32	6	1.5	0.60	0					16,000	16,000			
	Awadai Canal	Bahabini Canal		10	6	1.5	0.60	3									
	Awadai Canal	Eli Billi Canal	19200	22	6	1.7	0.62	12									
							TOTAL		78,000	90,000	66,500	232,000	105,500	107,500			

Notes

/1. Data on other WUAs lacking.
/2. Based on Earlier Appraisal Documents
/3. Email of Today
/4. Based on Gash (Swan) standard of 2l/s/fd.
/5. Using design duty and canal design Discharge provided by GAS Engineers
/6. Assuming 50% of area irrigated in any one season as per plan. Using GAS manager's areas.
/7. Flow rate for *Lebad* soils (4 l/s/fd) is twice that for *Badobe* soils (2 l/s/fd).
/8. Data in yellow are either missing or in question. Data in green have been estimated.
/9. For layout of Canals, see Figure 1.
/10. For layout of Misgas, see Figure 2 and Table 2.

3.1 Irrigation Offtakes on Gash River

The irrigation layout consists of seven main canal systems which are, from south to north, Kassala, (where areas are supplied by the Fota and Salaam Aleykum canals), Mekali, Degein, Tendelai, Metateib and Hadaliya (Table 1). Watering is achieved through canals taking off from the extremely wide and uncertain Gash River and must therefore always rely largely on the luck of the flood. Irrigation water is drawn off from the left bank through masonry headworks into the main canals. These are designed to take a full supply that varies from 10 m^3/sec. (Fota) up to nearly 40 m^3/sec (Tendelai) although the maximum discharge in the original systems was 20 m^3/sec. The head regulator/offtake is a strong (masonry) structure consisting of brick abutments and piers on a reinforced concrete slab. There are 2-3 or sometimes more openings that are 2.5 metres in width and that can be closed by 9x3 inch sunt timbers, which can be dropped into grooves in the brick work. These are operated by simple lifting hooks. The regulators are 3-5 metres in height and are provided with heavy stone protection of floor and side slopes both upstream and downstream and these slopes are normally 1:1 with pitching 0.25 m thick and a smooth finish. An access roadway is carried on top of the piers by rolled steel joists or brick arches in the older designs. As the river levels have increased over time, the invert at the offtake and outlet from the head structures need to be raised from time to time to ensure that sediment is restricted from entering the canals.

This type of regulator has the great advantage of drawing off only comparatively clean top water. The staff during the flood is from six to ten men in charge of a foreman, who works to a fixed downstream gauge. At full supply the depth of water in the main canal is usually about 1.5 metres. The ideal head regulator should have ease of operation as one of its first essentials and should draw maximum possible supplies at low Gash flows, but never take in excess silt. The correct siting of the head is highly important, and should be selected on the outside of a gentle curve, which appears to be stable, and the plan of the headworks should allow for an inclined offtake, that should present a tangential upstream face in reference to the flow of the river, and an abrupt downstream nose. This is aimed to obstruct the natural flow lines of the river thus causing back currents and eddies and inducing a good flow into the canal of comparatively clean top water. The same principle applies to the siting of *Misga* offtakes in canal (see below).

3.2 Canal Design

Canal long sections have slopes that vary between 1.0 down to 0.4 m/km[16] and cross sections are trapezoidal with steep sides (1:1.5) cut through solid silt with flat sandy bottoms. Small masonry structures are provided on the downslope side of each main canal at varying distances along the whole canal length. These serve as outlets to the land by channels known as *Misgas*. The height of the land to be commanded has increased overtime through sedimentation and the impact this sedimentation is overcome either by moving the land to be commanded further downslope or raising the invert and soffit of the intakes from time to time. The latter was the approach adopted in the rehabilitation process and this has the advantage of retaining the long slope of the main canal that has been optimised overtime to minimise sediment deposition in the main canal. Examination of the limited available data and drawings would indicate that this approach has not always been followed and that insufficient attention has been given to hydraulic slope and the need to maintain canal velocities. No design report for the improvement of the systems has been seen, probably as much of the work was completed using the Gezira canal design model, and thus it was not possible to confirm the design criteria and approach adopted. Indications are that in some cases canal slopes are too flat, that too much silt has been excavated from the canals and that insufficient command has been available at some *Misga* offtakes necessitating construction of cross bunds (*Sudd*) by the farmers that have encouraged localised sedimentation. Definitive data on all canals including cross section, long sections, invert elevations and all other relevant criteria must be made available to the O&M section

[16] The original designed bed slopes of the canals varied from 1:3,000 to gradients as steep as 1:1,500.

of GAS to facilitate preparation of annual estimates for cleaning as well as facilitating the control of contractors and GAS annual cleaning.

3.2.1 *Application rates and Offtake Design*

For canal and *Misga* design, the flow rate adopted at the offtake from the Gash River was 1 m^3/sec. for 500 feddans (~5 l/s/ha). This was suitable for the cultivation of a cotton crop on heavy soils (*Badobe* – a cracking clay soil) and enabled the upper sections of the *Misga* block to accumulate sufficient water during the first flood period, when the largest floods normally occur. Those lower parts of the *Misga* that did not get sufficient water in the first floods were used to plant millet and sorghum (Dura). For the Mekali and Kassala blocks, the alluvial Gash silt (*Lebad*) was the dominant soil and had much higher infiltration rates. The flow rate for these soils was doubled to be 1 m^3/sec. for 250 feddans (~10 l/s/ha). Table 1 has been prepared to present the design parameters of each canal. This has been compiled from incomplete data and some design discharge/target area[17] data (Degein; Metateib; Hadaliya) appear to be inconsistent and need checking and verification by GAS/PCU.

3.2.2 *Misga Head Structures.*

In the original concepts of Flush Irrigation[18], it was recognised that the structures at the head of each *Misga* should be designed to pass as large a flow as possible to take advantage of the large flood flows of short duration that occur in the Gash river. Open masonry *Misga* head structures were therefore preferred over pipe structures and the rehabilitation designs were correct in replacing the older existing pipe structures with open type structures. These structures were not only designed for large flows, they were also designed to limited restrictions that would encourage sediment deposition so that most sediment was carried either onto the *Misga* fields or into the *Haffirs* located at the end of the main canals. Traditionally *Misga* head structures were so located that the flow entering the *Misga* fields created a wide spread of flow resulting in most of the silt being deposited almost immediately on the field. Although this caused a gradual loss in head at the top of the *Misga* block, as land was not allocated to any single person, but allocated on a lottery system, as it came out of command, it was replaced with additional land further down the *Misga* block. Overtime this has meant that a *Balag* area of about 10-30 m wide now exists between the main canal and the *Misga* blocks in many areas.

3.3 Operation and Maintenance

3.3.1 *Gash Agricultural Scheme*

With the change in management of GAS and the removal of the involvement of the MIWR in the past, the technical understanding of how the systems are operated to reduce annual maintenance and to ensure equitable and regular water distribution were to some extent lost as this knowledge was not institutionalised The less experienced engineering and *Misga* field staff responsible for water allocation and distribution, together with a lack of sufficient skilled artisans that used to be engaged by the MIWR, has over a number of years meant that more sediment has been deposited in the canals than would normally be expected. It is not clear whether this extra sediment deposition is due to an increase in transported material within the Gash River or due to less experienced water management. However, the lack of resources provided in terms of both equipment and funding for annual maintenance meant that silt accumulations in the canals increased and that less flood water could enter the canal systems and reach the *Misgas* without breaches and problems on the way. This gave a backlog of deferred maintenance.

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[17] This relates to the total area that is irrigated in the two year rotation cycle with approximately 50% of the area being irrigated at any one time and the flow rate determined using this *Misga* area.

[18] The Recorded Behaviour of the River gash in the Sudan, C.H.Swan, Chief Engineer, Gash Board, 1954-55. Ministry of Irrigation and Hydro-Electric Power, Khartoum. 1959.

As mentioned above, the design work carried out by MIWR was limited to canal desilting and repair/replacement of existing structures. The intention of IFAD at Appraisal was to rehabilitate the canals and irrigation systems in such a way as to facilitate future O&M by a combination of GAS and Water Users Associations (WUAs) with annual O&M costs being minimised through appropriate designs and capital investments. Unfortunately this concept was not translated into implementation and there still remains additional works to be completed to ensure that annual O&M budgets are affordable by both GAS and WUAs. After the initial rehabilitation and cleaning works of the GAS systems, funding for annual cleaning derived from water charges and support provided by IFAD that covered 100% of the operating costs of equipment and machinery. Up to 2007, annual fee collection increased and WUAs were providing some of the funds needed to carryout annual maintenance activities. The impact of the 2007 floods together with problems with pests meant that the farmers did not pay any water fees for the 2006/07 season. The situation was muddied by rumours that government would assist and that the farmers would not need to pay water charges. This GOS support did not materialise and this combined with reduced support from IFAD[19] and virtually no support from the State or Federal Government[20] has meant that no cleaning works have been undertaken prior to this coming 2008 flood season. Farmers now understand that without their contributions, maintenance of the systems will not take place, but even if the outstanding fees are now paid, it will not be possible to finance cleaning costs before the upcoming irrigation season.

The O&M Engineering Department within GAS seems to have been ignored when translating the GSLRP proposals of support to GAS into practice. Whereas support for training of staff and the improved management of the systems was intended, with the structure that existed in 2004 and that differed from that assumed at Appraisal, little attention was paid to the O&M unit by GAS management. They have virtually no furniture, one computer and very little professional tools to enable them to carry out their activities[21] and most importantly to encourage the younger engineers to stay on the project. It is important that (i) adequate and appropriate support is provided to this Department, (ii) they receive training and guidance from more experienced engineers, (iii) they are given more appropriate equipment to complete their work, (iv) additional technicians are provided to assist with field surveys and flow measurements and (v) that sufficient and regular funds are provided to enable them to complete annual maintenance works, to rectify some of the inadequacies that remain and to fully utilise the GAS equipment that has been provided.

3.3.2 Maintenance Equipment

At appraisal, river training and O&M at GAS was handled by the same organisation within MIWR. With the creation of GRTU and the removal of some equipment to support it, insufficient equipment remained with GAS to undertake the planned annual maintenance by force account and to meet the other needs of the agricultural engineering department in relation to on-farm works. Considerable differences exist between these two departments on how the available equipment should be utilised and no clear programme is established annually so that each department can use the equipment to its best advantage. Poor guidance has been given to these departments to resolve this issue and to also ensure that the equipment does not remain idle. Although general records are kept by the head of the Agricultural Engineering Department on how equipment has been used, no consistent and accurate timeline programme seems to exist to follow and report on the progress achieved and the *Misgas* that

Comment [r2]: This needs to e verified as the GRTU predayes the GSLRP project

Comment [r3]: Which two departments as it is not clear from the earlier sentence: agric and O&M depts in GAS?

[19] That now covers 25% of the machinery costs for the remaining period of the project. The balance of 75% should be met by GOS with the funds channelled through the PCU.
[20] Only 30% of the three-month allocation budget for cleaning the canals had been provided by the time of the MTR mission visit. This means that effectively no maintenance will be carried out this year - salaries have been paid but nothing else.
[21] For example: The unit possess two survey instruments, but only one surveyor. It is meant to use laser operated equipment, but lacks the appropriate total station survey equipment and computer software to facilitate determination of the required "plains" to be fed into the controls of the laser operated machines.

have been completed. It has not been possible at this stage to examine whether GAS has sufficient equipment, how it would be best utilised and how contractors could be used to overcome equipment deficiencies. GAS needs to examine this issue as a matter of urgency so that the systems are properly maintained and do not deteriorate to the pre intervention condition.

Comment [r4]: Request as part of preparatory work to be carried by GAS prior to the August follow up mission

3.3.3 *Other GAS Infrastructure*

At appraisal, it was planned to renovate the GAS workshop and stores and a limited number of houses to accommodate field staff. This has not happened and further attention needs to be given to this.

3.4 On Farm Development/*Misga* Water Management

Floods in the Gash River usually come in two "flushes". The early flush which is denoted as the first rotation or watering takes place around July and usually covers about two-thirds of the targeted *Misga* area for irrigation[22]. This 2/3 is further sub-divided into two with the upper area receiving the lion's share of the water[23] being grown with cotton (in the past) or two higher value crops. The 2nd half is planted with sorghum as it receives a less deep watering[24]. Application of flood water in the Gash Scheme is based on border strip irrigation, called *flush* in this context whereby large unit flows are applied to the top of the *Misga* and allowed to pass down it following the land slope with *in-Misga* bunds[25] and assistants to the *Sheik al Misga* or water Master guiding the water to the higher spots.

Traditionally water passes first to the upper 1/3 of the *Misga* for about 15-25 days and then when it is considered to have sufficient water, flows are passed to the second 1/3 for the remainder of the first flush period either flowing over the first 1/3 of the *Misga* to reach the lower land or by means of the *Misga* canal using a second and lower opening or a combination of the two depending on the topography. This will lead to some over watering and deep percolation water losses. The second flush occurs past mid-August and comprises lighter floods that are used to cover the remaining one-third of the targeted *Misga* area[26]. Water reaches this land by passing over the middle 1/3 of the *Misga* land, as there is no *Misga* canal that leads directly to that part of the *Misga*. Again this leads to over watering and water loss that are more critical as the second flushes are almost always weaker than the first.

The above method of water management is followed by GAS Scheme management that distributes land on basis of 2 feddan in the 1st flush watering area and 1 feddan in the 2nd flush area. Members receive land in two paired *Misgas* that are irrigated in alternate years. Block managers and agricultural engineering department are assisting in the construction of inter-*Misga* and in-*Misga* guide bunds and the removal of Mesquite trees. In addition, farmers are given advice on alternative crops and combinations to take better advantage of the available moisture stored in the soil reservoir. This process is hampered by the length of *Misga* canal that should have been extended under the rehabilitation process to provide more effective water distribution for the lower 1/3 of the *Misga*. These canal extensions for all *Misga* canals should be constructed and this should be combined with

[22] Under the 2 year rotation system, about 50% of the *Misga* area is irrigated in any one year and is referred to as the target area. When the flood season has passed and the irrigated area has been plotted using the *Gitta* system (Figure 3), the final irrigated area is defined (around 80-90% of the target area in a good and well distributed flood season (Figure 4)). The actual cultivated area will be less than the irrigated area (about 70% of the target area) due to inadequate irrigation at the peripheries, non-allocation of land and other technical/social constraints.

[23] Aimed at 5,200 m^3/feddan and from past experience suitable for a crop of cotton planted soon after the end of the water application period.

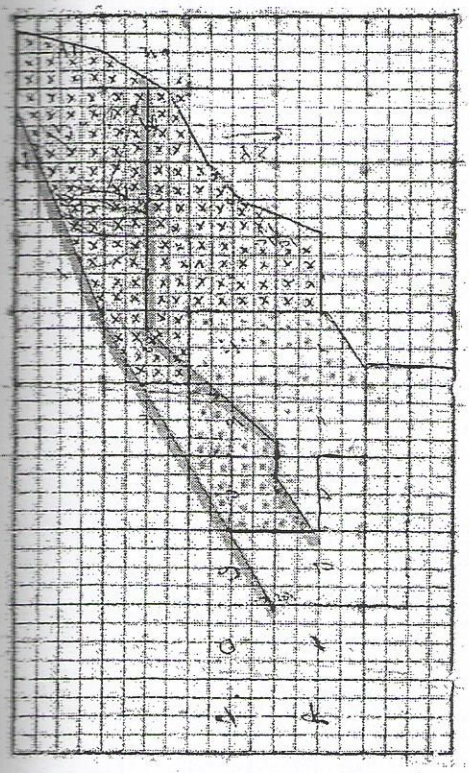
[24] Aimed at 3,200 m^3/feddan and from past experience suitable for a crop of sorghum planted soon after the end of the water application period.

[25] These are small bunds (*Sudds*) usually constructed by Grader within the *Misga* and that assist in spreading the applied water as evenly as possible. They "force" water onto the higher spots and spread out the flow fronts. This requires close attendance and the use of experienced assistants who are familiar with the process.

[26] This often receives less than the optimal amount of water due to the variability and amounts of flood water available and therefore results in lower yields than elsewhere in the *Misga*.

policies that would induce farmers to use the high water depth areas for cash crops with high water requirements and higher value.

Figure 3. Example of Mapping of Irrigated Areas with *Misgas*



At appraisal, the design foresaw a change in the crop rotation from 3 to 2 years to increase the area of land under cultivation per year and to benefit a greater number of farmers. This was coupled with better water control at *Misga* level. Pilot areas were proposed to examine methods for the control of mesquite, alternatives for land development and improved water management, and optimisation of in-*Misga* sub-blocks. These were not established as GAS staff examined previous work carried out in 1990-92 in Tendelai Block under previous project support (Netherlands Government. 1990), and concluded that the approach proposed at Appraisal had already been examined and found to be lacking. Shorter sub-blocks within the *Misgas* should be utilised and GAS staff have introduced smaller *Misga* sub-blocks using within-*Misga* guide bunds that divide the land into units of around 500 feddans. This is done by developing bunds through the use of bulldozers and graders under force account. The approach is being systematically implemented and by the end of 2008, almost all Blocks will have been covered. Block level and *Misga* level planning is done by GAS agriculture block inspector and *Sheikh Al Misga*. The ensuing bund works are implemented by GAS through force account, paid for through WUAs fees.

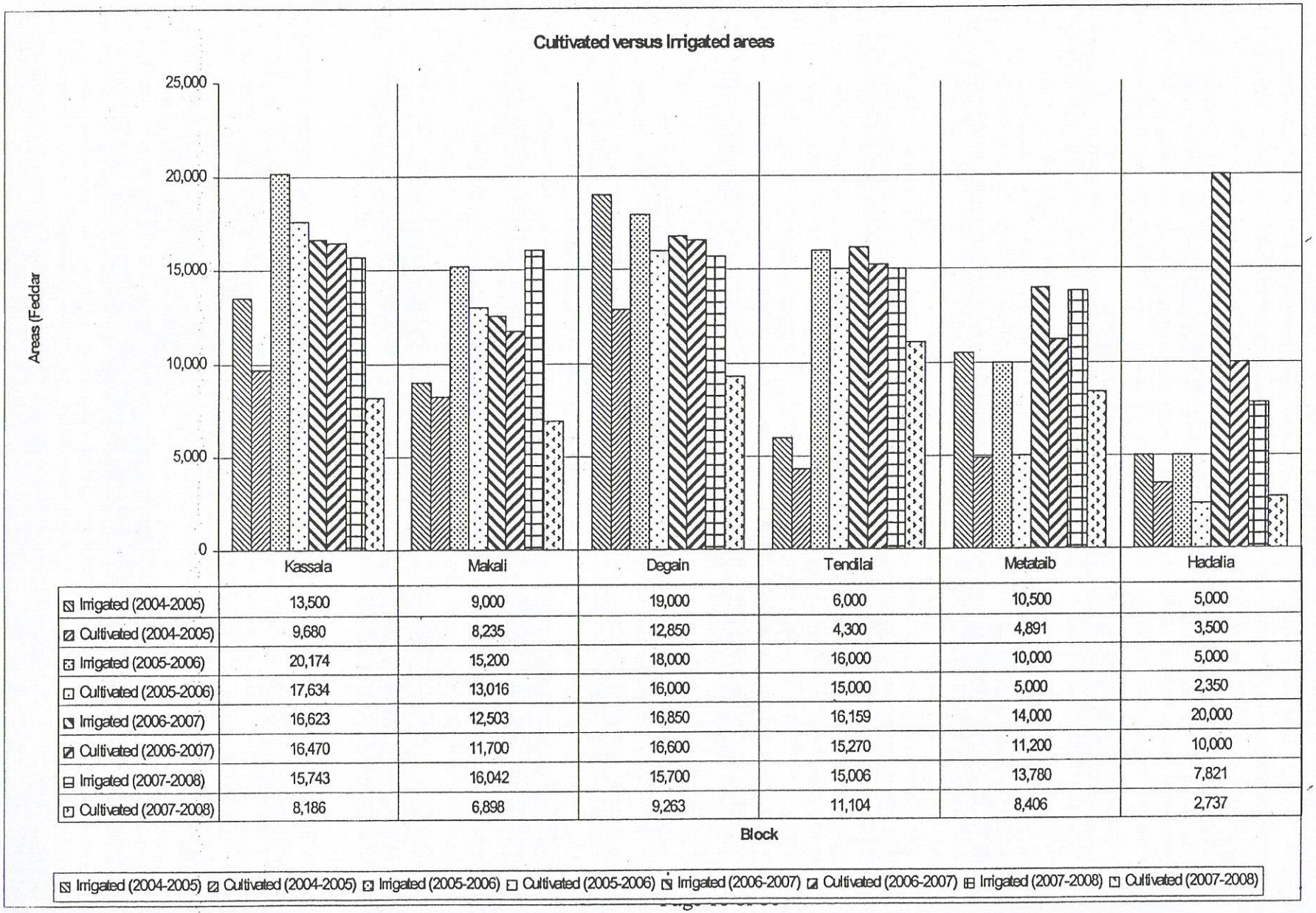
It was also concluded that major land forming although desirable was too expensive to contemplate at this stage, as farmers would not have the ability to repay the costs. GAS agriculture department correctly understands the issue, even though the change in approach has not been reported nor the results and useful findings of the adopted methodology. This needs to be rectified.

Comment [r5]: Can we consider this n innovation on the part of the GAS staff?

3.5 Mesquite Control

The Gash Scheme and surrounding area has been badly affected by colonization of the flood irrigated areas, canals and *Balags* by the thorny mesquite (*Accacia proposis*) tree. It had been intended that a **strategic plan for reducing mesquite infestation in irrigated fields and its containment on public lands and river banks would be given high priority at Project start-up.** Activities for the control of mesquite have taken place, but no strategic plan seems to have been prepared. Under separate funding in 2004, GOS cleaned all of the GAS *Misga* areas of mesquite using the same contractors that completed similar work at New Halfa irrigation scheme. However, this was done before WUAs were formed and subsequent limited management of the land after clearing has meant that much of the mesquite has been allowed to grow again. GAS is currently adopting a manual approach to mesquite cleaning and this is proving cost effective and sustainable, even if the progress is slower than by machine. WUAs are being encouraged to provide labour for the work that GAS is supporting with some machinery (bulldozers). The associated costs are discussed in 5.3.2.

Figure 4. Cwsqaqhange in Cultivated and Irrigated in Gash from 2004 to 2008



	Kassala	Makali	Degain	Tendilai	Metataib	Hadalia
Irrigated (2004-2005)	13,500	9,000	19,000	6,000	10,500	5,000
Cultivated (2004-2005)	9,680	8,235	12,850	4,300	4,891	3,500
Irrigated (2005-2006)	20,174	15,200	18,000	16,000	10,000	5,000
Cultivated (2005-2006)	17,634	13,016	16,000	15,000	5,000	2,350
Irrigated (2006-2007)	16,623	12,503	16,850	16,159	14,000	20,000
Cultivated (2006-2007)	16,470	11,700	16,600	15,270	11,200	10,000
Irrigated (2007-2008)	15,743	16,042	15,700	15,006	13,780	7,821
Cultivated (2007-2008)	8,186	6,898	9,263	11,104	8,406	2,737

3.6 Management, Operation and Maintenance

Improving the management, operation and maintenance (MOM) of irrigation and drainage (I&D) systems is included in project design to support and make best use of physical rehabilitation of the system and to reduce future charges on both Government and User Groups. This component of a project can cover a number of activities ranging from changing the culture of government I&D agency, to improved processes and procedures for water delivery and use. The terms management, operation and maintenance (MOM) are used to cover the following processes and procedures:

Management covers the overall management and administration of the I&D system. It includes: day-to-day administration of the organisation; hiring of staff; management of staff, liaison and communication with water users, government agencies, etc.; annual planning and budgeting; accounting; performance appraisal (of the organisation's activities and the personnel).

Operation covers the operation of the irrigation and drainage systems, and includes: seasonal water supply and demand planning; irrigation scheduling; water allocation; regulation of gates and control structures; measurement of discharges; control and operation of the water source (intake structures or pump stations); liaison and communication with water users; operational performance assessment.

Maintenance covers the maintenance of the irrigation and drainage system, and includes: planning, budgeting, inspection, designing, costing, implementing, supervising and recording of maintenance work; liaison and communication with water users on maintenance needs and activities; maintenance performance assessment.

A key element of future sustainability of project interventions is (a) effective water management and application, (b) proper costing of water delivery and application costs, (c) the distribution of agricultural land to eligible farmers and (d) the formation of farmers into effective WUAs at *Misga* level. The first two aspects are covered in this working paper with the assumption that the progress already made on the latter two aspects will continue and provide the framework for items (a) and (b).

The GSLRP design incorporated a number of reform measures regarding water fees:

- Application of the cost recovery system for effective irrigation maintenance to avoid future expensive rehabilitations;
- Adjustment of the water fees should be systematically adopted to avoid the need for massive increases; and
- Water fees collection should ultimately be the responsibility of the WUAs and for which certain percentage would be retained by the WUA for shouldering the responsibility of maintenance of the field level irrigation network, particularly at the *Misga* level.

The success of improved MOM can be measured by a number of indicators (Table 2.) some of which are output indicators in that they measure the impact (mainly on crop production and farm income) of the MOM of the system and other indicators are process indicators that measure the performance of the MOM processes.

Table 2. Key performance indicators for MOM

Indicator statement	Performance indicator(s) used	Definition	Indicator target value
Satisfactory ISF collection levels	Fee collection ratio	$\frac{\text{Annual irrigation fees collected}}{\text{Annual irrigation fees due}}$	> 0.80
Annual income from ISF collection sufficient for sustainable MOM of the I&D system	MOM funding ratio	$\frac{\text{Actual annual income}}{\text{Total annual budget required for sustainable MOM}}$	>0.90
	O&M fraction	$\frac{\text{Expenditure on MOM}}{\text{Total annual budget required for sustainable MOM}}$	>0.90
Annual expenditure on maintenance adequate to sustain the system in the medium to long-term	Maintenance fraction	$\frac{\text{Annual expenditure on maintenance}}{\text{Total annual budget required for sustainable MOM}}$	Gravity systems: >0.70

References: Bos, M.G, M.A. Burton, and D.Molden. 2005. Irrigation and Drainage Performance Assessment: Practical Guidelines. CABI Publishing, Wallingford, UK.; Hector, M., and M. Burton. 2001. Guidelines for benchmarking performance in the irrigation and drainage sector. IPTRID Secretariat, Food and Agriculture Organisation of the UN, Rome.

3.7 Water Charges

The land and water charge (LWC) levied by GOS comprises the cost of irrigation, land and agricultural administration. It is collected by the agricultural administrations of the respective schemes and in the case of Gash Scheme this lies with GAS. The collections of the charges are known to be far behind the levels set and thus only a small proportion of the management costs can be met, let alone the other requirements for MOM. This situation has been made worse in the past by the significant decrease in crop productivity arising from the collapse of the cotton market, poor water delivery systems and prolonged periods of drought.

Since the deterioration of the Gash scheme in the 1980s, land and water fees remained at low levels that could not meet the large annual Management, Operation and Maintenance (MOM) costs necessary for overcoming past poor maintenance and also in ensuring that adequate amounts of water reached the irrigable land. The Indeed low level of fee collections and the growing cost of irrigation network accumulated maintenance engendered a vicious circle of poverty. At project start up, land and water fees were at SDD 2300 (SDG 23) per feddan of sorghum and they currently stand at SDG 35 per feddan of sorghum (see Table 3. below).

Table 3. Land and Water Charges (Government of Sudan)

Item	Description	Amount (Per Feddan)			
		(SDD)	(SDG)	(US$)	% of Total
1	Water fees	2000	20	10	57%
2	Administration	1000	10	5	29%
3	Contributions to Kassala State Government	200	2	1	6%
4	Social services	100	1	0.5	3%
5	Farmers' Union	200	2	1	6%
	TOTAL	**3500**	**35**	**17.5**	

4. Domestic and Livestock Water Supplies

Component 3: Community Development, Capacity Building and Empowerment aims to establish more reliable and better quality domestic water supplies through the **refurbishment of existing facilities**, building the capacity and empowering communities through training, group formation and provision of community initiative grants - on a matching basis - for social services support.

4.1 Domestic Water Supply

Many poor communities suffer from insufficient/unreliable potable water supply and lack access to water, especially in the dry season for both themselves and most importantly their livestock (see also 4.2). Sources of water within the Gash area are constrained by the geology with the most reliable sources being located near to the Gash River. These are recharged annually during the flood season.

4.1.1 Consultancy services

The consultancy work to plan, design and supervise the implementation of the drinking water supply contracts was awarded by GSLRP to the Khartoum based consultancy firm of Environmental & Development Services (EDS). They have completed their tasks to a reasonable standard and at the verbal request of PCU have undertaken a variety of additional services[27] related to the successful completion of the works. The details of these services are not well documented in PCU and no

[27] Such as a Drinking Water Demand Study of domestic water demand (including livestock) for the Kassala to Aroma and Tendelai and Gammam to Wagar pipelines.

addenda to the contracts have yet been issued although from the outputs/reports, it is clear that the tasks have or are in the process of being completed.

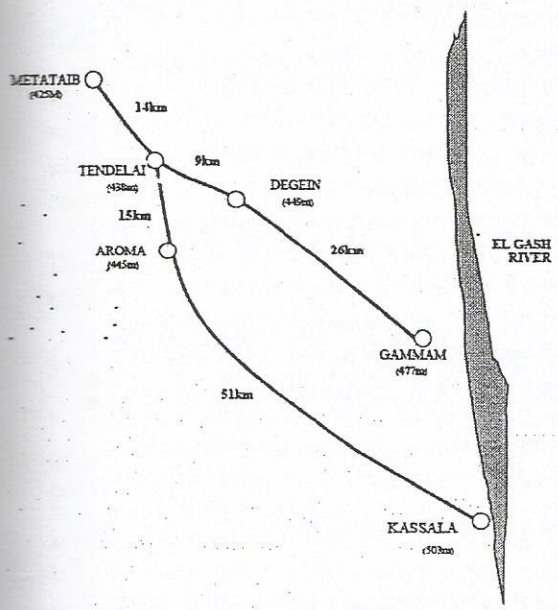
4.1.2 Water Demand

Livestock is an important and significant user of water in the GAS area and surrounds. In the past serious water supply problems have been experienced in the driest months of the year (April to July) when Haffirs have dried up and few other sources are available. Although EDS included livestock demands in their study for the whole area, due to cost reasons, only a proportion were included in the sizing of the Kassala to Aroma pipeline[28]. Assistance in meeting the demands of the livestock as well as rural communities was included at Appraisal and those demands that could not be met from the two main pipelines would be met from identification of additional local sources the locations of which derive from the planned hydro-geological study (see section 4.2). The identification of these additional sources is still outstanding and the relevant studies need to proceed as soon as possible. The basic work in assessing the overall demands of the extended GAS area has been done by EDS, but was not included in their Conceptual Design Framework report of July 2007. Some additional field work needs to be completed and an overall demand report prepared to present the full GAS demands, including livestock, to be ready at the same time as the results of the geophysical surveys (see recommendations under see section 4.2). This is estimated to cost less than US$ 10,000 if given to EDS as an extension to their contract. This is recommended as they have completed most of the work and retain all of the relevant unpublished data.

4.1.3 Pipeline Reticulation Network Rehabilitation.

The pipeline from Kassala to Aroma that was built in 1950s has been damaged over the years and requires replacement. Additional wells are needed to meet the projected water demands up to 2028 on route to and around Aroma and onto Tendelai. At Appraisal, the project included under IFAD contributions the repair and upgrading of the system and an additional pipeline from Gammam to Wagar. Although this latter pipeline is still included, due to cost escalations, it will now be funded by GOS. These funds have yet to be secured. The work for rehabilitation of the existing water pipelines and associated water points and accessories were divided into several contracts:

Figure 5. Layout of Water Supply Pipelines



Part I (1): Drilling and completion of 2 boreholes at Gharb El Gash together with installation of electric submersible pumps complete with pump/switch rooms and all accessories.
Part I (2): Supply and installation of 4 water points along Kassala – Aroma pipeline route.
Part II (1): Supply and installation of Kassala – Aroma UPVC pipeline of 300 mm diameter and 52,000 m length complete with accessories as valves, outlets, joints etc.
Part II (2): Supply and installation of Aroma – Tendelai UPVC pipeline of 150 mm diameter and 15,000 m length complete with accessories as valves, joints, outlets, crossings etc.
Part III: (1) Drilling of two boreholes at Gammam, installation of 2 electric submersible pumps complete with pump/switch rooms, and all required accessories. (2) Supply and installation of diesel driven centrifugal pumping unit. (3) Supply and installation of Degein – Wagar UPVC pipeline of 150 mm diameter and 35,000 m length complete with all accessories.

[28] The resulting projections included meeting the full demands of the local population in the main towns and villages up to 2037 with 50% of the livestock demands met in the first year declining to 10% in 2037.

Bakawi Investment & petroleum Services Company was awarded Parts I (1) & (2) and Hewa for water Drilling Company (Khartoum) was awarded Part II (1)° & (2). Bakawi Company later sub-contracted the drilling component of Part I (1) to Kassala Drinking Water Corporation (KDWC).

4.1.4 *Existing contract with Bakawi Company*

The contractor has consistently failed to comply with the timescales of the contract and the requirements of the specifications. Although the advance payment was received late, they have still failed to complete the works according to the revised timescales. To date the Contractor has recently completed the well drilling and development but has taken three times longer than was planned[29]. The results of the stepped pump tests needed to prepare the pump specifications and define the safe yield of the well are still awaited. After issuing the necessary warnings to the contractor[30], the Consultants (EDS) prepared a letter to the PCU[31] recommending the termination of the contract. Although the mission endeavoured to see whether the contract could be recovered without the termination of the contract, it became clear following discussions that the contractor is unable to complete the work within the agreed timescale and to the required standard to give a good quality product that is free of problems. Whatever happens with this contract, it will not be possible to complete the new pipeline to Aroma (being undertaken by the Hewa contractors under a separate contract – see next section) before the end of the current dry season due to the late start[32]. However, the part of the contract with Hewa involving the 15 km pipeline from Aroma to Tendelai, can be completed within one month from now and this will ensure water to Tendelai by the start of July 2008.

Quality control by the Consultant has been below expectations and contract management forms relating to variation orders and instructions to contractors do not seem to have been used. Verbal variations have been given but not supported with cost estimates and accompanying Bills of Quantities that set out the impact on the overall project cost. The bedding material originally proposed for the main pipelines have been modified and removed for some places and this is likely to result in a considerable cost reduction[33]. EDS needs to considerably improve on its level of site supervision and to ensure that all contractors closely follow the specifications. Although the Specifications for the pipeline and other work seemed to be rather brief, they will be supported by FIDIC *Technical Specifications* and *Specific/Particular Technical Specifications.* More details and supporting calculations are required in the Consultants' progress reports that should provide sufficient specific details as to where the changes have been made and the resultant cost changes.

4.2 Livestock and Rural Water Supply

Component 2: Animal Production and Rangelands Management aimed to improve animal health services, provide both men and women with improved animal breeds, to develop a sound land use policy through the **rehabilitation community stock water facilities, construction of water containment and spreading structures** and to **control of mesquite invasion.**

During the earlier irrigation developments, shallow basins and *haffirs* were established on the fringes of the Western delta to keep the animals away from the cropped areas. The capacity of the haffirs was

[29] The contractor blames the changes in screen size for the delay in completing the wells, but the final selection of screening will depend upon the result of the drilling tests. It should be noted that according to EDS the contractors in their offer claimed that they had the resources to meet the changing specifications if this occurred.
[30] 5th May 2008.
[31] Dated 1st June 2008. This letter lists all main defects as well as the chronology of problems and warnings.
[32] The Hewa contractors received their advance payment only on 5 May 2008 and the contract period extends for 4 months from this date.
[33] It should also be noted that at the time of bidding, it is unlikely that the contractor included the "free at source" cost of the bedding sand (taken from the river excavations at the Kassala Bridge) as this would not have been available if they had started when they were meant to some 2 months earlier.

estimated at 240,000 cubic metres and that of the 20 shallow basins at 787,200 cubic metres. Problems in the past related to the failure to desilt the haffirs and also the decline in the yield of the wells in Kassala due to insufficient maintenance and other technical problems has meant that insufficient water has been available throughout the GAS area and pastoralists have been damaging the pipelines to get some much needed water.

GSLRP set out to improve rangeland management through the establishment of water point sites to optimise the distance livestock travel to water. Linked with this is the cleaning and development of Haffirs and the rehabilitation of existing livestock water points The success of this component relies upon the examination of satellite imagery to identify potential locations for groundwater followed by hydro-geological resistivity surveys[34] to more closely identify possible sites for confirmation test drilling. This is anticipated to cost about US$ 100,000. It had been intended that staff from Kassala Drinking Water Corporation (KDWC) would be trained in geographical information systems (GIS) and provided with the necessary tools. This has not taken place. Although draft terms of reference (TORs) for the surveys have been prepared, they cover too many aspects such as EIA monitoring and detailed mapping. This has delayed the start of the basic surveys. This work is connected with component 3.

4.2.1 Geophysical surveys

Most of the past geophysical studies for the Kassala area concentrated on the area between the Eritrea border and Kassala. These were aimed at identifying suitable water sources for the city as well as the surrounding areas. The geological setting appears to be simple and comprises a pre-Cambrian basement overlain by its erosional products. A summary of the availability of water would be that close to the Gash, the coarse sands and gravel have the largest source and as one moves away from the river, only shallow surface aquifers that can dry out in the dry season exists. Groundwater near to the Gash can be considered as fresh with its electrical conductivity less than 1.5 micro Siemens per centimetre. With increasing distance from the Gash salinity increases. Previous studies show that the Gash River aquifer is mainly recharged by the circulation of water flowing through the river during the rainy season. The water subsequently spreads into the remainder of the aquifer by lateral subsurface flow. Direct circulation of rainfall plays a minor role because poorly previous clay surface deposits overlie most of the aquifer.

4.2.2 Groundwater

Although crystalline hard rock covers most of the Gash basin, due to the lack of major fault zones, very few promising locations in terms of groundwater potential could be found in these strata. In fact, no locations with groundwater resources, suitable for any purpose other than village water supply, could be identified in the basement of the eastern Gash basin. In general, groundwater occurrence follows that of surface water from the mountains towards the drainage channels of the Gash and Setit. In the plain between Tesseney and Omhajer, the groundwater flows westwards into Sudan. As indicated by the rainfall pattern, any direct recharge will be in the area south of Tokombia and around Omhajer, where the annual rainfall of about 500 mm theoretically permits some direct recharge. The lowest direct recharge of this basin occurs in the NW comer near Tesseney; however, most groundwater will originate from indirect recharge of the alluvial deposits along the main river channels. The storage capacity of these deposits is especially important in intermittent rivers like the Gash.

The average yield of the boreholes in the bedrock in Gash Barka in Eritrea is about 2l/s. Although the aquifer tests and number of boreholes was small, the results confirmed the relatively low transmissivities and yields of basement aquifers.

[34] Using vertical electrical sounding (VES) to determine the location of possible water bearing strata.

Alluvial deposits in the Gash basin are primarily situated along the main river channels, of the Gash and Setit rivers. Targets for groundwater exploration in these river basins are stretches with thick and extended alluvial deposits. These deposits are even more interesting if located adjacent to geological structures which could act as groundwater barriers.

5. Conclusions

5.1 Gash River and Protection Works

River protection works for the Gash have been problematic since the irrigation developments were started in the late 1800s. The history of these works has shown that each year and significant damage is done to the river banks and neighbouring villages and towns. Attempts to rectify the problems are well documented (Swan. 1959[35]) and show that in spite of many thoughtful and considered efforts, many structures do not survive the severity of the floods. Long-term experience from within the senior staff from the Ministry of Irrigation and Water Resources has shown that the nature of these floods has been changing in recent years and that the frequency of serious floods has changed from a 1: 10 to 1:20 year return period down to 1:3 to 1:5 year probability[36]. This change in size of design floods requires a different approach as well as an adjustment in the flood protection measures. In the past most of the flood protection works were achieved using manual labour and machinery with low outputs. The availability of modern high output machinery in sufficient numbers has enabled necessary protection works to be undertaken in a relatively short period. Although the capacity to complete the annual protection works has increased, the change in the government funding of such works has impacted negatively as machinery have sat idle during optimum construction periods.

The Gash sustainable livelihoods regeneration project was formulated in March 2003 with appraisal taking place in July and August of the same year. This coincided with the arrival of the very damaging flood and necessitated significant adjustments in the contents of the programme. At this time the Government of Sudan recognized the need to approach the problem in a more holistic way[37] and also to provide sufficient funds to enable a long-term strategy to be followed. Agreement was obtained from GOS for immediate implementation of a crash programme and this involved immediate works on river training and irrigation infrastructure rehabilitation. Crash or *fast track* programmes are always fraught with problems of inadequate detailed design/estimation coupled with significant cost increases during implementation. Although efforts were made to reduce these problems, these failed to produce the required increase in quality.

Since 2004, the GOS through GRTU has been implementing a longer-term strategy for the control of the Gash River. This covers the period of GSLRP and coincides with the 8 year project implementation period so that funds from both GOS and IFAD can be used in a complimentary manner. It has been based on the earlier work that has utilised this knowledge and experience gained to improve and extend the protection groyne (spur) system around Kassala. This has proved an effective mechanism for providing good quality control and monitoring as well as ensuring the longer-term sustainability of the interventions undertaken. Such works as the river training have to draw considerably on past experience, as many in of the problems experienced are not well dealt with in technical design manuals. They involve considerable costs in both capital and recurrent terms and need to be effectively planned to withstand the rigours of the annual floods.

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[35] Recorded Behaviour of the River Gash in Sudan.

[36] GRTU Report for MTR. This is also confirmed by the gauge operator at Gera station, who although a contract employee for 3 month per year has been in this position for over 30 years.

[37] Although it was recognized at appraisal that the rapid change in river slope as the Gash flows into Sudan causes the river to significant meandering during relatively short periods of intense flood flows, it was not fully appreciated how to approach the problem and that such control works need to be approached in a holistic way.

5.2 Gash River Control and Management

5.2.1 *Design and adequacy of the River Control Works*

Examination of the works during the mid-term review indicated that the overall approach seems reasonable with problems being addressed from upstream to downstream in a systematic manner. This aims to reduce the probability of bank breaches and ensure more water availability at the bottom of the system. Some problems were identified but importantly the works seemed to be relevant to the conditions experienced and the very real threat being experienced by Kassala city and its associated developments and infrastructure. GRTU has approached the problem in a systematic and serious manner and this has only been possible by the considerable financial commitments are to be made by the government of Sudan.

At the start of the GSLRP programme, it was noted that the old bridge at Kassala was an obstacle to river flows, particularly as the clearance beneath the bridge was insufficient to allow the free passage of predicted peak flood flows. Following the excessive flood of 2003, a high technical committee (HTC) was formed by the Minister of Irrigation & Water Resources and this recommended a number of measures to protect the City and surrounding villages. This included the extension of the existing spurs and dyke system with some modifications to cover all of the Kassala Reach. Although it was recognised that the old bridge was a problem, rather than removing it, it was recommended that the flood capacity at the site should be increased by jacking up the old bridge and raising the height of the spurs and dykes so that a free board of 1.5m during maximum flood periods was achieved. Excavation of River bed was not recommended although this has been out for several years and evidence from GRTU would indicate that this, combined with the river control works, has been effective to reduce constrictions and overall sedimentation.

During the last large flood that occurred in 2007, which was larger than the 2003 flood, the second bridge caused orifice flow under the bridges and the surge flow that resulted almost over topped the embankments upstream of the bridge. Computations by GRTU using available flow information on the impact of this surge and the resultant backwater resulted in the recommendation to increase the embankment height by one metre immediately upstream of the bridge. This has been completed and so will be in place by the time the 2008 floods arrive. It is hoped that this will be effective; however, the hydraulic jump that also occurs as a result of the damming effect of the second older bridge will still occur at flood flows of around 1,000 m^3/sec and tend to erode the embankments immediately adjacent to the bridge.

5.2.2 *Implementation of Civil Works*

All of the civil works costs for the river training works being undertaken by GRTU have been funded by GOS. This has proved very effective, but has not been as efficient as could have been possible if full advantage had been taken on the relatively limited construction season. With the financial year starting on the first of January, and funds arriving for the works at the beginning of April, only two months of effective construction have been available for GRTU. This has resulted in increased costs due to incomplete works being damaged by the following floods[38]. The slow and untimely flow of funds for the works has been the largest constraint experienced by GRTU.

Ideally, construction of new protection works and routine maintenance and repairs for existing works should start soon after the flood season has finished with capital repair works beginning in January at the latest. In practice, limited availability of funds in the first quarter of each financial year that ends

[38] Such as at Hadaliya where the offtake structure was started in May 2007, which is too late for completion of the works, and floods caused significant damage due to under-scouring of the main structure. Completion of the works was planned for this year but the contract for the works was only signed in mid-May. It is unlikely that for the second year running, the structure will be finished before the flood season starts.

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Comment [r6]: Are the works also suitable for the irrigation of the Gash spate irrigation scheme?

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on 31st December has meant that works have only started in mid April at the earliest. The very short construction periods have been extremely inefficient, cost ineffective and prevented the proper utilisation of construction machinery. Quality control has suffered as supervising engineers tried to meet unrealistic completion dates. The provision of equipment to facilitate force account work has benefited GRTU as it has enabled it to undertake a number of works in parallel with those being carried out by contractors. However, limited funds in late 2007 and early 2008 have prevented GRTU undertaking regular maintenance work outside the period of mid April to early July.

a) Capital Costs

Examination of the costs of the works during supervision missions has not fully appreciated the long-term plan of GOS/GRTU for the reinforcement of the Gash river protection. Comparison with the appraisal estimates that considered selective improvements, led to the conclusion that these works have been a continual drain on capital resources rather than being part of a comprehensive river control plan to protect infrastructure and economic assets as well as ensuring regular supplies of water down the river. During the commencement of execution of the works, considerable differences in volume and cost of the works resulted when comparing the actual works envisaged with those anticipated in the project documents. This matter was discussed in detail at the start-up workshop and IFAD follow up missions when it has been decided to use force account for the 2006 – 2010 works. It was agreed that river control works would be financed by GOS. Additional equipment was financed using IFAD funds allocated to river control with GOS meeting all materials and operation expenses as well as additional contract costs. The late arrival of this equipment coupled with inadequate operational funding did not permit the use of force account until 2007-2008 with contractors used to complete the interim works.

Considering the amount and scope of works undertaken (Appendix A), the costs do not appear unreasonable. This is particularly true considering the very short construction period that precludes many smaller contractors, the considerable volumes of work to be undertaken necessitating modern machinery in sufficient numbers, the uncertain local security conditions prevailing soon after implementation, the increase in unit rates due to fuel and construction price increases and the need to repeat between 5-10% of the works in the following year due to incomplete works and subsequent damage.

Examination of the final costs shows that there have been considerable cost increase (rather than overruns) when compared with the original estimates. The baseline cost at appraisal for the river control works was US$ 5.7 million (excluding machinery for GAS and GRTU) and the final costs have been 6 times greater at about US$ 29 million (Appendix A, Table A.1.). There is no doubt that if more time had been available to prepare and supervise the works, and that funds were available on a regular and timely basis, cost reductions would be possible. However, although much of the design work is adequately prepared, there are only a certain number of contractors with suitable construction equipment to meet the tight timescales.

b) Maintenance costs

Much of the work that would normally fall to annual maintenance has been undertaken as capital works. Part of this has resulted from inadequate funds for routine O&M works[39] and part from the lack of suitable equipment in sufficient numbers. The use of Force Account (see c) below) is only possible if equipment (either for hire or within the organisation) and funding are available. This was not the case until 2007.

[39] This lack of timely funding inevitably results in higher annual maintenance costs due to additional capital provisions to rectify the flood damage to unfinished works from the previous year.

Using data prepared by GRTU, estimates have been made in Table 4 of the annual needs for routine operation and maintenance of the river training works assuming that the remaining planned works are fully funded by GOS. Currently, the offtakes to the seven main irrigation canals are included under GRTU scope of works. In the future, it is considered that these should be included under GAS as they relate directly to the water made available in each canal for irrigation that in turn is dependent upon the management of each canal. The costs of the O&M of the main offtake structures from the Gash River have thus been included under the estimates given in Table 11. Government should consider raising funds locally from the Kassala city as most of the economical benefits will derive from the protection provided to the city and associated infrastructure and businesses. This will require awareness raising by the GRTU and the State Government. Any funds collected in this manner should be ring fenced for river training works and this would facilitate GRTU in both extending their maintenance period and also in making better use of its equipment (see section c) below.

Table 4. Estimate of Annual O&M Charges for GRTU

Item	Description	Cost [1] (SDG)	Cost (US$)
	GRTU - Operation and Maintenance Costs (annual)		
1	Vehicle and machinery replacement	1,220,000	610,000
2	Staff Allowances	300,000	150,000
3	Structures and earth works	1,000,000	500,000
4	Vehicle, machinery, office equipments, insurance and license of machinery	780,000	390,000
5	Offices and buildings	165,000	82,500
6	GRTU Staff Training - Mechanical section	15,000	7,500
7	Other staff (annual training needs)	20,000	10,000
	TOTAL	**3,500,000**	**1,750,000**
	Annual O&M Cost per target irrigated area [2] (US$/ha)		16.28
	Notes:		

Notes:
1. Based on data prepared by GRTU. The need for cross cableways needs to be assessed in relation to the feasibility of measuring at the sites proposed and also on the decision relating to a new high level road bridge at Kassala city.
2. Based on a Target area of 107,500 ha per annum.

c) Force Account and Contractors' Costs

The proposals set out in the Appraisal Document were prepared prior to the considerable injection of funds by GOS as a result of the damage caused by the 2003 floods. Examination of the activities to be undertaken and the considerable amount of work to be completed has shown that both GRTU and GAS need to have certain basic equipment to assist them with routine maintenance activities and to deal with emergencies when they arise. In addition, some capital repair and larger maintenance works will still need to be undertaken by contract to reduce the peak equipment requirements for both GRTU and GAS[40]. Although at appraisal an analysis of the amount of machinery needed was made in relation to existing equipment, this did not fully recognize the extent of the annual works needed in cleaning the canals or the extent of protection works required for the Gash River. It is clear that force account is cheaper than contractors' costs provided that funds for the force account are readily available and enable the equipment provided to be fully utilised. At the moment, funding arrives late, or not at all in the case of GAS in 2008, and thus the machinery is working for only 30% of its potential working time. Under these arrangements the advantages in purely cost terms of force account over contractors work are minimal, as equipment that stands unused still has fixed costs to be financed. (The GRTU workforce comprises some 8 engineers and 80 operators).

It is the opinion of the mission that both force account and works by contractor are needed by GRTU and GAS to enable them to complete the large amount of annual maintenance activities. These can be financed by a combination of WUAs, GAS and Government as illustrated in Tables 4 and 11. An analysis of the works to be undertaken annually by GAS as part of routine maintenance is needed

[40] Regular cleaning of main canals in the case of GAS due to the large number of canals.

Comment [r7]: Check recommendations for off-takes in appraisal report.

Comment [r8]: Not clear what these costs cover. O&M of what exists or also capital investments in equipment, offices, vehicles, etc...

Comment [r9]: This item is less than the third of he total costs?

Comment [r10]: It is excessive to charge all the O&M of river control to the spate irrigation scheme. Kassala city should shoulder the max...

considering the outputs of the existing machinery. This will assist in the better management and sharing of the available equipment between the O&M and Agricultural Engineering Departments of GAS and also identify gaps in available equipment.

5.2.3 *Relationship with Gash Development works.*

The benefits of the current combined approach to river training and irrigation system improvement is evidenced by the increase in the area receiving flush irrigation water and the area cultivated since the start of GSLRP. There is a direct correlation between the river training works and the Gash Scheme works as was illustrated by the impact of the 2007 floods that resulted in damage of the systems and towns as far as Aroma and the inability of many farmers to obtain sufficient returns to meet the annual water fees. However, without adequate and timely funding, the establishment of clear lines of authority and organisation for planning and implementing the annual O&M activities, the establishment of an effective O&M organisation within GAS to complement the approach adopted in GRTU, many of the past investments may prove to be unsustainable.

The rehabilitation and raising of the Tie bunds along the West bank of the Gash River is an important aspect of the effectiveness of the flood control works. Historically flood flows through the *Balag* areas has been slowed down by both the growth of the trees as well as the Tie Bunds that restricted the river to the wider meander belt of the flood plain. The raising of the bed of the Gash River coupled with the infestation of mesquite has reduced this effectiveness and brought about frequent breaches in the Tie Bunds.

Currently, each of the seven main canal offtakes is operated independently and on a first come first served basis with limited to no communication between GRTU and GAS. Under section 5.2.4 above, it has been recommended that radio communications between GRTU and GAS are provided to improve the flood warning system and to make better use of available flood flows. This will assist in advising maintenance teams down the GASH river when the first flood is coming so that they can both close the offtakes to let the first flood with its high sediment load to pass down the river to the Gash die and also to enable equipment within the river course to be removed and emergency protection works put in place if construction activities have not been completed.

5.2.4 *Flood Mitigation Strategy*

Since the GRTU has taken over responsibilities for river management and protection, useful progress has been made to improve the quality of data collection. Flood stages are now recorded on an hourly basis instead of 3 hours, and float measurements are made twelve times a day with and daily sediment sampling[41]. During flood flows, additional measurements are made with sediment samples collected during rising flood flows. Initial analysis of these data carried out since 2005 have shown a good correlation between flood stage and velocity that are considered by GRTU as sufficient for calibration of each gauge station site. Future data will need to be included to improve the accuracy of these predictions and also to facilitate further data analysis. This must be a priority for GRTU, as it will assist in the prediction of flood flows. GRTU have in place a system for flood warning, but this relies on mobile phone communications and conventional landlines. This is inadequate considering the urgent need in relation to peak floods and also the requirement to make better use of each flood flow for irrigation. Any improvements in communication must also include good links to the O&M section within GAS in Aroma.

Estimates of flood passage down the GASH are needed to show how the flows within the Gash decrease with distance down the river (particularly at each of the seven offtakes), how they are affected by the time of occurrence of flood and duration of flood and how much water is available at

[41] Samples are kept in watertight bottles and sent in batches to the Hydraulic Research Station (HRS) in Wad Medani for analysis.

each offtake for each type of flood flow[42]. This will facilitate the preparation of a more comprehensive system for following the flood progress down the river and informing each block in time of the size and nature of the flood and the potential use could be made for irrigation. Checking, recalibration[43] and improvement of the staff gauges at each intake and control section will be required for this and to link with the improved flow measurements at Fota and Kassala Bridge.

The facilities for the operational staff located at the main canal offtakes on the Gash River for each Block are very limited. These need to be improved to both encourage staff to stay there during the flood season and also to allow the management of GRTU and the O&M section in GAS to communicate easily and rapidly with them, knowing that they will be on site at all times.

The costs relating to the above are presented in Table 5. below. These will need checking and confirmation by PCU and GRTU as well as the source of funding.

Table 5. Equipment Required for Improving Flood Prediction and Monitoring

Item	Description	Period	Units	Quantities	Cost (SDG)	Cost (US$) /4.
	FLOOD MITIGATION AND EARLY WARNING					
	Improving Flood Prediction and Monitoring	2009				
1	Equipment for soil laboratory /5.	2009	Sum	1	25,000	12,500
2	Full equipment for sediment laboratory. /6.	2009	Sum	1	40,000	20,000
3	Rubber boat. /7.	2009	No.	1	15,000	7,500
4	Cross cable ways for river flow measurements. /8.	2009	No.	3	80,000	40,000
5	Total Station Real time. /9.	2009	No.	1	160,000	80,000
6	Traditional Total Station. /9.	2009	No.	2	50,000	25,000
7	Short wave ADCP. /10.	2009	No	1	60,000	30,000
8	Telecommunications. /10.	2009	No.	10	100,000	50,000
9	Buildings for measuring equipment etc. at Gauging site	2009-2010-2011	no	3	100,000	50,000
	TOTAL FLOOD MITIGATION AND EARLY WARNING				**630,000**	**315,000**

Notes:

/1. Based on data provided by GRTU. Consult presentation to MTR for more details and further justification.
/2. Needs further confirmation and checking by PCU/GRTU.
/3. Funded recommended form Federal Ministry of Finance budget as items are of strategic national importance.
/4. Figures do not include annual operation and maintenance costs, replacement costs for equipment and training costs.
/5. For improving quality control of earth works in Tie banks, bunds and structures.
/6. Needed to improve and timing the sediment monitoring program.
/7. For more accurate determination of some hydraulic flow parameters.
/8. For measurement of high level flows that are not possible using current sounding and flow equipment.
/9. Improvement in accuracy of measurement of topographic information and integrating this with flow measurement calculations for flood protection/mitigation.
/10. Improvement in communications within GRTU, gauging sites, offtakes sites and O&M Unit, Aroma.

As part of the flood warning and mitigation strategy, good access roads are required within the Gash Delta. This is discussed below in section 5.4.4 where priorities for road improvement suggested together with costs.

In addition to the above, and GRTU needs to have regular funding to complete the programme of works that were started using GOS funding under GSLRP. These works are part of the long-term plan prepared by GRTU after the disastrous floods of 2003. This is based on the longer term plan prepared by GRTU that will not only benefit the irrigation works in GAS but also and most importantly are aimed at providing better long-term security for Kassala and all the towns and villages within the Gash Delta. The amount of these costs are provisional estimates prepared by GRTU and reflect the

[42] Between Gera and Kassala past reports indicate that between 26 to 30 % of initial flow is lost by percolation.
[43] At present the gate operators judge the size of the flood from their past experience, which does not necessarily mean that they make adjustments for the changes to the offtake structures resulting from the rehabilitation process.

delays that are experienced annually in the delivery of funds from government budget. Some of these items will be carried out under force account using the equipment already supplied and other works which can be more carefully defined will be carried out under contract works. It is anticipated that with the presence of more contractors willing to work within the Gash Delta area, unit rates will become more competitive and this needs to be closely monitored by GRTU and PCU.

In Table 6 below, an indication has been given on works to be carried out by force account and contractor to complete the river training and protection programme. This will need to be checked and confirmed by PCU/GRTU.

Table 6. Estimates of Investments Needed for Completion of Gash River Training Programme

Item	Description	Period	Units	Quantities	Cost (SDG)	Cost (US$) /4
	RIVER PROTECTION WORKS					
	Kassala and upstream protection works					
1	Gash River - Gira Realignment – Erection of gauging station.	2009	No	1	1,400,000	700,000
2	Spur and spur reconstruction	2009 -2010 -2011	No	3	6,000,000	3,000,000
3	Masonry and tie banks	2009 -2010 -2011	No	3	24,000,000	12,000,000
4	River banks earth works	2009 -2010 -2011	No	3	2,100,000	1,050,000
5	River Bed Excavation - Kassala Reach	2009 -2010 -2011	No	3	2,485,000	1,242,500
		subtotal			**35,985,000**	**17,992,500**
	Gash Protection and offtakes works subtotal					
1	Kassala block	2010	No	1	3,500,000	1,750,000
2	Makali block	2009	No	1	5,000,000	2,500,000
3	Degein Block	2010	No	1	182,209	91,105
4	Tendelei block	-------	No	1	0	0
5	Metateib Block	2010	No	1	1,100,000	550,000
6	Hadaliya block	2009	No	1	3,750,000	1,875,000
7	River Bed Excavation	2009 -2010 -2011	No	3	517,500	258,750
		subtotal			**14,049,709**	**7,024,855**
	Flood Banks and protection downstream from Kassala					
1	Morris Bank and spurs	2009 -2010 -2011	No	3	8,000,000	4,000,000
2	Villages and cities direct protection works.	2009 -2010 -2011	No	3	300,000	150,000
3	Mesquite removal in areas near to Tie banks and bunds and in Balags	2009 -2010 -2011	No	3	300,000	150,000
		subtotal			**8,600,000**	**4,300,000**
	TOTAL RIVER PROTECTION WORKS				**58,634,709**	**29,317,355**

Notes:
/1. Based on data provided by GRTU. Consult presentation to MTR for more details and further justification.
/2. Needs further confirmation and checking by PCU/GRTU.
/3. Funded recommended form Federal Ministry of Finance budget as items are of strategic national importance.
/4. Figures do not include annual operation and maintenance costs, replacement costs for equipment and training costs.

Using funds made available for maintenance activities and emergency repairs, GRTU should build up a stock pile of suitable materials that will both make construction more durable and also enable emergency repairs to be effected rapidly. This includes gabion boxes and mattresses, geotextile membranes and sheet piles and a hydraulic hammer attachment for the excavator.

5.3 Irrigation Rehabilitation Works

5.3.1 Rehabilitation Approach

At Appraisal, funds were allocated for reforming the canals *to their original design.* This left the final decision as to what was meant by this to the implementing organisation and those working and

guiding it. As GAS did not have the capacity to design and supervise the programme for rehabilitation of the irrigation systems, the Ministry of Irrigation and Water Resources (MIWR) in Wad Medani was engaged as the "Consultants" to carry out the planning, design, supervision and implementation of the rehabilitation proposals. The terms of reference for the activities to be completed assumed that MIWR was very familiar with the needs of Flush Irrigation and the Gash systems and therefore these were not spelt out. For the main canals and structures, it was stated that "*The Project will support the engineering design and earthworks for the main canals and irrigation network to be reformed to appropriate design to meet the new field requirements resulting from the change of the rotation from 3 course to 2 course rotation and the area from 80,000 feddans/year to 120,000 feddans/year*". Unfortunately it was not clear what was regarded as "appropriate design" particularly as most MIWR Engineers were more familiar with the perennial irrigation systems of Gezira[44] rather than the Spate systems of the Gash. Although there are staff in MIWR with experience in Spate Systems (including Flush Irrigation), it appears that insufficient senior staff with such experience were active in the support to GAS.

The scope of work was set out in the GSLRP Appraisal Report and its Working Papers that showed that utilisation of the Gash water was constrained by the condition of the canal system deriving from a number of years of relative neglect and deferred maintenance. The need for support for cleaning the main canal systems was established together with the means for reducing annual desilting requirements. Estimates for the scope of works were based on data prepared by GAS staff prior to the floods of 2003. The size and force of this flood exacerbated the situation and resulted in immediate support from the Government of Sudan and IFAD and the start of the emergency phase of GSLRP. There was thus some pressure to clean the first canal systems and get water flowing. This may have resulted in insufficient attention being paid to the concepts of the IFAD support, the need to define carefully and agree the design approaches to be followed before start of work and to rehabilitate the systems with a view to reduce future operation and maintenance costs.

The engineering designs and scope of rehabilitation works that derived replicated that of the earlier systems[45], but without sufficient attention paid to the rationale for determination of levels and how flow was shared amongst the different canals and *Misgas*. Insufficient attention seems to have been paid to hydraulic slopes[46]. It appears that whereas offtake structures at the Gash were modified to account for increased bed levels in the river by raising the piers and road slabs, the invert levels were retained[47]. This meant that downstream canal slopes were either changed from the original relatively successful historical slopes or resulted in incorrect levels at some of the *Misga* offtakes. *Misga* inlet structures were repaired or new ones installed but again the invert levels do not seem to have been adjusted for rehabilitated structures. The net result of these design approaches has mean that (a) if sufficient stop logs are not provided and kept in place at the offtake structures, flows in excess of the design flows can enter the canal systems causing a wider range of flow velocities and scouring and siltation of canals; (b) water levels in the canals need to be raised to ensure adequate flow to some

[44] The design manuals of MIWR are based upon these norms. No design manual exists for Spate systems in Sudan and no design report and criteria seem to have been prepared and agreed for the Gash work.
[45] The basic criteria developed for the early systems relies on restricting the amount of Bed load entering the intake structure on the Gash River and then maintaining as far as possible constant flow conditions within the canal systems to limit the deposition of silt.
[46] From the data available to the MTR Mission, it is not easy to see the relationship between the levels within the Gash River and those at the start of the main canals.
[47] It appears that for *Misga* level structures, the outlet to both the main canal and to the *Misgas* was raised by up to a metre in most cases, but the invert level of the structures was left the same as before.

Misgas with the resulting deposition of silt in the canals[48], and (c) excessive amounts of silt are being excavated from the canals.

In the computation of bank levels, little consideration seems to have been given to the considerable silt mounds that exists on top of the banks when determining the design bank level. In general it would appear that the new canals could have probably been accommodated with much less excavation work if the intake structures had been modified at the downstream end to reflect the loss of command and field level. This would have reduced quantities and also enabled levelling of the silt mounds to have also been included. This would have improved access along the canals for both GAS staff and maintenance equipment and also facilitate the canal cleaning by the GAS and contractor machinery. The cleaning works when implemented exacerbated the situation as the machinery worked from within the canals in most case depositing the material on the old silt mounds increasing the problems of poor access further.

Experience with irrigation in Sudan has been dominated by the Gezira scheme. Although considerable knowledge has been built up on perennial irrigation, the same cannot be said of spate irrigation. Although such knowledge exists within the country, it has not been mainstreamed within the knowledge base of the country and only a limited amount is contained within the curricula of training institutes and universities.

The understanding by GSLRP and MIWR of the intention of IFAD therefore seems to be unclear. Support for improvement and rehabilitation of such systems that are based on future Water Users Association management, include upgrading to ensure that constraints within the system are removed, that the designs adopted result in lower operation and maintenance costs and that the designs are suitable for future WUA management. This concept does not seem to have been carried through in the designs and approaches that were followed. Preliminary costs prepared at the start of the process revealed insufficient budgets to meet the designs and quantities that derived and therefore compromises were made[49]. Instead of reflecting on the suitability of the approach and how selective improvements could be achieved within the budget, complete items were removed. Implementation of contract and routine future cleaning did not seem to have been covered.

Comment [r11]: Which items have been removed?

5.3.2 *On Farm Development/Misga Water Management*

Data on the achievements with respect to improved on-farm development and *Misga* water management is incomplete. Discussions with the Agricultural Engineering staff and Block Managers indicate that this has been approached in a systematic manner, but records of approaches adopted, conclusions reached and lessons learnt have not been well recorded. This must be addressed as a matter or urgency and when the work plans are prepared for the remaining period.

a) Water Users Associations (WUA)

Details on the progress of WUA development and empowerment are examined in a separate working paper[50]. In this Engineering WP, aspects that relate to the future management and financing of the irrigation systems are examined. WUAs formed are legal entities recognized for two years under the

[48] No data on canal velocities has been presented. It is probable that these and other data exist but the design report and data need to be made available so that it can be confirmed that resulting velocities are comparable to those velocities that have been derived over time and through practice in operating the Gash scheme.
[49] For Degein Block, one of the first group of canals to be cleaned, considerably higher costs resulted (twice as high as appraisal estimates) and this raised concerns about available budget and led to a reduction in the scope of works. No review of the design criteria and approach seems to have been made at this stage. It should be noted that the increase in the scope of works resulted to a large extent from the omission of the cleaning of all associated *Misga* canals.
[50] Consultant: Omer Egemi

Kassala State legislation on Community Organization Act passed in 2004 and enacted in 2005. A total of about 100 WUAs are envisaged based on the number of "paired" *Misgas* in each Block. A total of 74 WUAs have been formed to-date: 13 in Kassala block, 24 in Makali block, 19 in Degein block, 18 in Tendelai block. WUAs formation is under way in Metateib and Hadaliya blocks, together with infrastructure rehabilitation. Land tenure transfer has yet to be completed and the list of WUA members to be confirmed. Most WUAs formed earlier were renewed in 2007/2008. Four block level WUAs have also been formed. Training has been completed for WUAs in the 4 most upstream blocks, but these seem to be too academic and need to be shorter and more frequent with training content aimed at meeting farmer and GSLRP identified needs[51].

b) Land Preparation and *Misga* Water Management

Data on *Misga* works involving *inter-Misga*[52] and *in-Misga* bunds have not been well catalogued or reported with data available differing between GAS Departments. Work started in 2004 and continued to 2008 by which time most works for the 198 *Misgas* had been completed. A definitive list and details of each main canal and associated *Misgas* needs to be prepared and verified by PCU/GAS using the information presented in Tables 1 and A.2. These data should include an agreed numbering system that is used by all GAS Departments with those *Misgas* grouped together under the 2-year rotation being indicated. Table 7 shows reported progress to date. These data have been used in the estimation of remaining capital and O&M costs.

Table 7. *Inter* and *in-Misga* Dykes and Bund Construction

Block		Target Feddan	No. of *Misgas*	Year when Land Formation Carried out				Cost	
				2005	2006	2007	2008	Total (SDG)	SDG/fd
A	Kassala	20,000	32		141,750	131,440		273,190	13.66
C	Makali	20,000	30			137,060	425,000	562,060	28.10
D	Degein	39000	38		212,663	141,210		353,873	9.07
E	Tendelai	44000	32	177,934	155,575			333,509	7.58
F	Metateib	28000	28		207,275		322,000	529,275	18.90
G	Hadaliya	64000	30			121,240	375,000	496,240	7.75
TOTAL		215,000	190					2,548,147	11.85

Source: Derived from data provided by Agricultural Engineering Section. GAS. Aroma.

The current approach to on-*Misga* water management seems to be appropriate, but is not well documented in the annual reports. Staff involved seem to understand and agree with the approach adopted, but have not formally recorded details of how the system management works in practice and the successes and failures that are achieved. Current agricultural practices may be far from ideal, but are suitable for flush irrigation systems, provided that new higher value crops are introduced and adopted by farmers. The division of each *Misga* into 500 feddan units that are irrigated consecutively seems to follow moisture availability under flush irrigation and has facilitated water distribution. The subdivision also permits improvement in sowing timing to ensure effective water/moisture use.

GAS has identified the need to lengthen *Misga* canals to improve water management and to provide more water directly to the lower 2/3 of each *Misga* (see section 3.4). This would also permit improved water distribution inside the *Misga* and reduced weed growth (experienced in Degein block). Although this was foreseen at Appraisal, it was not included in the rehabilitation works planned by MIWR (as consultants to GSLRP). It has been estimated by GAS staff that each *Misga* canal needs to

[51] Three out of the 4 days of training were provided in classroom to farmers that are mainly illiterate (80%). Four continuous days of training were provided, regardless of farmers' availability and other commitments. Standard training was provided when Appraisal specified that themes for training should be on-demand.

[52] These divide the different *Misgas* and assist with water spreading and keeping water off the neighbouring fallow land. They are larger than the *in-Misga* bunds and are normally built and maintained using bulldozers.

be doubled in length. This can be done by force account or contract and will require a review of available equipment and other commitments.

It had been intended at Appraisal that six pilot areas would be established, one in each Block, to test different approaches to land and water management and to establish intervention costs. This approach has not been followed although suitable data have been generated from current and earlier work within the GAS area. Attention is now needed to catalogue these experiences and to define the range of costs of land development and *Misga* improvement works. Successful *Misgas* need to be identified within each Block to be used for in-field demonstration to other farmer groups and to show them the impact of these changes on improved water delivery and application efficiency.

Comment [r12]: The variations from the proposed design and their results should be documented to facilitate replication/ dissemination.

c) Crop Rotations

Although there are disadvantages in the 2-year rotation relating to weed growth and mesquite development, these are outweighed by the ability to accommodate land to many more farmers than is possible under the past 3-year rotation (Table 8). The considerable population growth that has occurred over the last 10 years (due to both natural growth and inward migration) has created considerable pressure on irrigated lands. It is therefore more likely that allocated land will be utilised and that the higher levels of farm management needed to ensure good crop growth will occur.

Table 8. Comparison between Crop Rotation Systems

2 Year Rotation	3 Year Rotation
Increased Mesquite growth if not attended to annually as sufficient moisture retained in lower root zone for tree growth.	Mesquite growth mainly in Balag areas where moisture can still be found in the lower root zones by the trees.
Increased grass growth as soils never dry out completely.	Soils allowed to dry completely so grass dies off.
More area available for increasing number of farmers.	Fewer farmers can be accommodated on GAS.
Increased gross returns from farmers	Gross returns available in only 2 years out of three.
Less likely to miss opportunity of floods in good years and effects of dry years less severe as some income available within household.	More likely to be affected by years of poorer flows.
Approach to "pairing" of Misgas means that farmers can access each parcel of land relatively easily and provide appropriate attention to land clearing and maintenance.	More difficult to allocate land close to villages and to facilitate easy access.

d) Mesquite Control

In the GOS supported mesquite removal programme using contractors, costs amounted to about 330 USD/ha[53]. GAS Agriculture Department approached the problem using *Misga* block farmers paid by the WUAs utilising the *nefir* (common works)[54] approach and a more reasonable cost of SDG 60/ha derived for the most infested plots. When this is converted into scheme costs considering different levels of infestation, an average cost of SDG 11/feddan (SDG 26/ha) derives (Table 9). This cost is offset by the sale of charcoal produced that reduces costs by about half. This approach to mesquite cleaning seems to be appropriate and has wider applications, particularly if other parts of the tree are used for fodder production as illustrated in Kassala by the NGO PENHA[55]. This needs to be followed up further and better documented. Possible support to WUAs should be considered as an

[53] Reference to New Halfa scheme, Page 30, Review of the River Training and Irrigation Scheme Rehabilitation Component, Main Report, Mission Report Abbas Abd Alla Ibrahim and Harry W. Denecke, 23 July 2005.
[54] Usually for desilting or mesquite removal works.
[55] http://www.penhanetwork.org/pages/Sudan.html

incentive although data indicate that this is not necessarily needed (Tables 11 & 12). Details of the associated land preparation works are discussed in section 3.4. and utilise earlier research findings.

Table 9. Estimates of Annual Manual Cleaning/Removal of Mesquite Trees/Bushes

Description	Mesquite infestation				
	Unit	Low	Medium	High	Total
Infested areas (Estimate)	fd	43,000	43,000	129,000	215,000
Rate for clearance	SDG	9	20	33	
Cost	SDG	387,000	860,000	4,257,000	5,504,000
Less Charcoal receipts	bag/fd	0.5	1	2	
Rate	SDG	10	10	10	
Return per feddan	SDG	5	10	20	
Average return per feddan	SDG	1	2	12	15
Net costs per Feddan				**SDG**	**10.6**

5.4 Costs

5.4.1 · Capital Costs

The costs of the civil work increased significantly from appraisal to implementation. The increases were not restricted to Component 1, but involved all components where construction works took place. Although there has been a difference in the exchange rate since 2004 with the dollar worth about 25% less now than it did then, it would appear that many of the works identified and estimated at appraisal were not based on sufficiently accurate information. The floods of 2003 and 2007 did increase the scope of works but this mainly related to the river training and stream regulation rather than to irrigation infrastructure. Changes in the scope of work are anticipated during implementation, but it is clear that for example in Degein, where estimates failed to include the cleaning and repair of the *Misga* canals and associated structures, more work was needed at preparation to define more accurately the precise amounts to be undertaken. Cost increases have also occurred as a result of price rises for oil and construction materials, the late availability of funds from the GOS budget, extra works resulting from flood damage to incomplete works, an unwillingness of contractors to work in the area due to security and other factors and a lack of real competition between contractors. The combination of these factors and the change in the exchanged rates caused about a doubling in the estimated cost with the changes in the scope of works accounting for the rest.

Examination of the unit rates would indicate that these are on the high side and in some cases nearly double what they should have been. Although evaluation of the tenders resulted in the lowest cost options, the monitoring of the contract elements was rather superficial and insufficient attention was paid to the possibility of some collusion between contractors[56]. The accurate estimation of quantities was also hampered by insufficient attention being paid to the peer review of the designs produced by MIWR, insufficiently detailed specification of the works and possible lack of detail in the determination of quantities by the consultants engaged for the design of the irrigation infrastructure rehabilitation. The Mid-Term Review Mission was unable to obtain complete information on the final costs of the contracts and the priced bills of quantities as well as details of the variation orders issued. It was thus not possible to examine these causes in more detail. The fact that these data are not readily

[56] Insecurity within the Gash delta areas during implementation meant that only a few contractors were interested in working on the GSLRP and this mean that uncompetitive rates derived.

available and accessible would indicate the insufficient attention paid by PCU, CCU and IFAD to this aspect.

Comment [r13]: This is a matter that needs to be discussed at MTR.

Some information was obtained from the Supervision Mission in Mid 2007[57] and from this it is clear that PCU should have been more proactive in monitoring these aspects and also in checking quantities estimated with those actually computed in the field. There are indications that the quantities for canal cleaning had exceeded what was actually necessary and if this over excavation had been identified early on, the costs of all contracts could have been considerably reduced and perhaps kept closer to appraisal estimates. In the case of the river training and stream control works, GRTU have shown that many of the quantities estimated within the Gash River that include meander cuts and rectification of damage from the previous year, can only be very approximately estimated. The option to do much of this river training work by force account is a good solution as this compensates for the rather approximate estimation. Where more accurate estimations are possible such as for bank protection and structures, the most cost effective solution is to use contractors. Works on Tie bunds is best completed using Force account and the two scrapers purchased for this purpose are being effectively used at the moment for this work.

5.4.2 *Management, Operation and Maintenance (MOM)*

A mission estimate of annual MOM costs for Gash irrigation systems based on data presented earlier and in Table 12, is given by assumed source of funding – WUA (Table 10) – GAS (Table 11). It is assumed that all O&M costs pertaining to water conveyance/distribution at *Misga* level should fall to the WUAs (water charges). These costs should be differentiated from the land preparation element and other farm input costs (production costs – Table 15) as the former costs relate to getting water to/across the *Misga* whereas the other reflect the input costs for crop production. Included separately are operator and administrative costs for both WUA and GAS that relate to their parts of the O&M responsibilities. Although these have yet to be fully discussed and determined together with the WUAs, indicative figures have been presented to guide GAS and the WUAs. In a well-run system, the ratio between administrative costs and material costs should be about 30% : 70%. This ratio has been adopted (Tables 10 & 11) and at *Misga* level, the total MOM cost per Feddan amounts to SDG 32.4.

Table 10. Estimate of Annual Water Charges for Water Users Associations

Description	Item	Amount	Rate	Annual O & M Costs					Remarks
			SDG	SDG	US$	SDG /fd	% of Total	US$ /fd	
Material Costs									
Desilting of Existing Misga Canals	m^3	212,539	1.00	212,539	106,269	1.0		0.5	Assume cultivate annually only 70% of target areas. 2 year rotation - 50% of canals cleaned in each year
Desilting of New Misga Canals	m^3	212,539	1.00	212,539	106,269	1.0		0.5	
New Inter/in Misga Bunds	fd	68,000	11.85	805,926	402,963	7.5		3.7	Carried out by GAS under payment from WUAs
Bund Maintenance @ 20%	sum	0.2	805,926	161,185	80,593	1.5		0.7	
Structure repairs - Misgas	sum/fd	1	400	400	200	0.4		0.2	
Structure repairs - Misga Head	sum/fd	1	2,000	2,000	1,000	1.8		0.9	
Mesquite Clearance by Hand	fd	75,249	10.6	797,644	398,822	7.4		3.7	Carried out by WUAs directly
Miscellaneous	10%					2.1		1.0	
		Sub-Total Materials Costs				**22.7**	**70%**	**11.3**	
Operators Costs									
Water Guiding Costs (Labour 10 No.)	P.D./fd	600	4.00	2,400	1,200	2.2		1.1	Under control of Sheik al Misga.
Operators on Main Canal	P.D./fd	180	4	720	360	0.7		0.3	2 irrigation periods; 10 labourers per Misga
Supervisors	sum	1	144	144	72	0.1		0.1	Under control of WUA
Transport Costs	Sum	1	1,000	1,000	500	0.9		0.5	
		Sub-Total Operators Costs				**3.9**	**12%**	**2.0**	
Management Costs									

[57] Annex 1/ Technical Paper. Supervision Report, April 2007. UNOPS.

All Admin and Related costs	sum	1	6,283	6,283	3,142	5.8		2.9	Under control of WUA
		Sub-Total Management Costs				**5.8**	**18%**	**2.9**	
	TOTAL MOM Costs for WUA					**32.4**		**16.2**	

Table 11. Estimate of Annual Water Charges for Gash Agricultural Scheme

Description	Item	Amount	Rate	Annual O & M Costs					Remarks
			SDG	SDG	US$	SDG /fd	% of Total	US$ /fd	
Material Costs									
Desilting of Main Canals	m^3	790,724	1.00	790,724	395,362	7.36		3.68	MTR Self Report quotes 1,300,000 m^3/annum for main and misga canals w/o extension
Structure repairs - Main Canal	sum	200	2,000	400,000	200,000	3.72		1.86	
Structure Improvements - Main Canal Offtakes	sum	7	10,000	70,000	35,000	0.65		0.33	
Silting Log replacements	sum	28	10,000	280,000	140,000	2.60		1.30	
Mesquite Clearance by hand lining canals	Sum	379	10.6	4,020	2,010	0.02		0.01	Under control of GAS Operation and Maintenance Department
Road repairs/surfacing-Priority 1	sum	1	49,751	49,751	24,876	0.23		0.12	
Road repairs/surfacing-Priority 2	sum	1	27,254	27,254	13,627	0.13		0.06	
Road repairs/surfacing-Priority 3	sum		30,264	0	0	0.00		0.00	
Miscellaneous Items	10%					1.5		0.7	
			Sub-Total Materials Costs			**16.2**	**70%**	**8.1**	
Operators Costs									
Operators on Main Canal	P.D.	8,280	4	33,120	16,560	0.31		0.15	
Other Operators & Staff	Sum	1	40,000	40,000	20,000	0.4		18.4	
Supervisors	sum	1	8,000	8,000	4,000	0.1		3.7	Under control of GAS Operation and Maintenance Department
Transport Costs	Sum	1	20,000	20,000	10,000	0.2		9.2	
Miscellaneous Items	10%					0.1		0.0	
			Sub-Total Operators Costs			**1.0**	**4%**	**0.5**	
Management Costs									
Staff Admin and related costs	sum	1	634,208	634,208	317,104	5.9		2.9	Under control of GAS
		Sub-Total Management Costs				**5.9**	**26%**	**2.9**	
	TOTAL MOM Costs for GAS					**23.1**		**11.6**	

Other costs at the moment need to be mostly borne by GAS have been compiled in a similar manner and comprise those costs incurred in conveying the water from the main offtakes on the Gash River to each *Misga* offtake (Table 11). It is recommended that these full costs are passed on to the farmers (WUA members). In addition to this, those costs currently included in the land and water charges (Table 3) should also be passed onto the WUAs and these have be included at the same rates except for the administrative costs of GAS determined in Table 11. Other costs estimated at SDG 17.2/fd can be included if average farmer yields match those anticipated at appraisal. Take up of new varieties and cropping patterns has been slower than anticipated and thus it would present too much a burden if full costs are passed onto farmers before higher improved yields are obtained. As a rule of thumb the WUA costs should not represent more than about 10% of the gross margin (Tables 13 & 15). It is therefore proposed that at the moment GOS meets the annual O&M costs for the main system above *Misga* level and that a gradual increase in charges is introduced over say 5 years that relates costs charged to a realistic increase in crop yields is developed.

Table 12. Proposals for Water Charges

Item	Description	Amount (Per Feddan)		
		(SDG)	(US$)	% of Total
Collected and managed by the WUA				
1	Water fees	32.4	16.2	46%
Collected by WUA and managed by the GAS				
2	Administration	5.9	2.9	8%
3	Contributions to Kassala State Government	2	1	3%
4	Social services	1	0.5	1%
5	Farmers' Union	2	1	3%
6	Materials Costs - Main systems	22.7	11.3	32%
7	Operators Costs - Main systems	3.9	2.0	6%
	TOTAL	69.9	34.9	

Table 13. Water Charges as % of Gross Margin

Crop	Annual Water Charges as % of Gross Margin	
	w/out Main Canal O&M Costs	with Main Canal O&M Costs
Ordinary Sorghum	26%	33%
Improved Sorghum	4%	5%

It needs to be borne in mind that these cost figures have a number of inherent assumptions that still need to be confirmed. This includes the removal of less material from the main canals and the correction of what appeared to be mistakes in determining the hydraulic slope and hence the bed slope in the main canals.

Although ideally, the cost of the investments made in rehabilitating the irrigation infrastructure should be passed on to the beneficiaries, the fact that the system has not been maintained properly for a number of years and that the water users associations have not had ownership of the systems or been involved in the earlier management, it is unreasonable to expect them to contribute to this cost. In addition, the amounts involved would be beyond the capacity of the farmer to pay particularly considering the previous paragraph where it is considered that the farmers would not be in a position at the moment to pay the full annual O&M costs of the main and *Misga* systems.

The substantial costs relating to the river training works should not be passed on to the farmers and water users associations in the Gash scheme as the start of National benefit and not only provide water to the Gash scheme and also protect the significant economic value of the city of Kassala and all the associated infrastructure, businesses and other assets including national, state and individual. If it is considered that such costs should be passed on to those benefiting, then not only should the Gash scheme be charged but all those people living and working in the State.

In determining the costs of Feddan, it is important to use the target area and not the cultivated area as this will encourage WUAs to make as much use as possible of the available water. By lengthening the *Misga* canals, it will be possible to bring more land under satisfactory irrigation in each year and therefore it is hoped that the current proportion of land cultivated annually is raised from 70% to 85%. This will of course vary from year to year depending on the size and distribution of the flood flows and it will be important to recognize that in drought years or years with limited runoff, farmers will not be able to contribute in full to the costs discussed above. In anticipation of this situation, some funds collected by WUAs in good years should be banked to meet the costs in bad flood years. From the above data, it will be necessary to develop a system of charges to WUA members that relates to the position of their plots within the *Misga* and hence the crop that can be grown and the gross margins received.

The approach presented herein differs somewhat from the proposals presented in the IFAD follow-up mission fielded in November 2006[58]. Experience has shown that it is important to separate out the costs relating to getting water onto the field and the other costs related to the inputs and farming operations. If these are combined, farmers have a tendency to use funds collected to operate and maintain the water supply system for agronomic purposes and this in turn will lead to a deterioration in the irrigation infrastructure as the farmer's concept of what is required to maintain a system in good operating and maintenance order is very different from that of a qualified engineering technician. In addition to this, much experience has been gained on charging beneficiaries for capital investments in rehabilitated systems. Whereas in theory this sounds good, it practice all have concluded that this is not feasible for situations such as Gash where farmers are at subsistence level and the systems are aimed at poverty alleviation and food security.

[58] Sudan, Gash Sustainable Livelihood Regeneration Project, Follow-Up Mission November 06, Dr. El Sayed A. A.Zaki and Eng Audrey Nepveu de Villemarceau.

Table 14. Annual Cleaning Estimates for Main Canals in Gash Agricultural Scheme

Block	Offtake /1.	Canal /1.	Length /2.	Discharge /2.	Bed Width /2.	Water Depth (d) /2.	Canal Slope /2.	No of Mesgas /3.	Assumed single season Target Area /4.	Approx. Silt depth /5.	Cleaning Volume /6.	Estimated Desilting (m^3) /6.	Cost /7.	
			(m)	(m^3/sec)	(m)	(m)	(m/km)		(fd)	(fraction of d)	(m^3/m)		(SDG)	SDG/ feddan
Kassala	Fota	Fota main canal	1,150	18	6	1.90	0.85	0	5,000	0.25	2.48	2,847	2,847	2.23
	Fota Main Canal	Fota branch canal	6,750		6	1.50	0.96	4		0.25	1.90	12,814	12,814	
	Fota Main Canal	Rabakasa Main canal	4,800	10	4	1.55	0.62	4		0.25	1.39	6,661	6,661	
Kassala	Salam Aleykum	Salam Aleykum Main Canal	3,150	20	10	1.50	0.75	0	5,000	0.25	3.02	9,524	9,524	10.93
	Salam Aleykum Main Can	Tograr Main Canal	14,500		12	1.50	0.97	19		0.25	3.59	51,996	51,996	
	Salam Aleykum Main Can	Gammam Well Canal	10,000		10	1.50	1.00	0		0.25	3.02	30,234	30,234	
	Gammam Well Canal	Amber Link Canal	2,200	16	5	1.46	0.93	0		0.25	1.57	3,451	3,451	
	Amber Link Canal	Adareif Main Canal	8,450	8	3	1.48	0.85	9		0.25	1.04	8,770	8,770	
	Amber Link Canal	Aldrip Makali Canal	5,100	8	4	1.20	0.78	0		0.25	1.04	5,279	5,279	
Makali	Dar el Mac	Dar el Mak	4,040	32	10	1.17	0.8	0	10,000	0.25	2.32	9,381	9,381	3.97
	Dar el Mac	Makali Main Canal	21,490	32	8	1.19	0.60	18		0.25	1.92	41,213	41,213	
	Makali Main Canal	Helaibet Canal	8,500	32	8	1.19	0.58	4		0.25	1.92	16,301	16,301	
	Makali Main Canal	Akla Canal	8,400	10	3	1.48	0.85	6		0.25	1.04	8,718	8,718	
	Makali Main Canal	Aras Stream	6,000		3	1.25	0.6	0		0.3	0.62	3,691	3,691	
Degain	Magauda	Degain Main Canal	32,900	38	10	2.68	0.5	44	19,500	0.25	5.70	187,476	187,476	4.81
Tendelai	Hashera Mawasir	Tendelai Main Canal	21,500	48	10	2.18	0.57	8	22,000	0.25	4.53	97,460	97,460	4.43
	Tendelai Main canal	Tendeli West Canal	22,000	48	10	1.71	0.41	16		0.25	3.48	76,568	76,568	
	Tendelai Main canal	Tendeli North Canal	8,100	14.4	8	1.32	0.50	8		0.25	2.14	17,361	17,361	
Metateib	Umbarasei	Metateib Main Canal	12,748	26	10	2.20	0.43	26	14,000	0.25	4.58	58,370	58,370	2.08
Hadaliya	Hadiliya	Hadaliya main Canal	20,200	32	6	2.18	0.64	17	16,000	0.25	2.90	58,540	58,540	2.23
	Hadiliya	Awadai Canal	3,200		6	1.50	0.60	0	16,000	0.25	1.90	6,075	6,075	
	Awadai Canal	Bahabini Canal	19,000	10	6	1.50	0.60	3		0.25	1.90	36,070	36,070	
	Awadai Canal	Eli Billi Canal	19,200	22	6	1.70	0.62	12		0.25	2.18	41,922	41,922	
		TOTAL	263,378					198	107,500			790,724	790,724	3.68

Notes:

/1. For Layout of Canals, see Figures 1 & 2
/2. Details provided by GAS & in PCU Reports
/3. For Details of Misgas, see Table 2.
/4. For Details of Misgas, see Table 1.
/5. Assume on average cleaning = 0.25d
/6. Assumes trapezoidal canal; side slopes 1: 1.5; freeboard 0.8 m; n = 50
/7. Based on average contractors price.

5.4.3 *Crop Production Costs and Gross Margins*

Farmers in Gash prefer to grow a local sorghum variety known as Aklamoe for its taste and its high forage content for feeding their animals. However it has virtually no markets beyond the Hadendawa. Under GAS, trials and demonstrations have been taking place to introduce higher yielding varieties and other cash crops that will provide more income to the farmers as well as meeting the annual O&M costs. The ability of the farmer to pay for water charges and also the returns to labour that are received are important considerations when examining the level of water charges. Although complete data on up to date gross margins still remain to be prepared, the draft data presented in Table 15 show that for the traditional sorghum, farmers will be unable, and most likely unwilling to pay for these charges at the levels suggested as they represent 33% of the gross margin per feddan. Even if only *Misga* level charges are passed onto them, they will still represent 26% of the gross margins per feddan. This has to be considered when fixing the charges and phasing in the rates to cover all O&M charges as discussed above.

For the improved sorghum, farmers will be able to meet all charges if they receive the yields indicated in Table 15 (obtained from recent supervision mission data). The sustainability of the rehabilitation of the systems thus relies upon the success achieved in persuading farmers to grow higher value crops under improved water management. Much more work is still required from PCU and GAS on this aspect with up-to-date and realistic crop budgets prepared relating annual improvements in yields to costs incurred and to be recovered.

Table 15. Crop Production Costs and Gross Margins

Ordinary Sorghum		Gross Revenue	
Gross Revenue	**Sack/ Feddan**	**SDG/ sack**	**SDG/ fd**
Average Output 6 Sack/Fed @ SDG 33 /Sack	6	50	300
Sorghum Stalks as fodder SDG 20 /Feddan	1	20	20
	Revenue/ Feddan		**320**
Cost of Production in SDD/Feddan			
Field Operations		**SDG/ Feddan**	**SDG/ Feddan**
Land Preparation		20	20
Watering		3	0
Seeds		3.5	3.5
Planting		15	13
Weeding		40	20
Harvesting		6	10
Labour			10
Packaging		12	15
Transporting to Market		3	15
Water Charges		35	44
TOTAL		**137**	**150**
Gross Margin (SDG/ Feddan)		**184**	**170**

Improved Sorghum	Gross Revenue		
Gross Revenue	**Sack/ Feddan**	**SDG/ sack**	**SDG/ fd**
Average Output 18 @ SDG 50 /Sack	18	50	900
Sorghum Stalks as fodder 20 SDG/Fe	1	300	300
Other Products			50
	Revenue/ Feddan		**1250**
Cost of Production in SDD/Feddan			
Field Operations		**SDG/ Feddan**	**SDG/ Feddan**
Land Preparation		20	20
Watering		2.5	10
Seeds		7	7
Planting		15	13
Weeding		40	40
Harvesting		26.5	10
Labour			20
Packaging		36	30
Transporting to Market		9	40
Water Charges		35	43.8
TOTAL		**191**	**234**
Gross Margin (SDG/ Feddan)		**1059**	**1,016**

5.4.4 *Access Roads within GAS*

At appraisal, it was recognised that access was a limiting factor in the GAS systems and that additional roads were needed on "*the main canal embankments, along Misga canals, along the western embankment of the river from Kassala to Wagar as well as to sites where river works will be undertaken*". In the first designs for the Tendelai Block, access roads were included along the canal banks. When tenders were received, it was considered that the costs of these roads were too high and the items were removed from the scope of works. Examination of the specifications for these roads indicates that general access roads were to be provided rather than inspection roads to assist the operation and maintenance of the GAS systems. Adaptation of the specifications to the latter requirements would have reduced the roads costs by up to 50% and would therefore have permitted some inspection roads to be included. In addition to this, the past practice of canal cleaning had resulted in the deposition of large amounts of silt in mounds along the banks of the main canals. This

has hindered the annual maintenance operation, prevented access for operation and maintenance staff along the canals and has encouraged slippage of some silt back into the canals due to animal crossing and erosion during periods of intense rainfall.

It had been intended that these silt mounds would be levelled before desilting and this would provide the basis for inspection roads along the canals. This was not translated into the specifications that were too general, did not contain typical finished cross sections and assumed that contractors would automatically know that this should be done. However, as the specifications were not clear, it was not possible for the supervision staff from MIWR to enforce these requirements.

Improved access is needed along all of the main canals. Past cleaning of these canals has not been carried out in a methodical and correct way with silt roughly deposited on the canal banks, allowing no access along the main canals. This is partly due to the unclear designs/specifications[59] and part to the control of the works by the supervising Engineers. The approach adopted in Gezira has been followed where land is a constraint and sedimentation is far less than in Gash and where berms of only one metre width have been provided. In Gash land is not a constraint along the main canals on the *Misga* side of the main canals that formally comprised agricultural land and that now form part of the uncommanded land that are regarded as *Balag* areas with widths between 10 and 30 m.

Access along all of the main canals is needed for the operation and maintenance team of GAS and for the responsible members of the WUAs. Routinely they should be able to inspect the condition of the canals and to identify areas for repair, strengthening and cleaning. During times of irrigation, it is essential that staff can travel quickly along the canals to identify how the flush irrigation is proceeding and at the same time identify possible problem areas that would need urgent rectification. This access is needed not only for the vehicles of GAS but also for the construction machinery for repair works. At times of peak flood flow in the Gash, responsible staff members from GAS need to be able to get to the river offtakes and head regulators as quickly and easily as possible to ensure that gate settings are correct and that excess flood flows are not allowed to enter the canals. Good access is an essential part of the flood mitigation and damage strategy discussed in section 5.2.4 and it is strongly recommended that improvements are made as discussed below. This coupled with the improved communications systems proposed for both GRTU and the GAS O&M Department should enable emergency interventions to be taken before severe flood damage occurs in the future.

It is proposed that the silt mounds that currently exist on all canals are levelled off and the costs have been estimated at about US$ 660,000 (Table 17). This may seem to on the high side but is reasonable when seen in the context of the total length of main canals within the Gash area (approximately 264 km). It should be noted that if this work had been done during cleaning operations, it would have added less than 10% to the cost of the average contracts. Levelling off the silt mounds will not provide improved access during the rainy season that also coincides with the first flood season. It will therefore be necessary to provide a 0.3 m layer of sand and gravel mix to the surface of the levelled canal banks to provide all weather access for the GAS vehicles only. For the figures shown in Table 17 below, it has been assumed that the surface would be provided for a width of 4 m, which is sufficient for the GAS operation and maintenance of vehicles and equipment.

As the estimated costs for the improvement of access amounts to about US$ 3.34 million, a series of priorities have been proposed and these are given in Table 16 below. Priority 1 would provide good connections between the key offtakes from the Gash River and the all-weather road that has been currently constructed from Kassala to Wagar and funded by the government.

[59] The specifications state that the silt removed should be located to form the banks "properly".

Table 16. Recommended Road Improvements

Block	Main Canal	Length (m) /1. /2.	Priority 1	2	3	Lengths (m) 1	2	3
Kassala	Fota main canal	1,150		2		0	1,150	0
	Fota branch canal	6,750		2		0	6,750	0
	Rabakasa Main canal	4,800			3	0	0	4,800
Kassala	Salam Aleykum Main Canal	3,150		2		0	3,150	0
	Tograr Main Canal	14,500	1			14,500	0	0
	Gammam Well Canal	10,000				0	0	0
	Amber Link Canal	2,200				0	0	0
	Adareif Main Canal	8,450			3	0	0	8,450
	Aldrip Makali Canal	5,100				0	0	0
Makali	Dar el Mak	4,040		2		0	4,040	0
	Makali Main Canal	21,490		2		0	21,490	0
	Helaibet Canal	8,500				0	0	0
	Akla Canal	8,400			3	0	0	8,400
	Aras Stream	6,000				0	0	0
Degein	Degein Main Canal	32,900	1			32,900	0	0
Tendelai	Tendelai Main Canal	21,500	1			21,500	0	0
	Tendelei West Canal	22,000	1			22,000	0	0
	Tendelei North Canal	8,100				0	0	0
Metateib	Metateib Main Canal	12,748	1			12,748	0	0
Hadaliya	Hadaliya main Canal	20,200		2		0	20,200	0
	Awadai Canal	3,200			3	0	0	3,200
	Bahabini Canal	19,000			3	0	0	19,000
	Eli Billi Canal	19,200			3	0	0	19,200
	TOTAL	**263,378**				**103,648**	**56,780**	**63,050**

Notes:
/1. For Layout of Canals, see Figures 1 & 2
/2. Details provided by GAS & in PCU Reports

5.4.5 *Remaining Works for GAS*

Considering the forgoing paragraphs, an estimate has been prepared (Table 17) of additional investments needed to complete the earlier investments and to ensure the longer term sustainability of the interventions. This also includes information provided by GAS on identified improvements.

Table 17. Additional Capital Costs for GAS Infrastructure

	Description	Item	Amount	Rate (SDG)	Cost (SDG)	Cost US$
1	***Misga* Development**					**2,943,857**
	Extending *Misga* Canals	m3	1,352,541	1.25	1,690,676	845,338
	New in *Misga* structures	No	396	10,000	3,960,000	1,980,000
	New Inter/in *Misga* Bunds for additional areas	fd	20000	11.85	237,037	118,518
2	**Access Roads** /1.					**3,340,181**
	Levelling of silt mounds along all main canals for access	m	263,378	5	1,316,890	658,445
	Surfacing of access roads along canals - priority 1	m	103,648	24	2,487,552	1,243,776
	Surfacing of access roads along canals - priority 2	m	56,780	24	1,362,720	681,360
	Surfacing of access roads along canals - priority 3	m	63,050	24	1,513,200	756,600
3	**New *Misga* offtakes** /2.					**868,317**
	Degein: New off-take for *Misga* zero, 8, 41, 36 (2 gates)	Sum	5	71,642	358,209	179,105
	Tendelei: Cross structure in the main canal (6 Km distance from the head regulator.	Sum	1	344,606	344,606	172,303
	Tendelei: New off-take for *Misga* 3, 5/8, 11, 13, 16, 17	Sum	6	86,152	516,910	258,455
	Metateib: New off-take for *Misga* 2, 19-1, 19-2, 19-3, 19 (2 gates)	Sum	6	86,152	516,910	258,455
				TOTAL		**7,152,355**

Notes:
/1. See Table on Recommended Road Improvements
/2. Taken from PCU MTR Report Recommendations

5.5 Institutional Support (Component 5)

5.5.1 Ministry of Irrigation and Water Resources (MIWR)

Much of the support planned at Appraisal has not yet materialised due to insufficient funds arising from cost increases and the reduced value of the US Dollar. Earthmoving machinery and equipment were provided to GRTU by both IFAD and GOS, and this unit is now well equipped to undertake the tasks assigned to it. River gauging stations have been re-established but adequate inter unit communications still remain to be supplied. Whereas GRTU has a good and well staffed structure with an active Engineering Manager who heads the MIWR team, the Engineering staff at GAS[60] lack any support (see above). This is seriously affecting annual O&M and puts in doubt the sustainability of past IFAD support for rehabilitation. Without proper planning and implementation of annual cleaning of the main canals before the flood season, a backlog of deferred maintenance will develop again. Recommendations have therefore been made to link the O&M unit with MIWR for a number of reasons:

- By bringing the design fully under the Federal MIWR, the necessary review can be carried out in-house without any additional cost to IFAD/GSLRP.
- It has been difficult to attract suitably qualified engineers to work with GAS particularly as the conditions are harsh and there is no established career structure. Adequate resource development may exist for the agricultural staff but is lacking for the engineering staff. By bringing the Engineering Department at GAS under the Federal MIWR, a sustainable career structure can be established whereby new irrigation engineers can gain experience on site and in the design office and this can be seen by them as one step in their career development.
- The recommendation is based on the institutional arrangements existing on other large irrigated areas such as New Halfa scheme where both the MOAF and MIWR are represented. The appropriateness of these institutional arrangements for adoption at GAS needs serious consideration.
- Although the GAS Act exists in draft, it is not yet been finally approved. Adjustments to the Act have been requested by IFAD in the past and have been made. These included the role of the WUAs. It is therefore possible to still make changes in the draft Act to accommodate the above recommended changes that will ensure a better and more effective organisational structure for the implementation of annual operation and maintenance of the irrigation systems.

5.5.2 Equipment Procured for the GRTU and GAS

The proposals set out at Appraisal were prepared prior to the considerable injection of funds by GOS following the flood damage of 2003. Examination of the activities to be undertaken and the considerable amount of work to be completed has shown that both GRTU and GAS need certain basic equipment to assist them with routine maintenance activities and to deal with emergencies when they arise. Although at appraisal an analysis of the amount of machinery needed was made in relation to existing equipment, this did not fully recognize the extent of the annual works needed for cleaning neither the canals nor the extent of river training and protection works envisaged and required for the Gash River. It was also formulated when GRTU was located under GAS.

The equipment procured for the GRTU and GAS seem to be appropriate although the justification for the GAS equipment was not adequately reviewed between Appraisal and implementation of GSLRP activities. GAS still has insufficient equipment to enable it to undertake routine O&M of the main canal systems and the actual status of use of this equipment is not clear. The equipment provided to GRTU by both IFAD and GOS are appropriate and comprehensive. This means that they will be able to undertake regular annual O&M of the Gash river protection works provided that sufficient funds are made available annually and in time. However, the roles of force account and contractors need to

Comment [r14]: Check status of the below recommendations based on corrective measures takn by Gvt.

Comment [r15]: To be verified as GRTU has existed independently from GAS

[60] They were previously under MIWR and are now under the Ministry of Agriculture.

be considered in the context of works to be undertaken (see section 5.2.2). GRTU equipment can be utilised for routine and emergency work and avoids the delays encountered when tendering for contractors. But with the timescales involved and the way in which funds reach GRTU, it is impossible for them to complete all required works within the financial year without the use of both force account and contractors. The current approach of dividing works into force account and others into contract provides a good balance, as contractors are able to mobilise the necessary resources to meet the very tight deadlines. Some capital works can be undertaken by GRTU on an annual basis and include activities such as raising and improvement of tie-bunds and the cutting of new river courses.

5.5.3 PCU

There has been insufficient *hands-on* engineering support within the programme that would have ensured that technical issues were dealt with in a timely manner rather than on completion of contract work. The roles and responsibilities of the Engineering position in PCU were not clearly stated and tasks that needed to be undertaken were not specified. The role that was adopted was thus of coordinator and no more than this. It is the MTR mission's opinion that the role of coordination should extend further than just receiving and delivery of information from the various parties involved. The approach that derived during implementation has meant that the quality and amount of work envisaged at appraisal, that was necessary for efficient O&M of irrigation systems by the WUAs and that would ensure longer term sustainability was not achieved. In addition to this, some cost overruns that have occurred could have perhaps been avoided through prudent interventions and adjustment of specifications and scope of work. These issues encompass all organisations involved in the management of the project[61] and need to be viewed more as an institutional failure rather than the responsibility of any one individual.

The greatest expenditure of the programme has been on engineering related aspects. Future preparation missions need to bear this in mind when considering the level of data available at preparation and also the composition of appraisal and follow up supervision missions.

6. Recommendations

6.1 River Control and Stream Regulation

6.1.1 Gash River management

1. To ensure the sustainability of the interventions already undertaken it is essential that the government of Sudan continues to fund these works to the same level and commitment and using similar mechanisms with direct funding from the Federal government.
2. The importance of the Gash River in a national context must be recognized and in this respect GRTU needs to be placed under the MIWR at Federal level to ensure adequate and regular funding allocated according to the agreed management plan.
3. A Flood mitigation strategy needs to be prepared using the current plan on GRTU up to 2012. Although no Flood Mitigation Strategy actually exists at the moment, the approach of GRTU is part of the overall process. There are two factors involved and the first of this is the protection of Kassala town with all related housing, infrastructure and factories/businesses. The second element is the protection of the areas downstream from Kassala Bridge mainly on the left bank of the Gash River, together with the provision of reliable flood flows into the six main block canals, and the maintenance of flows to the Delta Gash Die. In addition to this the possibility of flood relief sections needs to be examined.

[61] IFAD, UNOPS follow-up supervision missions, PCU and CCU.

4. GRTU needs to be supported with communications and additional flow measurement equipment to improve its flood warning capability and to be able to advise downstream users on the nature of impending floods.

6.1.2 *Flood Control*

5. The older downstream bridge at Kassala should be demolished as soon as possible rather than adopting the rather costly proposal recently received for raising the breach by 2 m. The continual increase in riverbed level would indicate that a more permanent solution is required that involves the replacement of existing bridges by a higher level perhaps steel truss bridge.
6. Access between Aroma and the offtake sites needs to be improved so that if and when emergency action is needed, staff and equipment can be moved quickly to the required locations.
7. Raising public awareness of the Gash River needs to be carried out. This should cover its behaviour, the GSLRP works and purpose and the implications of inadequate future funding for both the capital works as well as for O&M of the systems built.
8. The possibility of reducing the peak floods at Kassala Bridge needs to be examined and this would involve upstream protected sites of significant length over which flows in excess of about 900 cubic metres per second would pass. A possible suitable site exists on the right bank near Gira and the resulting overland flow could be led away to existing drainage channels.

6.1.3 *Funding of Works and O&M*

9. Government should examine the means for fully funding the proposed river training works as well as providing the estimated amounts much earlier in the financial year.
10. The current approach of combining force account with contracting out some of the works should continue to be followed.
11. GRTU needs to prepare regular estimates of annual operation and maintenance costs that relate to the output of the machinery currently engaged in and enable the federal ministry of finance to be able to allocate adequate annual budget for this purpose.
12. When GRTU prepare their annual O&M budgets, allowances should be made for works to be completed at the end of the financial year after the flood period (e.g. October to December).
13. Government should consider raising funds locally from the Kassala city as most of the economical benefits will derive from the protection provided to the city and associated infrastructure and businesses.

6.2 Rehabilitation of GAS Infrastructure

6.2.1 *Main Canals and Structures*

1. MIWR should revisit the designs used for the rehabilitation of the Gash irrigation systems. This should examine traditional levels and slopes in relation to adopted designs and provide a design report that clearly specifies the approach adopted and the results for each canal. The basis for estimation of siltation in each canal needs to be clearly set out. Hydraulic slopes and command at *Misga* level need also to be checked.
2. The current condition and requirements for improvements for all structures in the GAS systems needs to be reviewed considering (i) the results of 1./ above, (ii) the apparent substandard condition of a number of rehabilitated structures and (iii) the need to repair more structures.
3. On completion of 1./ above, it will be necessary to confirm whether more material is being excavated from the canal than is actually necessary and whether the over excavation is reducing the flow velocity in the canals and encouraging further siltation.
4. The calibration of the staff gauges located on the Gash River at each offtake and used by the gate operators to judge the stop log settings need to be re-examined considering the changes made to the intake structures. Stage discharge curves need to be established for each structure and gate operators trained in the use of the new settings in relation to flood utilisation and exclusion.
5. A design manual for the Gash river Flush irrigation and for the design of Spate irrigation in Sudan using the experiences from Gash needs to be prepared.

12.2 *Roads and Cross Structures.*

6. Access within the block areas along the main canals needs to be improved as a matter of high priority. This relates especially during the irrigation season when rapid access to the intakes or damaged areas is needed, but also during the maintenance period.
7. Silt mounds along the main canals should be levelled by bulldozer to facilitate improved access and annual maintenance.

12.3 *Operation and Maintenance*

8. The roles and responsibilities of the all Departments within the GAS organisation need to be reviewed and improved to ensure improved cooperation and responsive management. Links, roles and responsibilities between all players need to be established.
9. A capacity building programme needs to be established to overcome deficiencies within GAS.
10. Training, technical support and suitable career development opportunities should be established for all staff especially the engineering staff connected with MOM.
11. A Water User Association Unit should be established in GAS to facilitate the training and development of WUAs, particularly as the main complaint from farmers has been the inappropriateness of the training and the need to be more responsive to the WUA needs.
12. A clear plan for future O&M needs to be prepared. Historical records of amounts taken out from each canal should used to develop clear annual programmes for the removal of sediment from the canals. This should be related to machinery availability and output to estimate the equipment required, the annual sustainable O&M costs and the requirements contractor support.
13. A transparent and sensible GAS programme for use of machinery must be prepared and regularly updated to regularly reflect equipment availability, use and needs. The utilisation of this equipment for routine and emergency works and annual operation and maintenance needs to be shown so that the balance between force account and contract is made clearer.
14. The O&M Department in GAS should be institutionally linked with MIWR.
15. The main canal and branch canals as well as river offtakes should be included under the technical mandate of the MIWR staff at GAS.
16. When the next cleaning is carried out on each main canal all material should be placed at least 6 m from the edge of the canal and silt mounds levelled to ensure that flat berms derive. Cleaning of canals by placing of the machine within the canal bed should be avoided with preference given to contractors having excavators with long reach arms.
17. The O&M Department at GAS should be equipped with shortwave radios to allow them to communicate easily with the head regulator operators and GRTU.
18. As with GRTU, regular and early flow of funds are needed each year to enable timely annual main canal and *Misga* canal cleaning as well as the development of the *Misga* areas.
19. Future tenders and contract documents should provide clear cross sections for canals and much more detailed specifications.
20. The amounts of silt and sand that have been removed under the contracts paid for by IFAD loan need to be compared with typical annual amounts that have been removed from the canal systems since then to get an overview of what has taken place.
21. The proposals set out in this working paper for Water Charges should be examined and developed to form the basis for future sustainable funding of the systems. This needs to be linked with the training of the WUA members.
22. The ratio between management costs and actual works in the water user charges should be examined to establish realistic levels and targets for collection and use of funds raised.
23. More technical support in both design and supervision is needed from MIWR to support the irrigation staff located at scheme level.

Comment [r16]: Contractor survey needed.

6.3 Component 5: Institutional Support

6.3.1 *Water Users' Associations*

1. The programme for WUA training should be more practically oriented and include the training of trainers and the encouragement of lead farmers. More targeting is needed for the intended training of WUAs.
2. Literate individuals should be identified for the purpose of developing their capacities for book keeping and WUA administration.
3. The transition period from GAS operated to Water Users Association operated needs to be defined together with the possible end scenario with roles and responsibilities established for the initial, transition, and final processes. This will need to be supported by targeted training.
4. A training programme is needed for *Faraqis* (*Misga* water management delegates) in collaboration with the skilled temporary workers (two by *Misga* structure) of GAS agriculture department to (i) increase communication of *Misga* level water demand and (ii) develop their understanding of *Misga* water dynamics and management.
5. The Farmers Field School approach that has been initiated should be further developed to spread the know how on optimum application water levels to meet the water demand of a given crop and depending upon location within the *Misga*.
6. A training needs assessment study is required to elaborate a capacity building programme for both WUAs and GAS to ensure better targeted and appropriate training modules.
7. Direct communication between the block irrigation engineer and farmers is recommended on a weekly base, together with indirect communication through chainman and water master, especially during the irrigation season. This level of communication would allow for better mutual understanding, quicker decision making in case of emergency works, and would hopefully decrease farmers' direct interference in block canal/offtake management.
8. A large number of casual labourers are employed by GAS to support the irrigation process. The roles and costs of these staff should be examined to determine whether the draft costs in this WP are realistic and reflect the full costs to be passed onto WUAs.

6.3.2 *On Farm Development/Misga Water Management*

9. The land levelling and laser equipment provided to the Gash scheme seems to be incompatible with the previous research findings on land and water management in the Gash area and with the approach currently adopted by GAS for improvement of *Misga* water distribution[62]. It is therefore recommended that if there are no clear plans to utilise this equipment by GAS, attempts are made to determine whether the New Halfa or similar schemes could utilise this equipment in exchange for further much-needed additional bulldozers for land levelling and silt mound levelling activities.
10. All *Misga* canals should be lengthened to permit water delivery direct to the sub block within each *Misga* and to facilitate the proposed cultivation of Dura and other crops within each *Misga* during the second rotation. This will facilitate improved water management and reduced losses inherent in the old system that was designed for cotton production. Any improvements should also include the provision of appropriate check/division structures.
11. The experiences gained and approach to *Misga* level improvements need to be properly documented with training material produced for improving the understanding of the approach and for upscaling of the activities.
12. A clear programme needs to be developed showing current *Misga* level activities, where they are being undertaken, where capital works for *Misga* improvement are being carried out, where maintenance of *Misga* bunds is being undertaken, where *Misga* canals need to be extended or where problems exist.

[62] In addition to the land planes and tractors, suitable survey equipment that can transfer level data into information for the laser systems, training and additional surveyors levelling work will be slow and inefficient, and will be costly. Such land plane equipment as provided requires prior crude levelling by dozer or scarper and chisel ploughing before it can be used effectively and efficiently in these soils.

13. As with the main and branch canals, a clear programme for annual silt removal from the *Misga* canals by block needs to be prepared and related to machinery output to identify the possibility of utilising some of the GAS equipment for this purpose, for identifying contractor needs and for clearly estimating sustainable annual operation and maintenance costs.

6.3.3 *Ministry of Irrigation and Water Resources (MIWR)*

14. Spate design manuals and O&M manuals need to be developed over the next four years so that experiences gained from the rehabilitation of irrigation systems and handing over of part of them to WUA management are clearly recorded and can be utilised both to train younger engineers as well as enabling the lesson learnt to be utilised in other spate irrigation systems.
15. Training and technical support should be made available to staff working on GAS to facilitate proper planning for annual O&M activities and the production of suitable designs from the repair of damaged structures. This should form part of capacity building and career development for engineers and assist in the fulfilment of their professional qualifications.
16. Problems of resourcing the engineering support for GAS exist and will not be adequately addressed unless formal links are established with the Federal Ministry of Irrigation and Water Resources:
    - The O&M engineering staff at GAS should be made technically responsible to and be supported by the Federal MIWR.
    - MIWR needs to place an experienced design Engineer and an additional supervision Engineer at State Level to work with the existing Senior Construction Supervisor to support the field activities in GAS and the Gash Delta.
    - Responsibilities for the main and branch canals should be assigned to MIWR with the GAS administration (agricultural engineering; agricultural support activities; etc) taking over responsibility from the *Misga* turnout/off take.
    - Water Users Association should ultimately be given responsibility from *Misga* turnout/offtake with the costs of canal cleaning and other activities being borne by both GAS and WUAs utilising collected water fees.

6.3.4 *Equipment Procured for the GRTU and GAS*

17. Proposals for improving the existing workshop facilities at GAS need to be examined to determine whether the planned mobile workshops will be sufficient (Mobile workshops are being procured for both GRTU and GAS and this needs to be coupled with existing facilities and equipment maintenance facilities).
18. Training for storekeepers should be organised in relation to the provision and cataloguing of Spare Parts.
19. The shortage of trained Mechanics needs to be addressed by in-service training and the provision of essential smaller equipment.

6.4 Rangelands Management

1. Simpler TORs for resistivity and groundwater surveys should be prepared for examination of the GAS area to identify potential alternative groundwater sources. The work should be undertaken by a local experienced consulting company with a proven track record in such surveys and who are familiar with the Gash area and geology. The work should comprise three stages. It should start with a brief literature survey and examination of satellite imagery to identify possible water bearing strata. This should be followed by overall resistivity surveys covering the GAS and surrounds area from the West to the East. Once areas of potential have been identified, more detailed resistivity surveys should be undertaken. Recommendations should then be prepared on areas with potential that could be examined using test drilling.
2. Capable local consultants should be invited to tender for the work that is estimated to take 3 months to complete. This should be carried out as a matter of urgency.

3. The needs for these other water sources should be focused on meeting rural water demands for humans and livestock that will not be supplied by the current programme of piped rural water supply from Kassala and Gammam.
4. The main migratory routes for livestock and the locations of the more isolated villages within and across the GAS area should be mapped and the data from the new census used to define demands. This should be done in association with the updating of the Water Demand Study. The data collected should establish the times that these routes are utilised and the number of types of livestock using them. This will enable a plan for development of alternative sites for water points to be established to reduce the degradation of rangelands.
5. Procedures should be established for community maintenance of all water points and examine alternatives for cross financing for maintaining the water points in trans-migratory areas.
6. Links should be made with the National Water Corporation to utilise the findings of the planned water sources survey in Kassala and also to take advantage of the drilling rigs that they use in the joint programme with UNICEF.
7. The current water demand study excludes significant numbers of livestock. The 2007 study by EDS needs to be updated to cover all possible sources of water under consideration by the Kassala Drinking Water Corporation as well as full demands relating to livestock in the area and the locations of this demand.
8. The potential for the development of additional sources of water for livestock in the rural areas to meet the needs of both resident populations as well as seasonal migrants should be established utilising the outputs of the resistivity surveys.

6.5 Mesquite Control

1. A clear and scheduled mesquite control programme related to the land development works needs to be drawn up so that it is clear which *Misgas* have received support and have been cleared, those that need maintaining, those still to be included and those that have parts of the *Misgas* with severe mesquite infestation
2. For fields with severe infestation, the introduction of possible inducements for the WUAs should be examined to cover the extra works and to encourage clearance of these difficult areas.
3. Detailed methodologies of the approaches and findings need to be prepared so that suitable methods can be easily applied elsewhere both within and outside GAS.

6.6 Community Development, Capacity Building and Empowerment

6.6.1 Domestic Water Supply

1. IFAD/PCU together with GSLRP local legal adviser should review the documents prepared by EDS and consider whether it would be beneficial to terminate the contract with Bakawi.
2. The consultants should prepare an updated programme for all works to be completed in connection with the water supply component. This programme needs to include the inputs of the Kassala Domestic Water Corporation (KDWC), who are responsible for ensuring the timely agreements for crossing of two roads, one railway line, one remaining farmer's land, and the electricity supply connections by the Kassala electricity supply company[63].
3. More attention must be given to the contract supervision and management by the consultants with clear and unambiguous records maintained of variation orders and cost implications.
4. The reasons and details of any subcontracting arrangements connected with the water supply component need to be examined by the procurement specialists from IFAD/PCU to determine whether this is in line with IFAD procurement rules.

[63] Although verbal assurances were received during the MTR from Hashim Mohammed, Projects & Construction Department Manager, KDWC, it is essential that these are received in writing together with firm dates by which the necessary permissions will be obtained.

5. Once the stepped pumping tests have been completed and the safe well discharge determined, the ability of the wells to meet the predicted demand needs to be reviewed[64].
6. The PCU needs to prepare an Addenda to the contract of EDS specifying in detail the tasks that they have been ask to complete, the costs of each aspect and details on the amounts remaining or the estimated additional costs that will be needed (particularly as the construction supervision will exceeded the provisional time estimates).
7. Funds need to be secured for the new pipeline and facilities from Gammam to Wagar.
8. The contract documents for the Gammam to Wagar pipeline have already been prepared and the contract awarded to Bakawi Investment & Petroleum Services Company. This company has performed badly under Part I Contract for the Kassala to Aroma pipeline rehabilitation and does not have the experience stated in the tender documents. Serious consideration must be given to retendering of this contract.

6.6.2 *PCU*

9. The role of the PCU and the supervision missions in overseeing the quality and completeness of the engineering aspects of the GSLRP needs serious review. Many of the aspects that have been commented upon in this MTR have resulted from insufficient hands on approach by PCU Engineering and procurement staff. It is not sufficient to just "coordinate".
10. Proposals related to engineering aspects must be examined by the PCU for consistency with the proposals contained in the Appraisal document or agreed during implementation. Many decisions seem to have been taken without properly evaluating the proposals or the consequences. This will be elaborated on further in the working paper.
11. Procurement monitoring of on-going contracts is weak and not proactive enough. The procurement section of PCU relies on contract data from the on-going procurement organisations and this does not reflect possible/potential cost over runs or the impacts of delays in procurement on-going activities such as the late arrival of equipment and/or spare parts. This needs to be addressed.

[64] The resistivity surveys carried out by EDS identified VES 43 and VES 46 as the best locations for two new wells. Unfortunately these wells were located within private agricultural areas and the owners were unwilling to permit the drilling take place on their land. Alternative sites were found nearby, but as the sources of water are site specific, the yield may not be the same as predicted.

Figure 6. Schematic Layout of Main Canals and *Misgas* in Gash Scheme

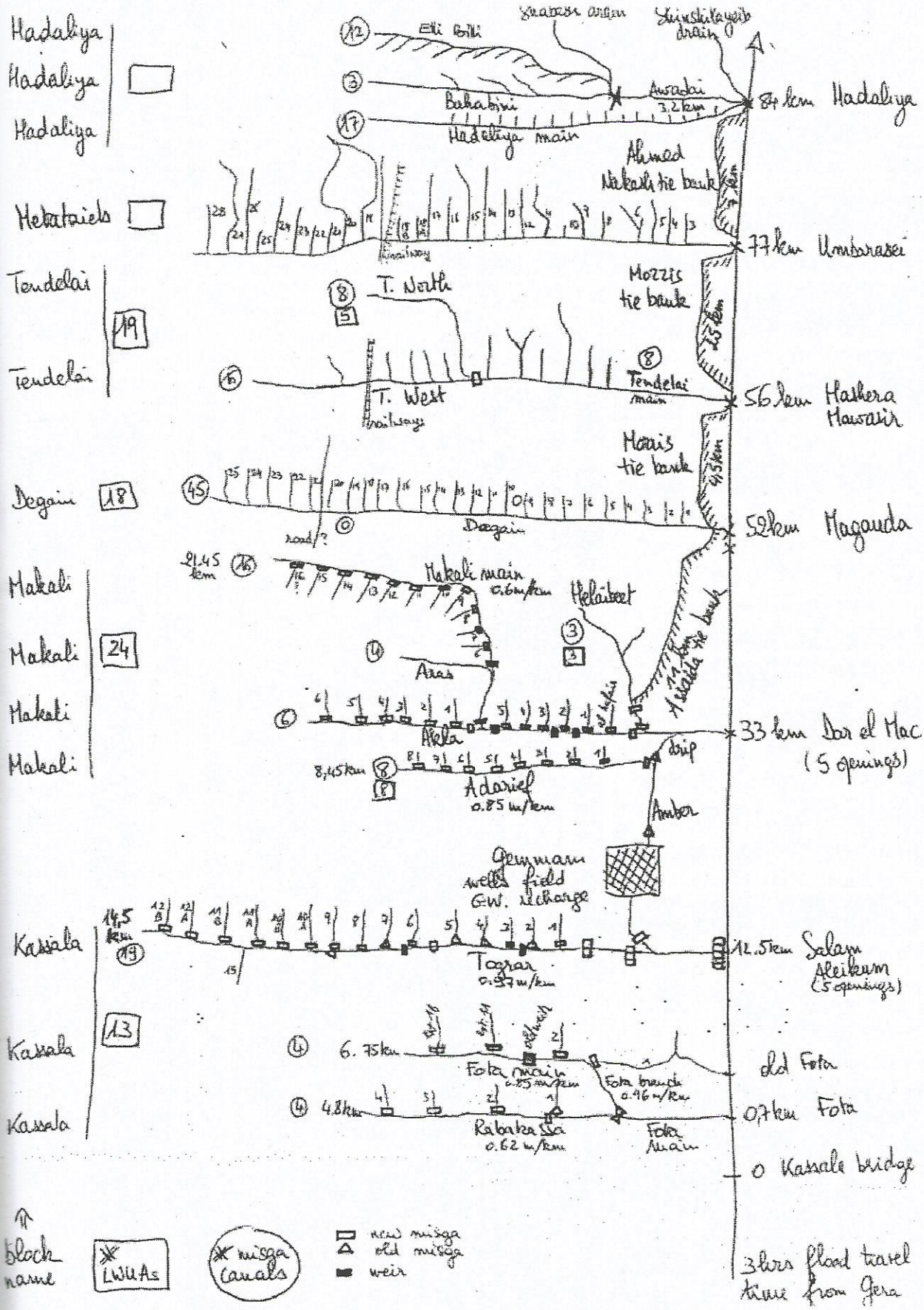


Figure 7. Schematic Layout of *Misgas* in Gash Scheme

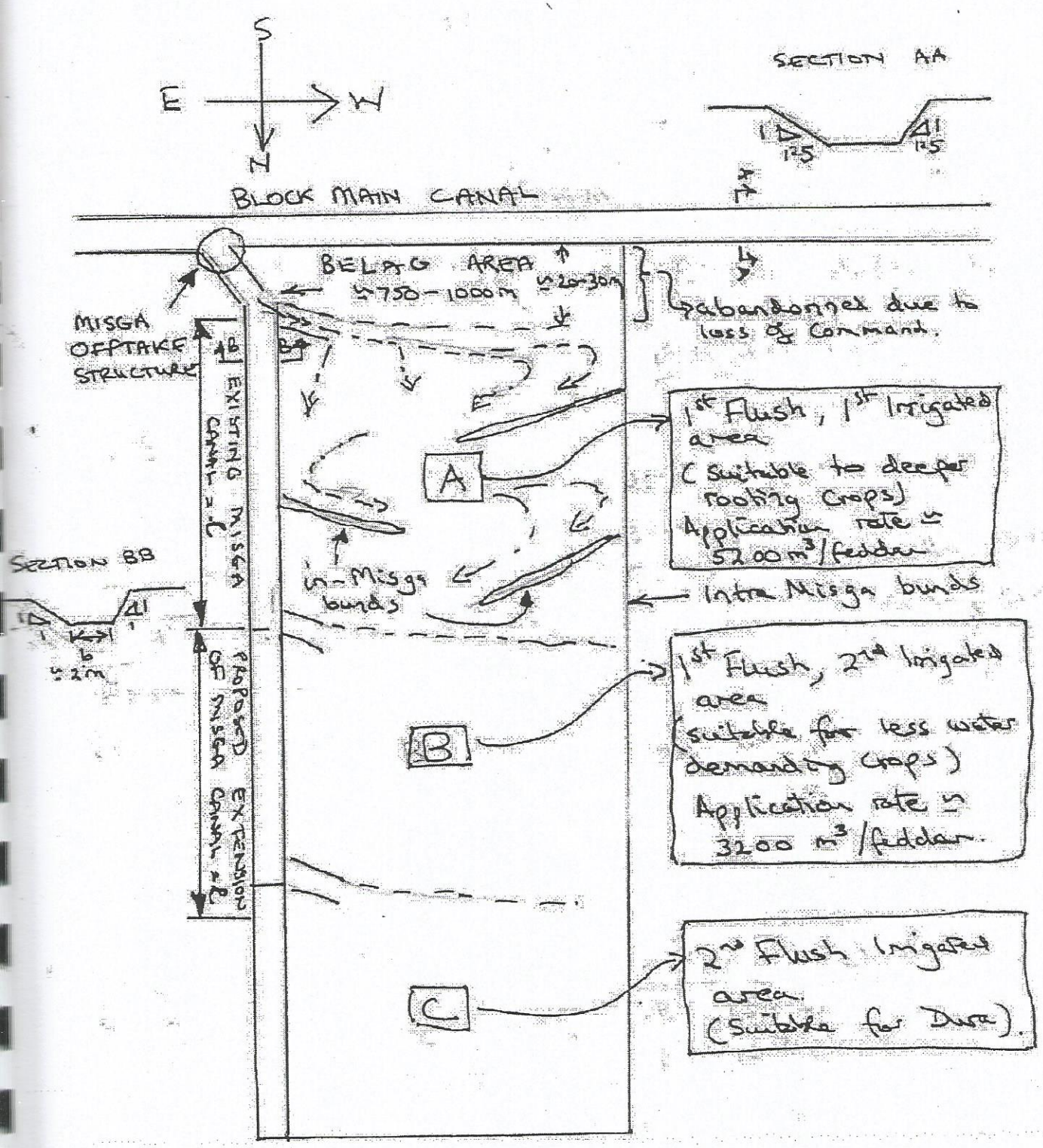
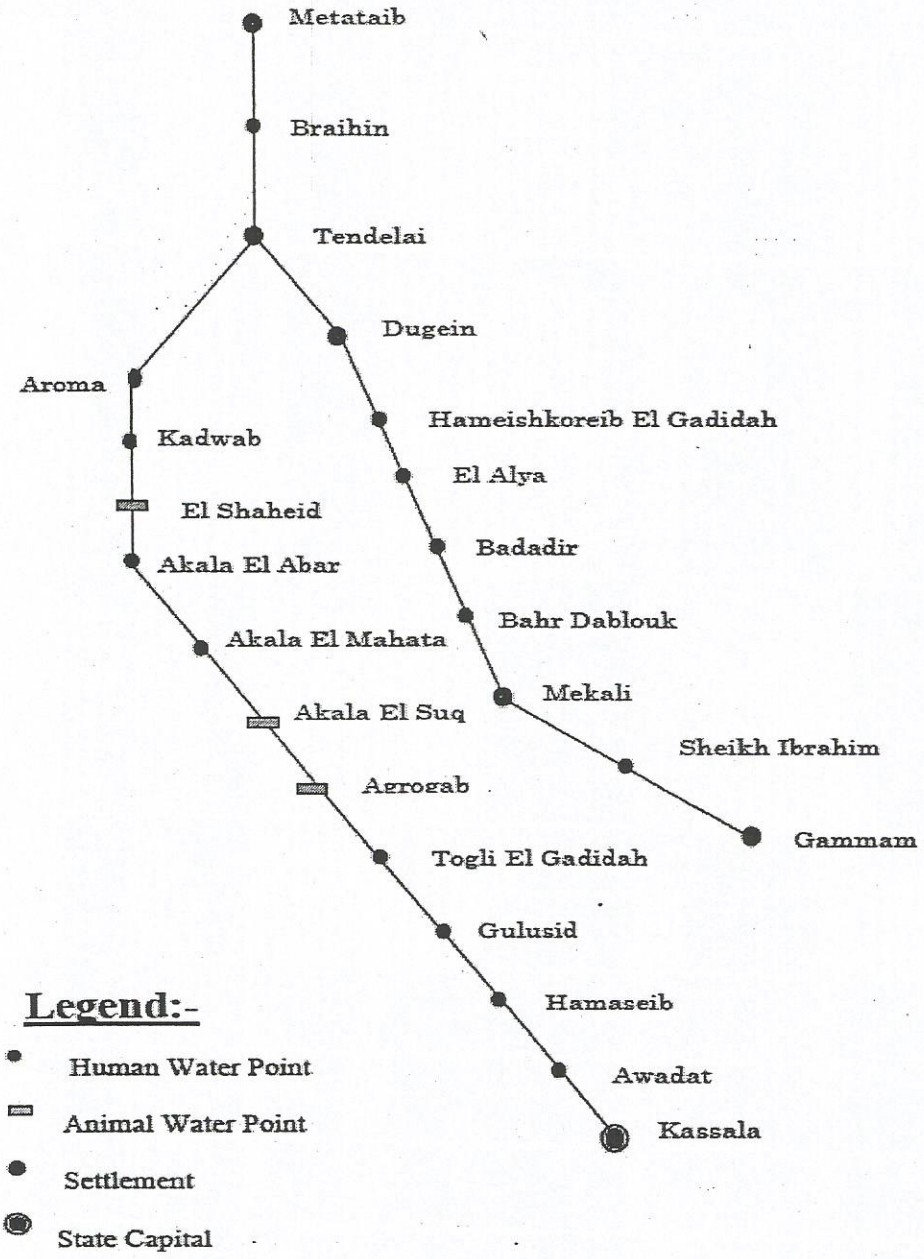


Figure 8. Location of pipelines and Water Points to be supplied



Appendix A.

Table A.1. Details of GRTU Costs for 2004 to 2007

Item	Description	Proposed works	Period	Cost (BDG)	Cost (US$)	% Achieved	Out put	Impact	Inadequacy	Interpretation
1	Realignment of the river channel at Algera to prevent the tendency of the river to go westward	Construction of 600 m length of masonry dry pitching + 20000 m3 earth embankment to construct a masonry and earth dam and excavating 250000 m3 to dig a diversion canal 715 m length,120 m width and 3 m average depth	Mar-04	3,462,000	1,731,000	100	The river channel was realigned in the new track	The tendency of the river to go westward and /or to leave its original course was entirely stopped so the river channel conveyed the whole flow to reach Kassala reach and the agricultural scheme.	The river flow remains threatening the area down stream the earth dam by erosion . This was resolved by constructing 2 stone groins to orient the flow and preventing the area.	this happened due to the meandering phenomena that often occurs in the alluvial canals
2	Construction, reconstruction and rehabilitation of the spurs in Kassala protection system	construction of 3.750 kilometer length of masonry pitching and 183184 m3 of a selected transferred and processed earth embankment	March 2004 to June 2007	12,030,771	1,731,000	94	A number of 31 spurs was rehabilitated and 3 spurs was newly constructed	Kassala protection system is nearly to be completed as what the HTC recommended and the river flow in Kassala reach is almost soothed its track in the proposed centerline	Partial damage to some rehabilitated spur heads was experienced during the last 4 flood season. To resolve this a study was performed to assess the scour depth and to replace the conventional building materials with the gabion construction to accommodate largely differential settlement under structures	In such shallow alluvial rivers the scour depth is the main problem for foundations. The old system since 1930 constructed from brittle materials which do not allow differential settlement.
3	Construction of the masonry stone pitching of the external protection earth banks of Kassala city . The aim is to protect the earth embankment from the erosion.	construction of 21.75 kilometer length of the masonry pitching	March 2004 to June 2007	4,382,685	6,015,386	21	4,650 Kilometer length was achieved. Because of the insufficient fund for this program then the priority is given the most critical positions that subjected to direct	The banks that constructed in masonry pitching was strengthen enough and they was capable to resist the erosion caused by the river flow during the last 4 floods. Securing the city. Conveying the full discharge to the agricultural scheme.	The system is properly functioning but it needs to be completed.	.....
4	Reconstruction, strengthen and heightening of the external protection earth embankment of Kassala city.	Redesign and reconstruction of Kassala earth embankments to satisfy 1.5 m free board from the maximum recorded level (507.00) at Kassala bridge. 682.562 m3 of a selected, transported and fully processed soil and 19.544 m3 of gravel soil to resist erosion due to rainfall and facilitate movement during the rainy season, was achieved	March 2004 to April 2007	6,582,954	2,191,343	99.3	21.75 Kilometer length of the earth embankments covering the eastern and western banks of the river through Kassala city	The banks that constructed was sufficiently functioning to protect the city and the neighboring areas from overtopping of the high stages flow occurred during the last 4 floods. Securing the city. Conveying the full discharge to the agricultural scheme.	A. In the year 2007 flood the upstream east bank was partially beached below the formation level caused partial damage to the houses neighboring the bank this was resolved by changing the soil configuration and the grain gradient of the clay expansive cracked soil just beside the bank. also a plastic fiber reinforced membrane was planned to placed under the formation level beside the banks. B. During the passage of the highest wave 2007 (507.40) at Kassala bridge the free board was seemed to be submerged at some locations this was because of the flow energy conversion. This is resolved by enhancing the component of the energy conversion in the banks design and heightening the upstream system by 1 m height.	A. The original soil of the vicinity around the banks is classified as expansive cracked soil . That prone to extended cracks occurrence at draught. This may enable the passage of the flow in the lower layers of the soil causing partial breaching of the banks. B. From the principle of the open channel flow; At the abrupt contraction the flow converts some of the kinetic energy in the form of levels rising (in Kassala reach case it was measured and calculated ranged (0.68 - 0.84)m
5	River Bed Excavation - Kassala Reach	A continuous program targeting to resolve the problem caused by the Kassala bridge which form a bottle neck and cause an obstruction during the passage of the high flows , also rising the efficiency of the entire system in lowering the river bed in Kassala reach. This achieved by annually scheduled excavations of the river bed downstream Kassala bridge	March 2004 to June 2007	1,501,860	3,291,477	62	A total of 383000 m3 of silt was removed in Kassala reach.	A chart was developed showing river bed levels in Kassala reach after floods of years 2003, 2004,2005 and 2006. The chart shows that the river bed level has dropped down in 2004,2006 and no remarkable changes in 2005. Although the data is still limited for firm judgment, there is indication that continuation of river bed excavation will decrease silt deposition in Kassala reach and helps in lowering the river bed.	Limited time for execution due to the late and insufficient financing leads to incomplete work often.	.....
6	Rehabilitation of Kassala block offtakes	Construction of Fota weir to improve the efficiency of the offtake . By satisfying the full supply level in the canal	April 2006 to June 2007	929,000	750,930	100	A 86 m width weir was constructed, but it was not yet functioning because the river breaches the eastern bank u/s the weir , expanding the with of the canal and divert a	NO IMPACT GAINED FOR THE LAST SEASON	The river width in the offtake section needs to be widening after taking an ample time to measure, monitor, and study the river behavior and morphology in the vicinity around.	The lack of the accurate data makes it difficult to asses the appropriate width of the canal in the offtake section However a study to re-assess the weir coefficient after the morphological changes is going on. Some manipulation works should take place this year
7	Rehabilitation of Dar almak block offtake	Construction of Dar almak weir and one spur and masonry pitching to improve the efficiency of the offtake. By satisfying the full supply level in the canal.	April 2007 and not yet completed	3,277,730	464,500	40	The construction of the western masonry pitching and 600 m length spur in the eastern bank was	Reasonable increase in the efficiency of the offtake operation.	Due to incomplete work the flow attacked the eastern spur causing partial damage.	Late and insufficient financing.
8	Rehabilitation of alsayda bank to prevent the tendency of the river to go westward and getting the rid of the frequent overtopping and breaching of the bank that causing entire isolation of the offtakes downstream	Redesign and reconstruction of ALsayda earth embankments to satisfy 1.5 m free board from the maximum remarked level . 365000 m3 of a selected, transported and fully processed soil planed to be achieved	February 2008 and still the program is carried over.	1,994,900	1,638,865	45	11 Kilometer length of the earth embankments covering the western banks of the river through Makaly and digin blocks.	The banks that will be constructed will protect the neighboring areas from overtopping of the high stages flow .Conveying the full discharge to the agricultural scheme blocks downstream.	.....	.....

Table A.1. (Continued) Details of GRTU Costs for 2004 to 2007

Description	Proposed works	Period	Cost (SDG)	Cost (US$)	% Achieved	Out put	Impact	Inadequacy	Interpretation
Rehabilitation of Digin block offtake	Excavating of 1000 m length and 10 m width, with a total of 36500 m3 to dig'a diversion canal in order to orient the river flow towards the offtake.	June 2004 to July 2004	148,000	997,450	100	1000 m length diversion canal was excavated	The diversion canal excavated was adequately functioning to orient the river flow towards the offtake and is now changing its main course through the canal. Providing highly impact in improving the efficiency of the offtake and increasing the total discharge.	The masonry pitching rehabilitation is later needed to strengthen the banks u/s the offtake	.....
Rehabilitation of Morris bank and the earth spurs to prevent the tendency of the river to go westward and getting the rid of the frequent overtopping and breaching of the bank that causing entire isolation of the offtakes downstream and threatening the neighboring cities and villages and the national road.	Redesign and reconstruction of Morris earth embankments to satisfy satisfactory free board from the maximum remarked level .50000 m3 of a selected, transported and fully processed soil planed to be achieved	Not yet Executed	8,000,000	74,000	0	Transferred to 2009	.....	.....	.....
Rehabilitation of Tenddly block offtake	The offtake structure is rehabilitated	2005	4,000	4,000,000	100	The offtake structure is rehabilitated	The rehabilitation works was adequately functioning . Providing highly impact in improving the efficiency of the offtake and increasing the total discharge.	.....	.....
River training works in Matateib - Hadalya Reach (earth work) to Irrigate Matateib and Hadalya blocks that entirely isolated though over the last decade. And protecting the neighboring cities and villages and the national road.	Excavating a canal of 7.15 Kilometer length and 50 m width and 3 m average depth as a river channel , with a total of 830000 m3 . And excavating 3 canals with total length 12.5 Kilometer and 10 m width and 3 m average depth as main canals and drainage system , with a total of 192000 m3. and 474000 m3 of selected transported and processed earth embankments.	May 2005 to June 2007	12,500,000	2,000	100	7.15Klm river channel and 12.5 klm of Irrigation canals and drainages. And 7 klm of protection earth embankments was achieved	The system executed was adequately functioning towards its objectives conveying the river flow to the two blocks. Reasonably functioning irrigation system . Increasing the cultivated area. Securing the neighboring cities and villages and the national road.	Some locations in the canals and earth embankments are slightly subjected to erosion. An executed program was planed to resolve the problems encountered in the year 2007 and it is now going on.	Such alluvial processes are often anticipated in similar alluvial canals, also the fragile soil forming the bed and the banks of the river in the further downstream reaches is not capable to resist the boundary shear stress of the river flow.
River training works in Matateib - Hadalya Reach (Masonry work) to Irrigate Matateib and Hadalya blocks that entirely isolated though over the last decade.	Rehablitation and heightening Matatieb offtake, construction of 300 retaining wall downsream matatieb offtake, constructuion of the eastern masonry pitching, construction of New hadalya offtake and the construction of the control and intermediate structures in Awadai, Bahabini, Elibily.	Contracted 2005 started in 2006 the work is not yet completed.	3,035,456	6,250,000	80	The system of the structures is nearly to be completed	The system executed was reasonably functioning towards its objectives, guiding the current flow, protecting the banks of the river, controlling the in flow to the irrigation canals and conveying the river flow to the two blocks. Reasonably functioning irrigation system . Increasing the cultivated area.	due to the incomplete work Hadalya offtake was subjected to differential settlement, so it should be rehabilitated . Now an expert team in such type of works from the MOIWR is carrying over the rehabilitation works in Hadalya offtake.	Late and insufficient financing.
			57,849,356	29,137,950					

Table A.2. Details of *Misga* Canals for Gash Agricultural Scheme

Detail		Canal	No of Misga	Name of Misga Canal	Length (m)	Extra and Desilting (m3)	Excavation/ Fill for Misga canal subst. (m3)
[illegible]	A - Kassala	Rabakasa Misga canals	1	Rabakasa 1	800		
[illegible]	Fota		2	Rabakasa 2	450		
[illegible] Canal	Rabakasa Main Canal		3	Rabakasa 3	300		
			4	Rabakasa 4	1,200		
		Total	4		2,750	1,547	9,844
[illegible] Canal	Fota Main Canal	Fota Branch Misga canals	1	1	4,500		
			2	2	800		
			3	Extension 1 A	550		
			4	Extension 1 B	450		
		Total	4		6,300	3,544	22,551
[illegible]	B - Kassala	Tegrar Misga Canals	1	1	1,000		
[illegible]	Salam Aleykum		2	2	1,200		
[illegible] Canal	Tegrar Main Canal		3	3	600		
			4	4	600		
			5	5	1,200		
			6	6	600		
			7	7	1,200		
			8	8	900		
			9	9	600		
			10	10A	1,200		
			11	11B	400		
			12	11A	300		
			13	11B	450		
			14	12A	550		
			15	12B	400		
			16	13A	700		
			17	13B	400		
			18	14 E	900		
			19	14 M	1,200		
		Total	19		14,450	8,100	51,544
[illegible] Canal	Adarsif Main Canal	Adarisf Misga canals	1	1	500		
			2	2	700		
			3	3	1,200		
			4	4A	700		
			5	4 B	1,500		
			6	5	2,500		
			7	6	900		
			8	7	1,000		
			9	8	1,200		
		Total	9		10,200	5,738	36,512
[illegible]	C - Makali	Makali Misga Canals	1	Makali Basins (Al Hafir	600		
[illegible]	Der al Mac		2	1	9,000		
[illegible] Canal	Makali Main Canal		3	2	2,000		
			4	3	1,000		
			5	4	2,000		
			6	5	2,200		
			7	6	8,000		
			8	7	4,200		
			9	8	2,200		
			10	9	2,000		
			11	10	800		
			12	11	4,500		
			13	12	3,000		
			14	13	2,500		
			15	14 W	3,000		
			16	14 E	2,500		
			17	15	3,000		
			18	16	400		
		Total	18		52,900	29,756	189,361
[illegible] Canal	Akla Canal	Akla Misga Canals	1	Area 1 A	800		
			2	Area 1 B	1,200		
			3	Area 3	1,800		
			4	HADAI 1	800		
			5	HADAI 2	1,200		
			6	HADAI 3	5,000		
		Total	6		10,800	6,075	38,640
[illegible] Canal	Halaibat Canal	Halaibat Misga Canals	1	Halaibaat E	1,200		
			2	Halaibaat W	800		
			3	Algaba mat.	800		
			4	Halaibaat W ext.	11,000		
		Total	4	Total	13,800	7,763	49,398

Table A.2. (Continued) Details of *Misga* Canals for Gash Agricultural Scheme

Details		Canal	No of Misga	Name of Misga Canal	Length (m)	Estimated Desilting (m3)	Excavation/ Fill for Misga canal const. (m3)
Block	D : Degsin	Degsin Misga Canals	1	misg (W)	900		
Offtake	Maganda		2	misg (M)	300		
Supplying Canal	Degsin Main Canal		3	misg (E)	2,000		
			4	1	1,700		
			5	3	5,200		
			6	4	300		
			7	5	300		
			8	6	1,000		
			9	8	3,000		
			10	9	900		
			11	10	2,200		
			12	11	2,200		
			13	13(E)	3,000		
			14	13(W)	4,000		
			15	14	300		
			16	15	3,400		
			17	16	3,000		
			18	17	2,200		
			19	18	2,200		
			20	19(E)	4,000		
			21	19(W)	3,000		
			22	20	3,000		
			23	21	1,000		
			24	22	4,000		
			25	23	4,200		
			26	24	1,600		
			27	25	2,200		
			28	26	300		
			29	27	1,600		
			30	28	300		
			31	29	1,000		
			32	30	300		
			33	31	300		
			34	32	1,000		
			35	33	2,600		
			36	34	1,100		
			37	36 (E)	1,000		
			38	36(W)	200		
			39	37	6,000		
			40	38	400		
			41	39	2,000		
			42	40	4,000		
			43	41	300		
			44	42	500		
		Total	44	Total	84,000	47,250	300,686
Block	E - Tendelai	Tendelai Main Canal Misga Canals	1	1 Adeam	800		
Offtake	Hashora Mawatir		2	1 Meeis	800		
Supplying Canal	Tendelai Main canal		3	1 W	7,000		
			4	2	1,500		
			5	3	2,000		
			6	4 E	800		
			7	4W	800		
			8	4 M	1,200		
		Total	8		14,500	8,156	51,904
Supplying Canal	Tendeli West Canal	Tendeli West Canal Misga Canals	1	5	800		
			2	9 E	1,000		
			3	9 M	1,000		
			4	9 W	2,500		
			5	10A	1,300		
			6	10B E	1,100		
			7	10B W	600		
			8	10 C	800		
			9	11	1,100		
			10	12	1,000		
			11	13 E	1,000		
			12	13 W	600		
			13	14 E	800		
			14	14 W	1,400		
			15	15	1,200		
			16	16	9,600		
		Total	16		25,600	14,400	91,638
Supplying Canal	Tendeli North Canal	Tendeli North Canal Misga Canals	1	6 E	1,000		
			2	6A	1,000		
			3	6B	500		
			4	7	1,500		
			5	8/E A	1,250		
			6	8/E B	500		
			7	8 W	1,100		
			8	8 E	1,600		
		Total	8		8,450	4,753	32,243

Table A.2. (Continued) Details of *Misga* Canals for Gash Agricultural Scheme

Details		Canal	No of Misga	Name of Misga Canal	Length (m)	Estimated Desilting (m3)	Incremental Fill for Misga canal water (m3)
Block	F - Metateib	Metateib Main Canal Misga Canals	1	3	400		
Offtake	Umbarasai		2	4	1,000		
Supplying Canal	Metateib Main Canal		3	5	1,700		
			4	6	3,800		
			5	8	1,392		
			6	9	2,702		
			7	10	2,687		
			8	11	1,700		
			9	12	2,000		
			10	13	2,300		
			11	14	2,310		
			12	15	2,850		
			13	16	2,610		
			14	17	1,400		
			15	18 A	2,810		
			16	18 B	2,300		
			17	19	13,950		
			18	20	9,000		
			19	21	2,390		
			20	22	600		
			21	23	300		
			22	24	4,700		
			23	25	1,100		
			24	26	1,100		
			25	27	1,170		
			26	28	700		
		Total	26		69,147	38,895	247,519
Block	G - Hadaliya	Hadaliya Main Canal Misga Canals	1	K 0.5	1,000		
Offtake	Hadiliya		2	K 1	1,000		
Supplying Canal	Hadaliya Main Canal		3	K 1.5	1,000		
			4	K 2	1,000		
			5	K 2.5	1,000		
			6	K 3	1,000		
			7	K 5.5	1,500		
			8	K 6.2	2,900		
			9	K 8	1,000		
			10	K 10	1,000		
			11	K 11.2	2,800		
			12	9	700		
			13	10	7,000		
			14	12	1,200		
			15	12	2,000		
			16	15	11,700		
			17	16	1,500		
		Total	17		39,300	22,106	140,678
Supplying Canal	Bahabini Canal	Bahabini Canal Misga Canals	1	Dewanya	1,500		
			2	K 3	1,000		
			3	K 4.4	1,000		
		Total	3	Total	3,500	1,969	12,529
Supplying Canal	Eli Billi Canal	Eli Billi Canal Misga Canals	1	K 3	1,500		
			2	K 4	1,500		
			3	K 5	1,500		
			4	K 6	1,000		
			5	K 7.4	1,500		
			6	K 8	1,000		
			7	K 9	1,500		
			8	K 11	1,500		
			9	K 12	1,500		
			10	K 15	1,500		
			11	K 18	1,000		
			12	K 19.2	7,200		
		Total	12	Total	22,200	12,488	79,467
				TOTAL	377,847	212,539	1,352,541