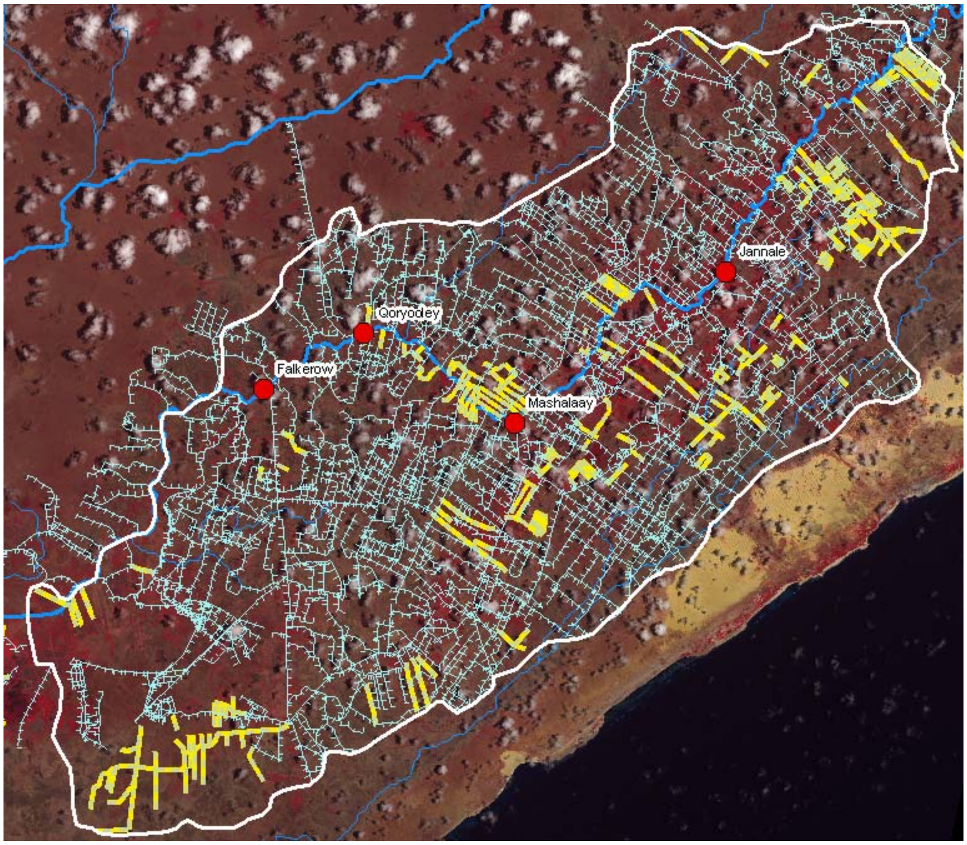
Status of Medium to Large Irrigation Schemes in Southern Somalia



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Acknowledgements

This report is a result of an initiative by FAO SWALIM to identify the status of medium to large irrigation schemes in Southern Somalia for partners and donors active in the irrigation sector in Somalia.

The assessment is based on document reviews and key contact interviews, digital irrigation infrastructure datasets developed by SWLIM using GIS and remote sensing as well as on the consultants' experiences in irrigation and drainage.

The consultants appreciate all the SWALIM staff for their valuable support throughout the assignment. Special thanks to Mr Musse Shaye for his contribution in identifying and verifying all irrigation schemes and to Mr. Craig von Hagen and Mr. Dickson Aduwo for the GIS work.

Last but not least, the consultants appreciate the roles of AGROSPHERE, CEFA, CARE-Somalia, UNDP-Somalia, FAO Somalia and PACSU for the provision of detailed information on activities and programmes undertaken by their organisations in the irrigation sector in Southern Somalia. Special appreciations are due to Mr Renato Marai, Coordinator of the ARDOPIS project of FAO Somalia.

Executive Summary

The Juba and Shabelle river basins have been, and could again be, the breadbasket of Somalia. They have considerable potential for irrigation development, and several irrigation schemes have been developed on these two major river basins to provide sustainable food security and alleviate poverty in the country. However, due to 16 years of civil insecurity and unrest the majority of these schemes have collapsed.

Based on the conclusions and recommendations of the "Banana Sector Study" prepared by the European Commission (EC, 2002), the European Commission has moved to restore some irrigation facilities, and rehabilitate and maintain former irrigated plantations and irrigation schemes.

The EC-funded Somalia Water and Land Information Management (SWALIM) project, as part of its objectives, addresses the need for information products and services to improve agricultural production. In line with this objective, SWALIM undertook a comprehensive study to identify the status of medium to large irrigation schemes in Southern Somalia. The overall objective was to provide a database and information on the status of the irrigation infrastructure, which has been progressively declining since the break out of the civil war in 1991. The assessment consisted of:

- (i) A desk-based assessment
- (ii) Built up of a baseline irrigation infrastructure database from existing topographic maps and satellite images
- (iii) A rapid field assessment on the major river regulation infrastructure in the Shabelle River basin.

In the desk-based assessment, the documents reviewed included a number of pre-war studies, designs, concept papers, feasibility studies and scheme assessments. All these documents contain information on individual schemes or a cluster of a few schemes, which provides very fragmented information, without giving a general overview of a larger area required for the management of several inter-related schemes. Based on the fragmented information this report presents a systematic collection of most available data and information on the irrigation schemes and irrigation infrastructure.

Extensive GIS work was carried out to identify major irrigation canals. The canals were digitised from the existing topographic maps, originating from the 1970's and reflecting the existence of the irrigation schemes at that time. These maps were overlaid by another set of data on canals. This latter set was derived from mainly Landsat satellite images reflecting the situation at the beginning of the new century. Even a simple visual interpretation gives very quick and interesting impression of the development. Surprisingly, the comparison shows that numerous new canals can be detected. NDVI analysis was also performed to try to identify if the schemes around the canals are operational or not. This work has not been completed yet. However, one of the main achievements of this exercise, besides identifying more than 5,000 km of canal infrastructure, is that of identifying the real boundaries of the irrigation schemes. The irrigation schemes many times were not developed to the size planned in their designs, and little information was available before this study on the actual size implemented.

Field visits and interviews were organised with barrage operators and communities. These interviews provided valuable information on the operational status of the irrigation

infrastructure. Digital photos linked to GPS coordinates were also taken to provide information on the status of canals and flow regulators. Key contact interviews were conducted with lead agencies active in the irrigation sector in Southern Somalia. Information gathered determined operational status, types of crops grown, management and administration of schemes and their major irrigation infrastructure, including river regulation works, primary and secondary canals and their command areas, areas currently under irrigation, potential for future development and on-going rehabilitation efforts. Preliminary results gained in GIS work were discussed in detail at workshops and interviews in order to verify the data derived by remote sensing.

The report is divided into five main sections:

(i) Methodology
(ii) Natural resources
(iii) Legal-institutional aspects
(iv) Establishment of digital irrigation infrastructure dataset
(v) Status of irrigation infrastructure and schemes

The above structure is supposed to provide baseline data and information for various users including (i) donors and investors considering various options of rehabilitation; (ii) designers of irrigation schemes who need all natural resources and other information if possible in one report; and (iii) scheme managers and operators who need detailed infrastructure information.

Based on the literature review, contact interviews and information and data gathered during the study, the following can be summarised:

Pre-War Status

1. Agriculture was the primary water user in Southern Somalia with the pre-conflict irrigation systems. The medium to large irrigation schemes relied on water from the Juba and Shabelle rivers.
2. There were two major types of river water use for agricultural production in the Juba and Shabelle basins: a) flood recession (*deshek*) cultivation, and b) irrigated agricultural systems (pump or gravity supplied), originally based on a limited number of gated gravity fed river intakes.
3. Irrigation water was abstracted either by barrages with weirs controlling water flow into primary supply canals, or by pumped intakes drawing irrigation water directly from the rivers into primary canals.
4. Ten river regulation systems (barrages) existed, viz. the Fanoole Barrage, which is the only barrage identified on the Juba River, and the Sabuun, Balcad, Genale, Mashalley, Qoryooley, Falkerooy, Kurtunwareey, Sablaale and Haway barrages, all of which are situated on the Shabelle River.
5. Water uplifting infrastructure in Juba valley in 1990 consisted of 2 major and 2 minor pumping stations in Badheere dam for sugarcane production in Juba sugar project, a pumping station at Mogambo for rice production and 140 pump sets with an average lifting capacity of 170 l/s for banana production at Kamsuma.
6. The canal system comprised of primary, secondary and numerous tertiary canals. However, some small (private) canal systems originated directly from the two rivers. The primary canals were designed to have enough head to reach fields through secondary canals and, further down, through smaller tertiary canals to the individual farm intakes.

7. Pre-conflict irrigation infrastructure was intact and delivered the required amounts of water to medium and large irrigation schemes as planned, designed, operated and managed, up to the time the war broke out in 1991. Nearly 90% of the schemes were operational before the war, the majority being located in Lower and Middle Shabelle and Lower Juba regions.
8. From literature, estimates of the area under controlled irrigation for all the schemes in Juba and Shabelle before the break out of the civil war is 161 583 ha. However, some of these schemes may not have been fully operational all the time. The ministry of Agriculture estimates that in 1987/88 cropping year, 112 950 ha were under controlled irrigation, while 110 000 ha was under flood recession irrigation, giving the total irrigated area to 222 950 hectares. The main crops grown included sesame, maize and vegetables (Ministry of Agriculture, 1988).
9. Pre-conflict management and administration of medium to large scale irrigation schemes and irrigated farms in Southern Somalia were under the overall supervision of the Land and Water Department in the Ministry of Agriculture. Commercial concessions for bananas and sugarcane growing and processing were considered private investments and were therefore managed and administered privately.

Present Status

Regarding the present status of the irrigation infrastructure, the study made a big step towards identifying the boundaries and the relevant canal systems of 32 irrigation schemes. The study further identified that:

10. All the ten barrages used for regulating water for irrigation before the break out of the civil war are currently not operational and require major rehabilitation work. Generally, the gates are stuck and embedded in mud, while lifting gears are broken. The main cause of failure is neglect and lack of maintenance during period of civil unrest.
11. The efficiency of canals in delivering water to the irrigation fields decreased to almost zero, with some breaking down completely. This is as a result of poor maintenance, leading to build up of silt and vegetation along the canals.
12. The 125 pump sets used for water uplifting before 1990 in Lower Juba are all either looted or failed and have been inoperative since the outbreak of the civil war.
13. River embankments for both Juba and Shabelle have been weakened by farmers in an attempt to access water after the breakdown of canals and barrages.
14. There are new canals developed in the irrigation schemes, and in some cases improvements done on the existing canals. From the GIS work, over 5,000 km of canal currently exist in Southern Somalia. Majority of the canals however require rehabilitation, as they are not currently operational.
15. The irrigation schemes which existed before the break out of the civil war are either partially operational or not operational at all. Less than 50% of what previously existed before the break out of the war is currently operational.

Further analysis of the conditions of the more than 5 000 km of canals, including siltation survey and data on culverts, road crossing and flow diversion structures will however require either extensive field surveys of many teams or the use of very high resolution aerial photography (Lidar). Analysis of the present, ever-changing, ad-hoc management structures of the schemes would also require new socio-economic field surveys.

Glossary of Somali Terms

Dyer	Rainy season that normally occurs from October to December
Gu	Rainy season that normally occurs during April to June
Jilaal	Dry season from January to April
Hagaa	Season of coastal showers, normally between July and August
Wadi	A non-perennial (seasonal) stream

Abbreviations and Acronyms

ARDO	Aaran Relief and Development Organisation
ARDOPIS	Agricultural Rehabilitation and Diversification of High Potential Irrigation Schemes in Southern Somalia
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
Care SSS	Care Somalia South Sudan
CCS	Committee of Concerned Somalis
CEFA	European Committee for Agricultural Training
CIDA	Canadian International Development Agency
CIDRI	International Co-operation for an Intergrated Rural Development
CINS	Cooperazione Italiana Nord Sud
DBG	Daryeel Bulsho Guud
EC	European Commission
EDF	European Development Fund
FAO	Food and Agriculture Organization of the United Nations
FEWS	Famine Early Warning System
FSAU	Food Security Analysis Unit
GIS	Geographical Information System
ITCZ	Inter-Tropical Convergence Zone
ITF	Inter-Tropical Front
JOSSR	Jowhar Off-Stream Storage Reservoir
JSP	Juba Sugar Project
LANDSAT	Land Satellite
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetative Index
NGO	Non Governmental Organization
PACSU	Project Assistance, Capacity Building and Supervision Unit
RCMRD	Regional Centre for Mapping of Resources for Development
REMPAI	Resource Management and Policy Analysis Institute
SACB	Somalia Aid Coordination Body
SACO	Somali Agriculture and Commercial Operation
SADO	Social Life and Agriculture Development Organization
SDA	Settlement Development Agency
SDIO	Society Development Initiative Organization
SOM	Somalia
SSHDA	The Sool, Sanaag & Hawd Development Agency
SSS	Somali Support Secretariat
SWALIM	Somalia Water and Land Information Management
TCP	Technical Cooperation Programme
TOPO	Topographic Map
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
US/A	United States of America
USAID	US Agency for International Development
USBR	United States Bureau of Reclamation

Spelling of Places Names

Spellings on place names in Somalia are very variable. Attempts have been made to use the same spellings throughout this document. To avoid misunderstanding, English and Italian spellings are given where these differ.

Somali	**English**	**Italian**
Afgooye	Afgoi	Afgoi
Awdheegle	-	Audegle
Balcad	Balad	Balad
Baraawe	Brava	Brava
Buulo Mareerta	Bulo Marerta	Bulo Marerta
Falkeerow	-	Falcherio
Gayweerow	-	Gaiuero
Golweyn	-	Goluen
Hargeysa	Hargeisa	-
Haway	Avai	Avai
Janaale	Genale	Genale
Jilib	Jilib	Gelib
Jowhar	Jowhar	Giohar
Kismayo	Kisimaio	Chisimaio
Marka	Merca	Merca
Muqdisho	Mogadishu	Mogaddiscio
Qoryooley	-	Coriolei
Shabelle	Shebelli	Scebeli
Shalambood	Shalambot	Scialambot

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1. Introduction
1.1 Background

Somalia (Figure 1.1) is one of the poorest countries in the world. Most Somalis live well below the poverty line and the country has the highest infant mortality rate in East Africa and the Horn of Africa region, EC (2002). Somalia does not posses significant mineral resources, although oil prospecting in the eighties showed some encouraging results. The water resources potential has not been fully exploited for the benefit of the general population. The vast majority of the Somali people depend on livestock and farming or a combination of both and have very limited access to social services, including health and education.

The Juba and Shabelle river basins have been and will probably remain the breadbasket of Somalia. Both have considerable potential for irrigation development. Several irrigation schemes have been developed on the two river basins to provide food security and to alleviate poverty in the country, EC (2002).

1.2 General overview of irrigation schemes

Irrigated agricultural development started in 1920 with the implementation of the Jowhar Sugar Estate. The scale of irrigation development increased rapidly thereafter and by 1980 some 60 000 hectares had been developed in Jowhar and Balcad Districts, located in Middle and Lower Shabelle Regions respectively (Mott McDonald and Partners, 1969).

Between 1980 and 1990, irrigated areas benefited from a well-established network of canals and drains, allowing a consistent supply of water that was supplemental to the scarce and unreliable rains, with abundant surface and underground waters from the Shabelle and Juba Rivers. For many years, the fertile soils and climate had sustained good performance of both cash and food crops under irrigated conditions, while extra water was used for leaching practices that kept salinity build-up under control.

Irrigation systems were originally based on a limited number of gated gravity - fed river intakes, feeding main canals designed in such a way as to have enough head to command the fields through secondary canals and, further down, smaller tertiary canals to individual farms' intakes. But, due to 16 years of civil war the majority of these schemes have collapsed. River embankments have eroded, and barrages, pump intakes and canal systems show some degree of sedimentation and vegetation growth which have reduced the canals' hydraulic sections. Silting up of the drainage system was accelerated by the lack of terminal outlets and the flat topography of the irrigation area which restricted drainage water to return by gravity into the rivers. The rivers also spread into large swamps, never reaching their ends (EC, 2002). As a result, only fractions of design discharges were delivered, thus considerably reducing the area under irrigation.

An overview map with details of the irrigation schemes in Juba and Shabelle River basins is discussed in Chapter 5 of this document.

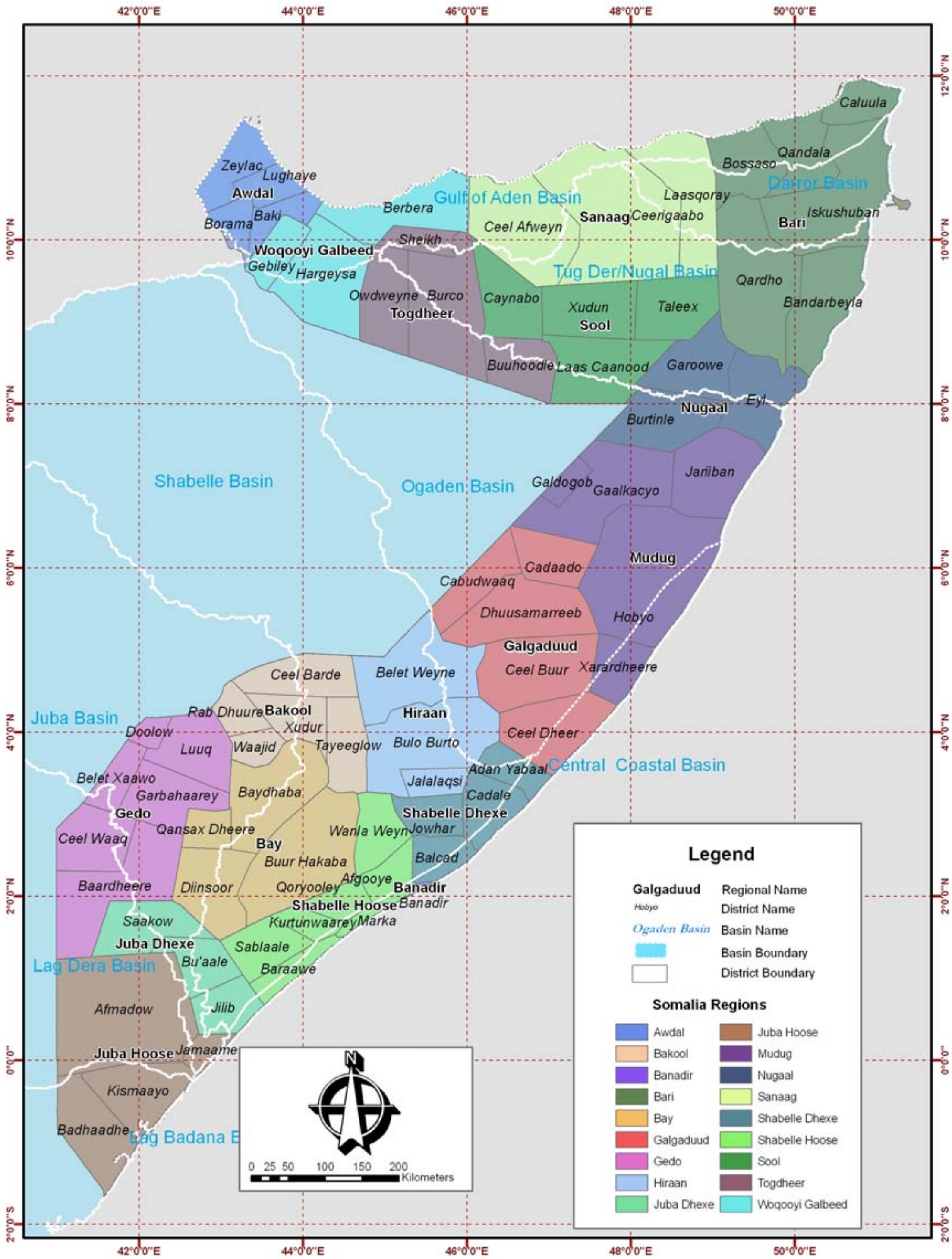

Figure 1.1: Administrative Map of Somalia

1.3 Current situation

The break out of the civil war in Somalia in 1991 had many negative effects on the irrigation sector. At present, only certain parts of the irrigation facilities in the area operate, at diminishing levels of efficiency, and only a limited percentage of the area is currently irrigated in the two river basins. Available evidence suggests that approximately less than 50% of the originally irrigated area is presently under irrigation, one of the reasons being the poor state of irrigation infrastructure.

Another result of the dysfunctional canal system is the breaching of riverbanks by farmers to obtain irrigation water, which causes uncontrolled flooding and water wastage. Water shortages have also caused conflict when farmers blocked canals and breached riverbanks for irrigation, thus depriving farmers further downstream of water. Farmers have done their utmost to take over management of irrigation systems from the dissolved government agencies and to some extent have partially succeeded.

Agencies in the irrigation sector have an important role to play in sensitising rural communities on the social and economic reach of the issues at stake, as well as providing technical advice and support. However, much more needs to be done as the irrigation infrastructure continues to deteriorate rapidly.

1.4 Problem definition

There are two problems affecting the present condition of irrigation systems and associated infrastructure. The poor condition of barrages, canals and control structures is primarily the result of years of extempore operation and inadequate maintenance. Secondarily, the most obvious causes are the neglect, plunder and effects of marauding gangs when war broke out in 1991, EC (2002).

1.5 Objectives of the assessment

The EC-funded Somalia Water and Land Information Management - SWALIM project, as part of its objectives, addresses the need for information products and services to improve agricultural production. The main objective of this study was to produce a report on the *status of the medium to large irrigation schemes in southern Somalia* and primarily to establish their operational status, including river regulation infrastructure, primary and secondary canals and their command areas, areas currently under irrigation, crops grown and potential for future development

1.6 Structure of the report

This report is organized into seven chapters and annexes. An executive summary is followed by an introduction outlining the country background, a general overview of irrigation schemes, the current situation and problem definition, objectives of the assessment and structure of the report.

An assessment methodology including document review, key contact interviews, field assessment, GIS work and expert consultative workshops is presented in chapter two. The country’s natural resources including physical features, water and land resources are contained in chapter three, and the legal institutional aspects in chapter four. Establishment of digital irrigation infrastructure dataset is presented in chapter five; while the status of irrigation infrastructure and schemes in Southern Somalia is discussed in chapter six. Conclusions and recommendations are contained in chapter seven. A bibliography and extra information are provided as annexes.

2. Assessment Methodology

A SWALIM review of the status of medium to large irrigation schemes in Southern Somalia was carried out by an assessment team comprised of technical specialists from REMPAI, SWALIM and other partner agencies:

- Charles Mbara, Consultant and Senior Associate, Resource Management and Policy Analysis Institute Ltd (REMPAI LTD), Nairobi, Kenya.
- Hussein Gadain, Water Coordinator, FAO/SWALIM.
- Dickson Aduwo, GIS Technician, FAO/SWALIM.
- Craig von Hagen, Spatial Data Coordinator, FAO/SWALIM.
- Hussein Iman, FAO/SWALIM Liaison Officer for Southern and Central Somalia.
- Technical experts from SWALIM, UNDP, CARE, AGROSPHERE, CEFA, PACSU and other partners.

The assessment consisted of:

(i) A desk-based assessment
(ii) A baseline irrigation infrastructure database from existing topographic maps and satellite images
(iii) A rapid field assessment on the major river regulators and surrounding in the Shabelle River basin.

The team spent three months conducting the assessment, drawing on numerous information sources described below.

2.1 Document review

A number of documents were reviewed, providing detailed information on irrigation schemes in Southern Somalia and ongoing infrastructure rehabilitation and development activities. The documents reviewed include reports on the feasibility studies for irrigation schemes in both the Juba and Shabelle valleys, summaries of water activities from the FAO SWALIM library and archives and implementing partners in the agriculture and irrigation sectors, and the Banana Sector Study conducted by the European Commission.

Other documents consulted were from non-governmental organizations (NGOs). Information on agencies working in the irrigation sector was sourced from the *NGOs in Somalia Handbook* of 2005, produced by the Somalia NGO Consortium in cooperation with the Somali Aid Coordination Body (SACB, now the Somalia Support Secretariat – SSS). The handbook contains lists, addresses and locations of both local and international NGOs working in the agriculture sector in Somalia.

Through examination of information on irrigation development in Southern Somalia, valuable information was gathered on the historical genesis of irrigation development, current situation and problem identification. The document review further examined and recorded the natural resource base, pre-conflict irrigation schemes, major irrigation infrastructures and assessment results. Documents sourced from agencies were also examined and data recorded for comparison with SWALIM data sources as well.

A list of key references consulted appears in the bibliography section at the end of this report.

2.2 Key contact interviews

Consultations with agencies active in the irrigation sector in Southern Somalia were necessary in order to understand various perspectives on on-going irrigation and agricultural development activities being carried out in the country, as well as priority needs in the sector.

Key informants consulted included over 30 representatives from varied institutions, including FAO Somalia staff (FSAU, SWALIM & ARDOPIS projects), European Commission (EC), EC implementing contractors and grantees (CEFA, AGROSPHERE, CARE and PACSU), other NGOs, UN agencies (UNDP), other donors and the private sector. A list of agencies active in the irrigation sector in Southern Somalia from which some of the informants were selected from is presented in Annex 2.

Interviews with these agencies recorded current agency involvement in development activities, including rehabilitation work, emergency-based activities and the roles of NGOs and other agencies. The interviews further investigated crops grown and the management and administration of schemes in which the agency is currently involved.

2.3 Field assessment

Four barrages and their primary canals were visited to assess their operational status. During this field visit, the barrage and canal operators and village irrigation water management committees were met and interviewed. A photo gallery of barrages and canals and their status is given for each barrage.

Information from similar assessment by NGOs like CEFA, CARE and AGROSPHERE were also availed during this assessment.

2.4 GIS work

This part of the assessment aimed at establishing a comprehensive spatial dataset for Somalia’s irrigation infrastructure along the riverine areas. The data generated established the pre-war and current status of irrigation infrastructure in Somalia. During this part of the study SWALIM managed to create an irrigation infrastructure dataset for Somalia including; canals, barrages, and irrigation schemes and projects.

The spatial dataset was developed in three stages; first, digitizing canals from scanned and georeferenced 1:100,000 topographic maps, secondly digitizing irrigation canals from satellite imagery and finally, digitizing irrigation schemes/projects from feasibility studies and/or project reports. A detailed methodology of the spatial dataset development is explained in chapter 5.

2.5 Expert consultative workshops

SWALIM held two expert workshops in order to verify the information compiled from document review and GIS work. The first workshop was held in February 2007 in Nairobi. Participants (besides the consultant and SWALIM team) were senior experts from NGOs (CARE, CEFA, AGROSPHERE and PACSU), and UNDP and EC staff. The second workshop was conducted in May 2007 in Baidoa, Somalia. Participants were the barrages and canal operators and village irrigation water management committees for the middle and lower Shabelle irrigated areas only. There were no participants from the Juba valley due to security issues and inaccessibility. More than 50 people participated in the two workshops.

3. Natural Resources

3.1 Introduction

The successes and constraints of the operations and management of medium to large scale irrigation schemes in Southern Somalia depend on among other things the natural resources in the region. Both the water and land resources in South Somalia are generally conducive for irrigated agriculture, especially along the riverine areas of the two perennial rivers, the Shabelle and Juba.

3.2 Physical features

3.2.1 Geology

Most of the southern parts of Somalia consist of the basement complex rocks, overlain by Mesozoic sediments of limestone, marls and sandstones. A distinct scarp (the Baidoa escarpment) indicates the limit of these sediments, with the basement peneplain made of sediments from the beginning of the Tertiary period where the only relief is provided by granite inselbergs known locally as *burs*. The southern limit of this peneplain is marked by a major fault zone running parallel to the coast, which is probably part of the fault system of the East African coastal area. The coastal zone is characterised by various alluvial colluvial, marine and Aeolian deposits of the Quaternary and recent periods, FEWS (1988).

3.2.2 Soils

Irrigated soils of schemes in Southern Somalia are mostly montmorillonitic clays that swell and shrink under wetting and drying conditions. Infiltration rates for such soils are low, frequently less than 25 mm/hour. They have high water holding capacities, usually as much as 200-240 mm/m or more. In some cases, soils have salinities above 5 millimhos/cm leading to serious salinity problems unless careful irrigation practices are followed.

According to FEWS (1988), clay, black cotton and laterite soils are prominent in the Juba and Shabelle River basins, with huge areas of these characterised by very thin soil cover over rocks. A survey, agriculture and water survey done in 1968, identified an area of 450 000 ha with soils suitable for irrigation development in Shabelle valley between Bulo Burti and Haway. From the survey, 73% of the area above Bulo Burti is rocky, with shallow saline soils unsuitable for cultivation. Only 59 000 ha located in the narrow floodplain are considered to be of suitable soils for irrigated agriculture. Soils in most of the riverine areas below Bulo Burti and Mahaddei have been used extensively for rain-fed and not irrigated agriculture.

From Mahaddei to Jowhar the soils on both banks adjacent to the river consist of fine-textured brown vertisols with good water-holding capacity and have been extensively used for rain-fed agriculture and flood - and controlled irrigation on the Jowhar Sugar scheme. Between Jowhar and Balcad the soils adjacent to the river were grey vertisols, suitable for irrigated agriculture. From Balcad through Afgoi and Genale to Coriole, the river is bound on both banks by a wide expanse of fine-textured, dark brown vertisols suitable for irrigation. The soils immediately adjacent to the swampy areas are suitable for paddy rice cultivation.

FAO SWALIM also conducted a detailed soil survey for the riverine areas of the two river basins. According to the survey, soils in the alluvial plains are characterized by stratified fluvial deposits which, because of the semi-arid climate, have been little-affected by soil-forming processes. Despite their variability, most of these soils share the characteristics of heavy texture (clay) and low permeability, and with a tendency to poor drainage. They have been classified as Vertisols and Fluvisols mainly (Figure 3.1). The hilly terrain and associated pediments, piedmonts and erosion surfaces predominantly have shallow and stony soils of medium texture (loamy), classified as Leptosols, Regosols and Calcisols. Pockets of deep Cambisols and Luvisols also occur. The soils of the dune complex are sandy and classified as Arenosols. Details of landform and soils are given in FAO-SWALIM Technical Reports N^{o} L-02 and L-08 respectively.

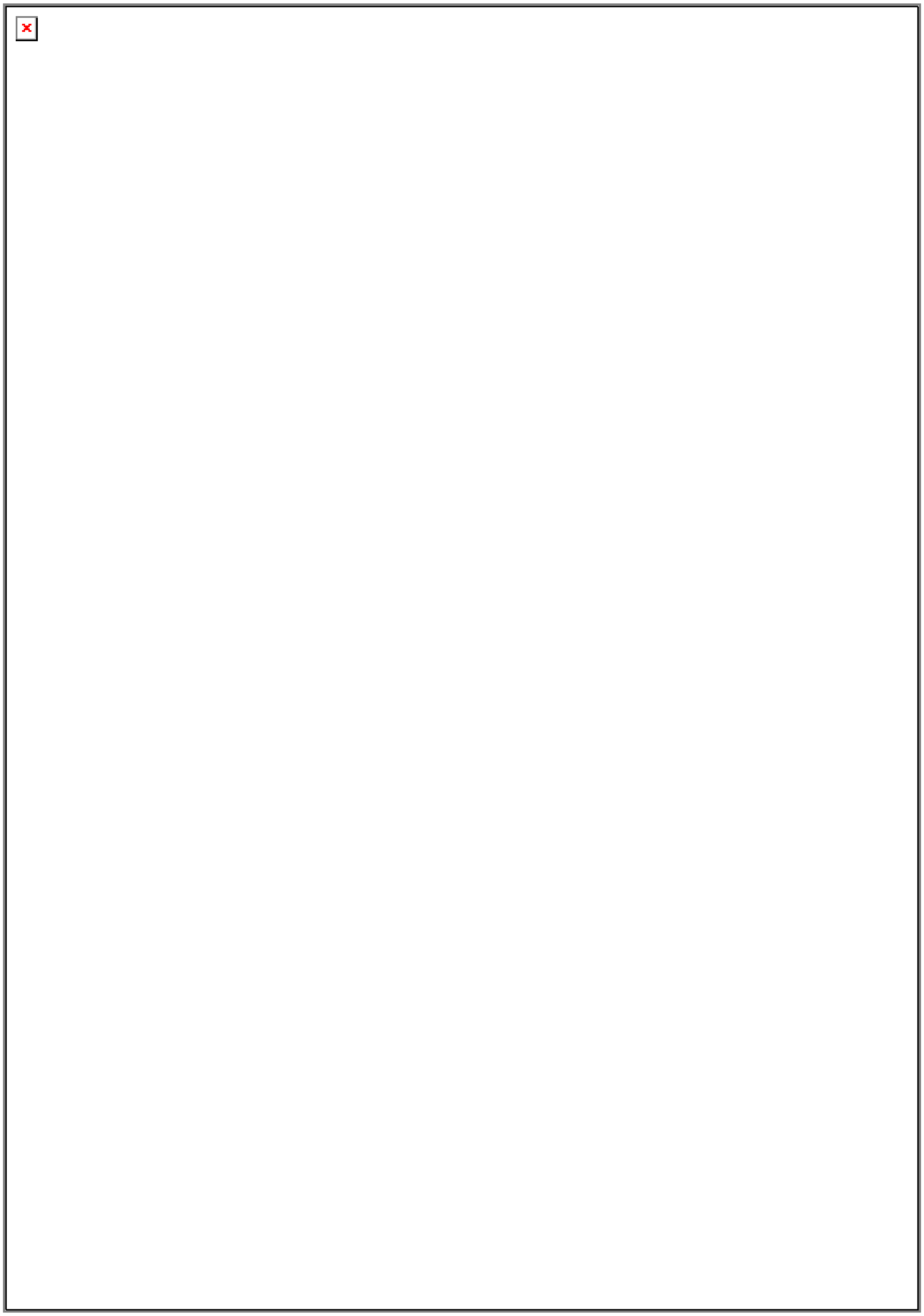

Figure 3.1: Soil types along the riverine areas of the Juba and Shabelle Rivers[1]

[1] Source: adoped from, FAO SWALIM Land Report N° L-08

3.3 Water resources

3.3.1 Climate of Southern Somalia

The climate of Somalia is controlled by the north- and southward movements of the Inter-Tropical Convergence Zone (ITCZ), a climatic area in which north-westerly and south-easterly trade winds converge and air is forced upwards. The two air masses have different temperatures and humidity, and the plane where the air masses meet, known as the Inter-Tropical Front (ITF), often represents a transition of one type of weather to another.

The north and south movements of the ITCZ follow an annual cycle, which lags behind the apparent movement of the sun between the Tropics of Cancer and Capricorn by one month. The movement of ITCZ is in response to meteorological variations over a wide area including the Indian Ocean, the Arabian Peninsula, and East Africa and beyond.

Southern Somalia, like many other parts of the country, experience four distinct seasons:

Gu	Main rainy season (March/April to June)
Hagaa	Hot and windy season (July– September)
Deyr	Short rainy season (September/October – November)
Jilaal	Very dry and cool season (December – February/March)

During the two rainy periods, rainfall is used as part of an effective water management programme in which level-basin irrigation systems permits effective rainfall use. During these periods, irrigation water deliveries are managed so as to prevent over irrigation and wastage of irrigation water.

Below is a simple graphic showing these rainy seasons, while Figure 3.2 gives a map for the mean annual rainfall distribution for Somalia. For more information about the climate of Somalia, the reader is referred to FAO SWALIM Project Report N° W-01 – Climate of Somalia.

3.3.2 Juba and Shabelle River basins

The two perennial rivers, the Shabelle and Juba, dominate Southern Somalia, and a vast area of sediments formed by these two rivers constitutes the country's most fertile lands. For almost their entire length, both the Juba and Shabelle flow in canal-like riverbeds with steep shoulders. Alluvial soils of these ancient rivers sometimes reach a width of up to 35 km or more.

The Juba and Shabelle rivers have over the centuries provided water for agricultural production in the riverine areas shown in Figure 3.3. Juba River, with a total length of 1 100 km has a channel capacity of 700 m^3/s at Luuq (FEWS, 1988). The river has an average annual flow of 5.5 billion cubic metres. Shabele River on the other hand is approximately 1 700 km long, with a channel capacity of $400m^3/s$ at Belet Weyne and $100m^3/s$ near Jowhar. Flows vary between 1.21 – 3.2 billion cubic metres at Belet

Weyne and 0.75 – 2.0 billion cubic metres at Afgoi. In both rivers, there is a decrease in river flow downstream as a result of several factors among them: minimum contribution of flow from the Somali catchments, high losses to infiltration and evaporation, water spillage into flood plains and water diversion for irrigation purposes.

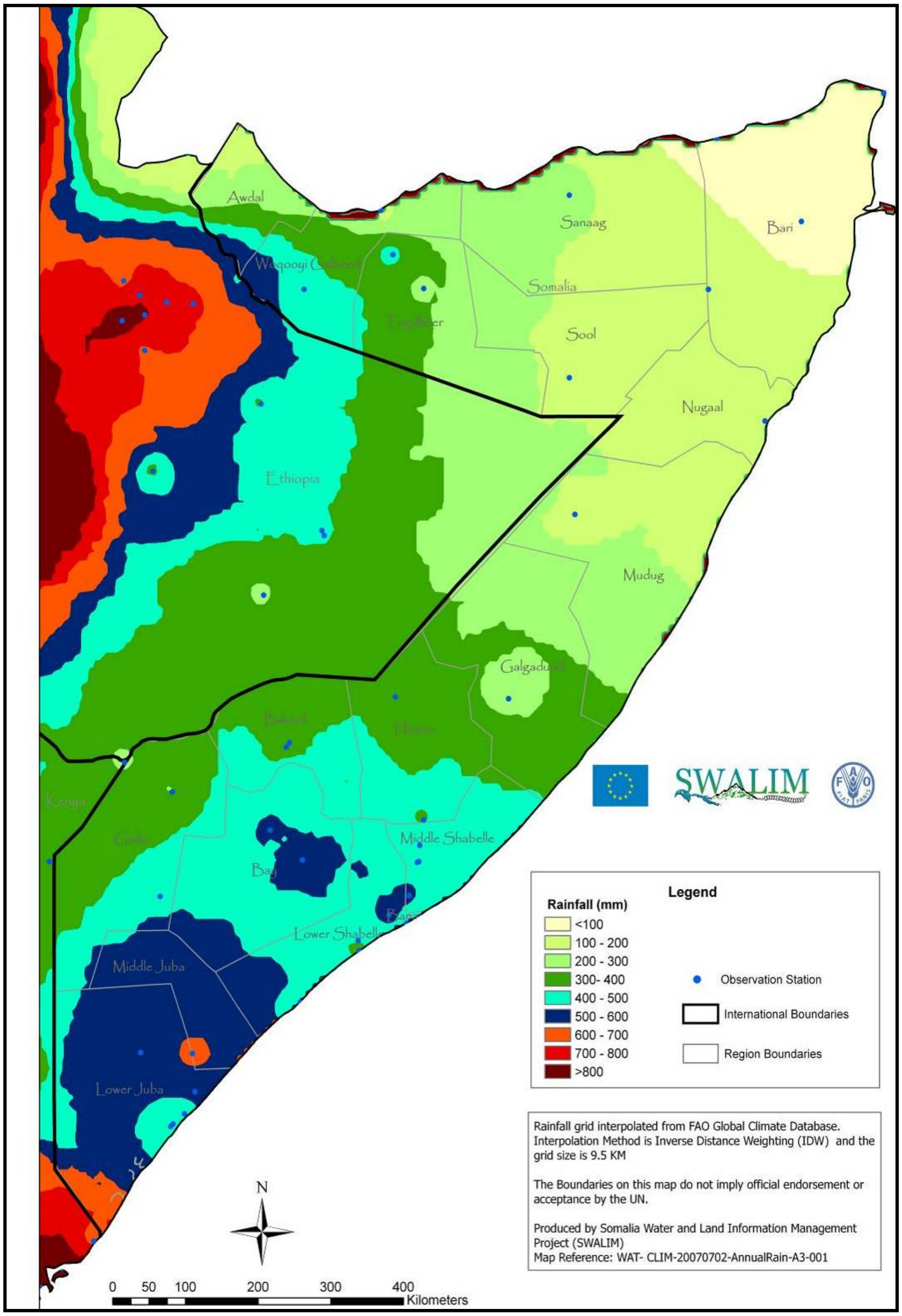

Figure 3.2: Mean annual rainfall distribution in Somalia

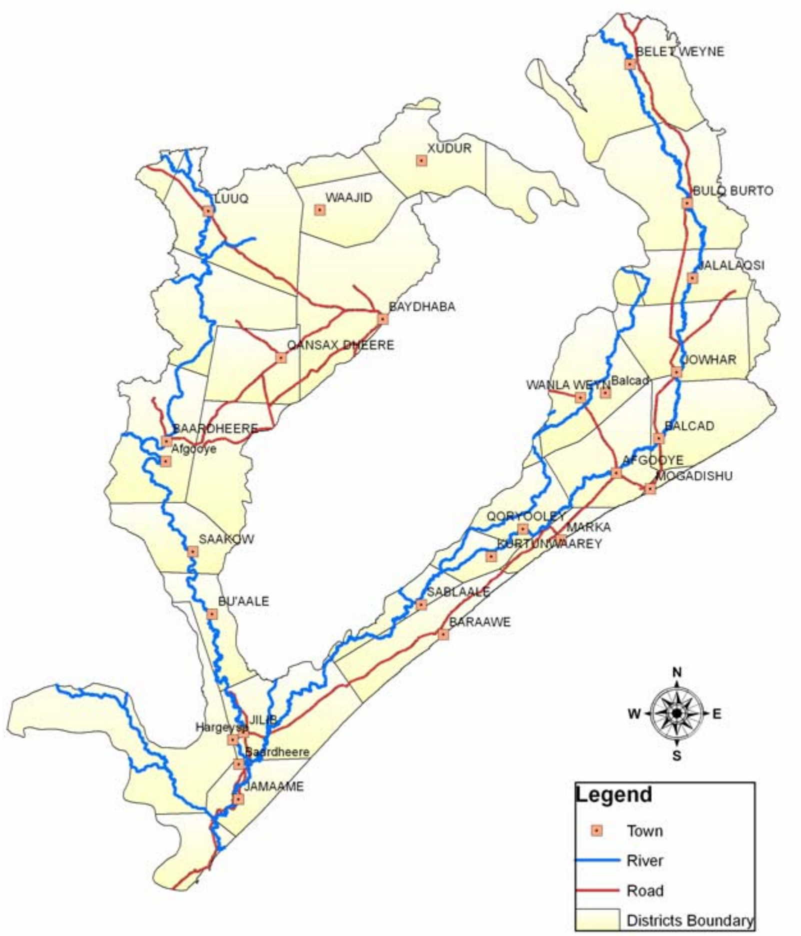

Figure 3.3: Potential riverine irrigation areas in the Juba and Shabelle Rivers

3.3.3 Water catchments and ground water sources

Groundwater developed in irrigated areas is known to supplement surface water resources, particularly during periods of low river flows. Complementary use of ground and river water is an important part of any effective management programme, groundwater providing an important supplemental water source during periods of peak demand. Groundwater also meets some water demands during periods of low river flow, therefore providing some major benefits.

The groundwater sources common in Southern Somalia are mainly springs and shallow wells. Rainwater harvesting in traditional water catchments is practiced as well, with most of the catchments being individually owned and managed. A widespread form of rainwater catchment is field bunding, a simple storm water storage device serving a dual purpose of rainstorm protection and water conservation, FEWS (1988). There are however no records showing the use of these water sources for irrigation in the Southern Somalia.

3.4 Land resources
3.4.1 Land cover and land use

The land cover of Southern Somalia consists mainly of degraded natural vegetation. The natural vegetation consists of riparian forest, bush lands and grasslands. Woody and herbaceous species include *Acacia bussei, A. seyal, A. nilotica, A. tortilis, A. senegal, Chrysopogon auchieri* var. *quinqueplumis, Suaeda fruticosa* and *Salsola foetida*. Other cover types include crop fields (both rain fed and irrigated), urban and associated areas (settlement/towns and airport), dunes and bare lands and natural water bodies. Details of land cover are given in FAO-SWALIM Technical Report N^{o} L-03.

Before the break out of the civil war in 1991, it is estimated that 1 243 000 ha of land were under rain-fed agriculture in Southern Somalia (World Bank, 1988). The rain-fed farming holdings varied from 1 to 100 hectares, with average family units being in the order of 15 ha, of which 5 ha were cultivated at any one time while the remainder comprised secondary bush or fallow. In the densely populated areas such as Wanle Weyn and parts of Bay Region (Figure 1.1 above) fallow and foreshortened cultivation cycles were more intensive with a general expectation of two crops per year. In other areas, dry land sorghum farming was practised on a more extensive basis with fallows extending from three to fifteen years. The subsistence small holder farms did not exceed 5 ha, while registered large farms, typical for the district of Afgoi, generally exceeded 20 ha, FEWS (1988). The capacity to expand irrigation schemes remained high, with estimated 350 000 hectares in the central and 500 000 hectares in the southern regions of Somalia available for further development. Most of these lands were believed to be located in the districts of Dinsor, Sakow, Brava and Jilib, for the south; and El Dhere, Harar Dhere and El Bur for the central Somalia (Somalia Agricultural Sector Survey, 1988).

Irrigated agriculture was also practiced in South Central Somalia. In 1987/88 cropping year, FEWS (1988) estimated that 109 350ha of land were under irrigated agriculture (46 800 ha in Juba, 61 750 ha in Shabelle and 800 ha in Bay Region).

In d*esheks* - natural depressions in the flood plain of the Juba and Shabelle rivers, recession irrigation was practiced. Both rivers flood/overflow their banks every year, but to a very variable extent from year to year. In addition, these flood plains may be flooded by underground flow from the rivers or by runoff from adjacent areas. River levee or artificial bunds hinder the return of flow when river levels recede. When water levels have dropped due to evaporation and soils still retain enough moisture to support one crop, farmers plant these *desheks,* the main crops cultivated being sesame, maize and vegetables. According to FEWS (1988) an estimate of all *desheks* under cultivation in 1990 in both river valleys amounted to approximately 110 000 hectares.

Figure 3.3 shows the present land use in the irrigated areas of the Juba and Shabelle. The main land use types are transhumance pastoralism, rainfed agriculture and irrigated agriculture. Semi sedentary pastoralism also occurs. Pastoralism is often combined with wood collection, either as firewood or for charcoal production. Figure 3.4 and the detailed land use in general, are described in detail in FAO-SWALIM Technical report N^{o} L-07.

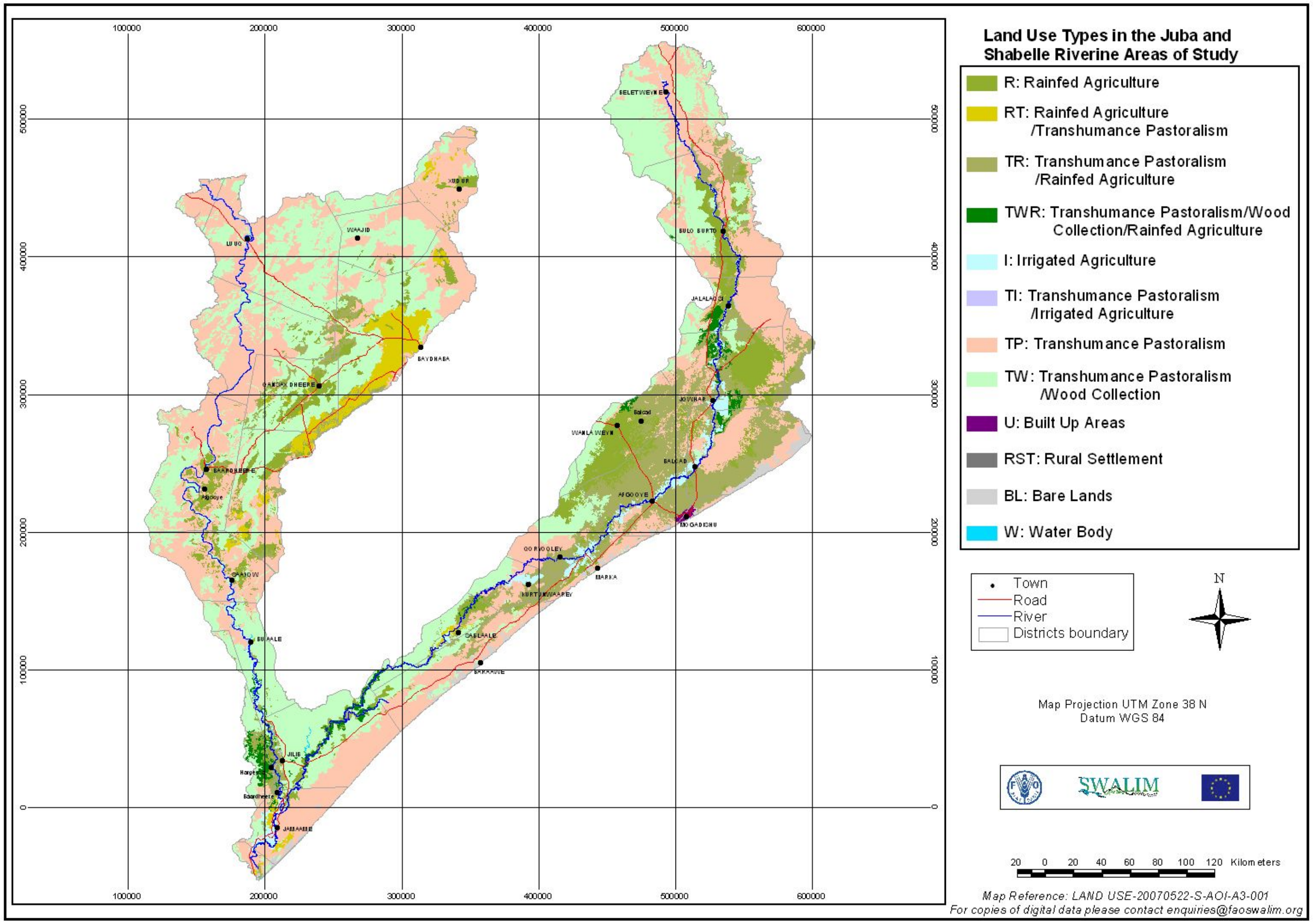

Figure 3.4: Land use types in Juba and Shabelle riverine areas[2]

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[2] Source: adoped from, FAO SWALIM Land Report N° L-07

4. Legal-Institutional Aspects

4.1 Land tenure

The *Farm Tenancy Law No.75* of 1975 stipulates that all land in Somalia is owned by the state. Concessions for use for agricultural purposes were granted by the Land and Water Department of the Ministry of Agriculture. Individuals applied for 50 year leases for up to 30 ha. of irrigated land, 60 ha of rain-fed land or 100 ha of plantation land, though no such limit applies to companies, cooperatives and state farms.

Applications for leases were made to district representative of the Department of Land and Water, and full details posted for 30 days in the local police station. If no objections were received by that time, the application was passed by the regional office for the Department headquarters for issue of a lease. Leases were inheritable but could not be hired or sold to a third party. However, under exceptional circumstances a lease could be sold in order to pay a bad debt. While the lease was issued free of charge, annual tax was payable for use of the land (FAO, 1968; FEWS, 1988). The only available land tenure system categorically written down for Somalia is contained in Chapter 1 (Land Tenure Conditions) of the UN Special Fund/FAO Agricultural and Water Surveys (FAO, 1963).

4.2 Water laws

The medium to large irrigation schemes in Southern Somalia are characterised in the following management units:

- Commercial concessions for bananas and sugar
- State farms
- Farms for settlement of nomads
- Other areas where the government developed diversions supplying water to farmer-owned operators
- Private or group developed diversions or pumping stations

Water for irrigation in Southern Somalia comes primarily from the Juba and Shabelle rivers through either gravity diversions or pumping stations. A major constraint to diversions from rivers is unreliability of supply, especially when water demand in irrigated areas exceeds available low-flow supply. It is a primary responsibility of the overall irrigation agency to ensure effective use of available supplies.

Gravity diversion of water from the Juba and Shabelle rivers before the start of the civil war involved either a project area or private farmers' association. Some projects constructed barrages to control river levels and the resultant diversion rates, while others used gravity diversions. Most canal inlets had gates to regulate canals inflow. There were two important functions at each diversion that needed to be established and managed by an organization:

- the quantity of water that needed to be diverted, and
- the quantity of water allowed to be diverted as a fraction of the river flow (to maintain equity among diversions)

During that period, maintenance of the irrigation systems was lacking, structural control was inadequate and water measurement was absent, although measurement was essential for the management of water delivery. Improved structures were needed for diverting water with reduced sediment content, as many canals were affected by sediment and had reduced capacity, causing excessive losses and requiring excessive labour to maintain. Technical assistance was also needed by farmers' associations and others in the delivery of water. The same constraints cited above existed, but were accentuated. Inappropriate centrifugal pumps were used and difficulties in extracting water during low river levels were major problems.

4.2.1 Legal aspects

The former Italian Somalia had a legal enactment until independence in 1960. Parallel to this legal enactment, Islamic and Somali customary water law were also applied. The Majelle (Ottoman) code which regulated the use of water in Somalia until 1922 had a provision that entitled everyone to use the water from rivers and lakes for irrigation purposes without infringing the rights of third parties.

According to traditional local customs, the right to use water for irrigation depended only on access to land along the river, and anyone who purchased a pump and owned a right to use land along the Juba and Shabelle Rivers could pump water. No approval or registration was required. Such a situation resulted in water misuse and wastage. In 1984, FAO mission within the project TCP/SOM/2314 (ma) finalized a bill making provision for Coordinated Planning and Implementation of Water Resources Development for the regulation of water use and for the control of water pollution (Natural Water Resources Law, 1984).

4.2.2 Institutional aspects

The mechanisms for coordinated water development and management in Southern Somalia existed in relevant legislation, especially the National Water Resources Law of 1984. This law ensured the regulation of access to and use of the Juba waters. Water legislation institutionalized water management through laws that regulated functioning of the institutions involved. This arrangement established the ways in which water could be exploited nationally, and endowed organizations with certain resources and the authority to facilitate development and efficient utilization of water resources.

4.2.3 Organizational structure

Several organizational approaches to the diversion and delivery of water to farms existed. One such structure involved the Lands and Water Department in the Ministry of Agriculture.

The functions of the Land and Water Department for water control for improved irrigation were:

- Administration of water law and allocation of water rights for both surface and groundwater:
    - Planning, design, and supervision of construction of irrigation works
    - Management and monitoring of diversions, and use rights to surface and river waters
    - Delivery management of irrigation water (including planning. design, construction, operation, and maintenance) for projects, estates, private groups and others

  - Development of water supplies
  - Monitoring and evaluation of water resources for irrigation
  - Initiation of an on-farm water control service
- Extending irrigation areas through better management of water and the development of additional supplies.
- Providing technical and administrative support and any necessary backstopping for effective management of both the project and the entire irrigation sector.

Within an irrigation scheme, there was a well defined structure of management from the top to the lowest level. An example of such organization for Mogambo irrigation project is given in Annex 4 of this document.

4.3 Water management agencies

Water management was most effective if regional agencies were established within the physical limits of a catchment, and were responsible for regional water planning and management. Efforts have been made to create water development agencies for both the Juba and Shabelle River basins with the aim of streamlining the water sector. The major development agencies are discussed below. However, it should be mentioned here that the development agencies were never implemented, mainly due to the lack of a central government. They however provide a good basis for future developments in the water sector.

4.3.1 Juba Valley development agency

The Master Plan for the Juba Valley development recommended the establishment of a Water Development Agency for the Juba Valley. The functions of the agency were outlined as follows:

2) Formulating and maintaining an inventory of water supply and uses in the catchments.
3) Operating and maintaining water installations necessary to regulate quantity and quality of water in the catchments.
4) Reviewing and, where appropriate, approving execution and operation of public or private projects that might affect the quantity and quality of water resources in catchments.
5) Determining measures needed to ensure efficient distribution and use of water in the region, including measures to be taken in the event of drought.
6) Determining measures needed for flood protection.
7) Determining measures for water conservation and catchment protection.
8) Determining measures to be undertaken for preventing or controlling the transmission of water-borne diseases.

The Water Development Agency would manage the implementation and operation of irrigation as well as water development, using the following instruments:

- Licences for water use (of limited duration, specifying maximum quantities to be used for relevant periods of time).
- Discharge permits (specifying effluent quality, and specific levels of contaminating ingredients in relation to the river flows).

- Abstraction and discharge tariffs (based mostly on systematic measurement of water quality supplied and promoting the efficient and beneficial use of water).

The Water Development Agency for the Juba River was constituted to be managed by a National Water Committee consisting of the following:

- Ministry of Planning
- Ministry of Juba Valley Development
- Ministry of Agriculture
- Ministry of Livestock
- Ministry of Forestry
- Ministry of Range
- Ministry of Health

The Committee dealt with water and water-related issues, including water legislation. The administration of water development in the Juba Valley rested with the Ministry of National Planning and Juba Valley Development (Agrar-Und Hydrotechnic GMBH, 1990).

4.3.2 Shabelle River authority

In 1963, the United Nations commissioned a consultant to examine the need for an authority to control the abstraction of water from the Shabelle River. The report submitted included a draft water law, "*the Organization of Water Law No.13"*, which was published in 1964 and adopted by the Somali Government.

The Organization of Water Law No.13 was passed and became effective on 1st August 1966. However, there was no evidence that the provisions of the Act had been implemented which was essential to ensure an orderly development of the Juba and Shabelle River basins. Article 7 of the Act provided for the Water Department to maintain a register of water users. The implementation of this article was to ensure that the register would be complete to enable verification of pumps recently used and/or with ownership rights.

Article 10 of the Act allowed for any rights to be revoked if a user had not made good use of it during the preceding year. The present Water Law in Articles 14 and 16 provided for the setting up of water committees at both national and regional levels. A single regional water committee was proposed for the whole of Shabelle River basin, with the following members:

- Ministry of Planning and Commerce (Representative)
- Ministry of Public Works (Representative)
- Chief Engineer, Shabelle Division-Irrigation Department
- Director, Water Department
- Ministry of Agriculture (Representative)
- Ministry of Justice (Police Representative)
- Ministry of Health (Representative)

The Article further recommended that the representative from Planning and Public Works act as the co-chair to the committee. The functions and responsibilities of the chair were:

- To oversee the overall implementation of the Shabelle River basin development agenda
- Review water permit applications
- Compile a first register of river users
- Factual and technical investigations concerning the granting of water permits
- Ascertain existing water use
- Declare restricted use areas
- Assist the Water Department with planning and administration of water use on local, regional, or watershed basis.
- Provide technical assistance to individual water users` associations, local administrations, other users and all aspects of water utilization

The overriding logic was premised on the ability of the committee to carry out these functions efficiently and to provide a firm base for effective future management of the waters of Shabelle River basin. The roles of the Shabelle River Authority were as follows:

- Flood control
- River gauging
- Monitoring ground water levels and quality
- Registering present users of river water and groundwater
- Development planning for the river basin
- Licensing abstraction of river water and groundwater for both present and future users
- Operation of the Jowhar Off-stream Storage Reservoir (JOSSR)
- Enforcement of abstraction controls
- Maintenance of barrages and canals
- Control of water-borne diseases
- Development of fisheries

Water allocation passed to the Director of Land and Water in the Ministry of Agriculture, now responsible for the whole of Somalia. This Department maintains canals and barrages in the irrigation areas and is also responsible for flood control in both Shabelle and Juba Rivers.

4.3.3 Settlement development agency

The Settlement Development Agency (SDA) was established in 1975 and was responsible for drought rehabilitation programmes in the country, direction and coordination of the settlement programme and liaison with other Ministries and donors. Secondly, the agency provided technical supervision, procurement of production plants, agricultural machinery and other physical inputs, and was closely involved in detailed planning and aid agencies (Hunting Technical Services Limited, 1980).

The socio-economic efficiency of water use was determined to a large extent by legal tools and fixing of charges for water, in-stream water use and effluent disposal, etc. as well as variations and exemptions from such charges. The degree of such influence depended on local and particular economic conditions. Medium- and large-scale users represented the major part of water demand and overuse. Adequate economic tools were formulated and enforced to manage these categories of irrigators. Water for large-scale agriculture and industry was applied under economic conditions, because these consumers derived economic benefits from water utilization and were able to pay.

5. Establishment of Digital Irrigation Infrastructure Dataset

This part of the assessment aimed at establishing a comprehensive spatial dataset for Somalia's irrigation infrastructure along the riverine areas. The data generated established the pre-war and current status of irrigation infrastructure in Somalia. The study managed to create an irrigation infrastructure dataset for Somalia including; canals, barrages, and irrigation schemes and projects. The information available in the dataset can be useful for future rehabilitation programmes of irrigation infrastructure in Somalia.

It must be noted from the outset that the construction of this spatial dataset is based on digitisation of historical maps/reports and interpretation of satellite imagery. Although care was taken in the construction of the dataset, there has been no field exercise to verify the work at this time and therefore some errors or omissions may occur in the dataset.

5.1 Methodology

The spatial dataset was developed in three stages; first, digitizing canals from scanned and georeferenced 1:100,000 topographic maps, secondly digitizing irrigation canals from satellite imagery and finally, digitizing irrigation schemes/projects from feasibility studies and/or project reports.

Irrigation infrastructure was digitized from scanned and georeferenced 1:100,000 topographic maps of Somalia, as shown in Figure 5.1 below. The maps were produced by stereo photography using aerial photography in the early 1970's. They were originally printed by the Bureau of Cartography, Ministry of Defense, Somalia Democratic Republic in the late 1970's, reprinted by Canadian Forces Mapping and Charting Establishment from reprographic material of native Somalia mapping by the British Director General of Military Survey. Revisions were made by the Defense Mapping Agency Hydrographic / Topographic Centre, Bethesda, MD, in cooperation with the Canadian Forces Mapping and Charting Establishment in the early 1990's.

Digitizing was originally done by the Regional Centre for Mapping Resources for Development RCMRD (2004). This dataset contained omissions and errors when checked against the topographic maps available at SWALIM. SWALIM, cross checked and re-coded the lines to correct the previous errors. Irrigation infrastructure that was omitted was re-digitized and topological errors such as overshoots and undershoots were also eliminated. These corrections were done only using topographic maps covering the irrigation areas of South and Central Somalia. Canals digitized from the topographic maps were considered to be baseline canals. Figure 5.1 shows a screenshot of the canals as shown on a topographic map sheet.

SWALIM further digitized canals from LANDSAT and ASTER satellite images between the years 2000-2002 while verifying the previous digitization work from the topographic maps. LANDSAT is a series of NASA satellites that collects data of the Earth's surface on a global basis and the program has been in operation for over 32 years. The current LANDSAT 7 collects data at a resolution of 30m in the multi-spectral bands and 15m in the panchromatic band.

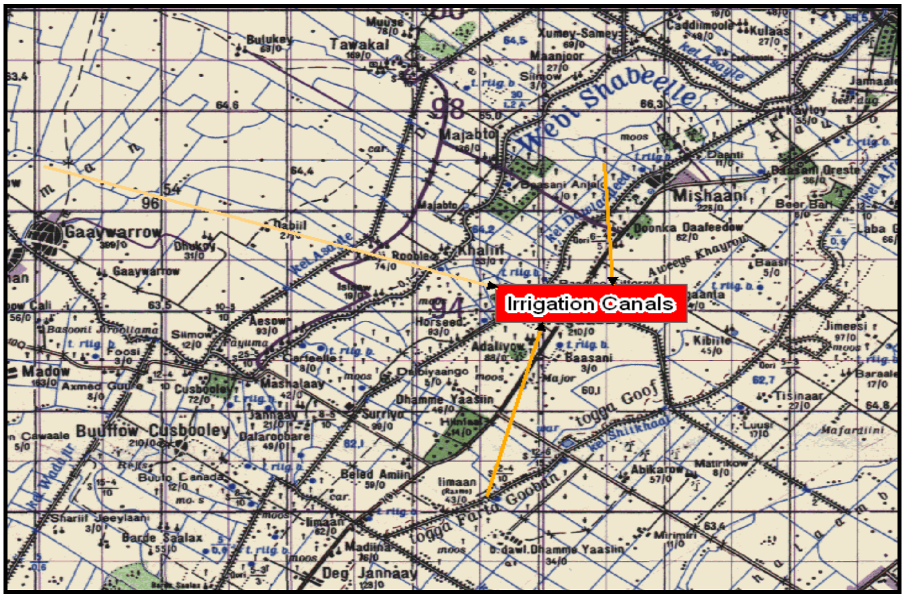


Figure 5.1: Toposheet canals

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System. ASTER is a cooperative effort between NASA, Japan’s Ministry of Economy, Trade and Industry and Japan's Earth Remote Sensing Data Analysis Center. ASTER captures high spatial resolution data in 14 bands, from the visible to the thermal infrared wavelengths. The resolution is 15m in the visible and near infrared wavelengths.

New canals identified on the satellite imagery were added and classified as recent additions i.e. not found on the topographic maps. The study found out that, some new canals were developed in the 80s and 90s, while in some cases, the development of new canals was an improvement of the previous canal infrastructure. Figures 5.2 and 5.3 show canal infrastructure on satellite images.

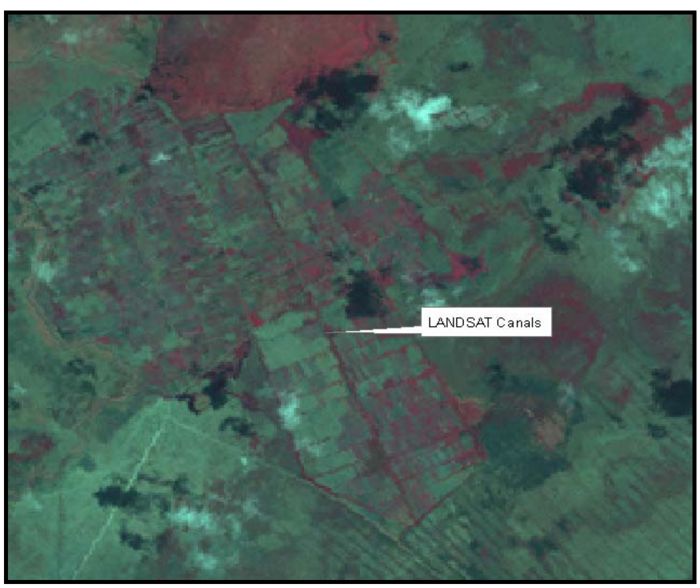


Figure 5.2: Landsat imagery canal infrastructure

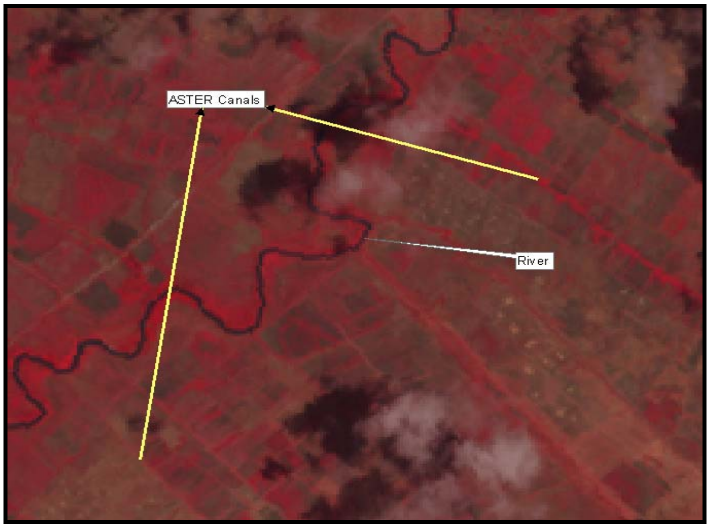


Figure 5.3: ASTER imagery canal infrastructure

Figure 5.4 show some comparisons between the canal infrastructure as seen on the topographic maps and the same area, Balcad in Lower Shabelle Region, on the satellite imagery. As can be seen from the figure, the image shows canal infrastructure but none shows on the topographic map. This means that canals were built sometime during the 1980s or 1990s.

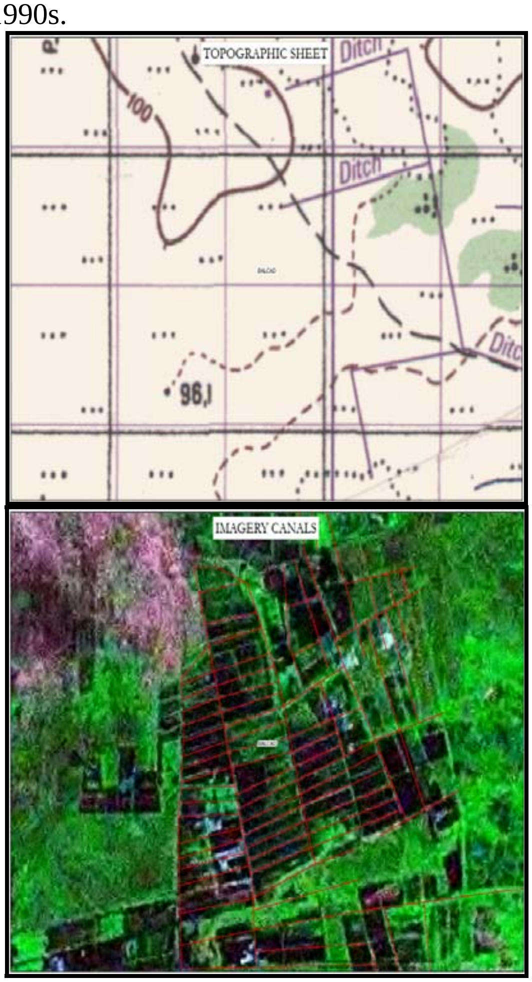


Figure 5.4: Change comparison between toposheet and imagery

In some cases as noted in Figure 5.5 below for the Afgoi area, canal infrastructure of the topographic maps (yellow) differ with the infrastructure as identified from the satellite imagery (red).

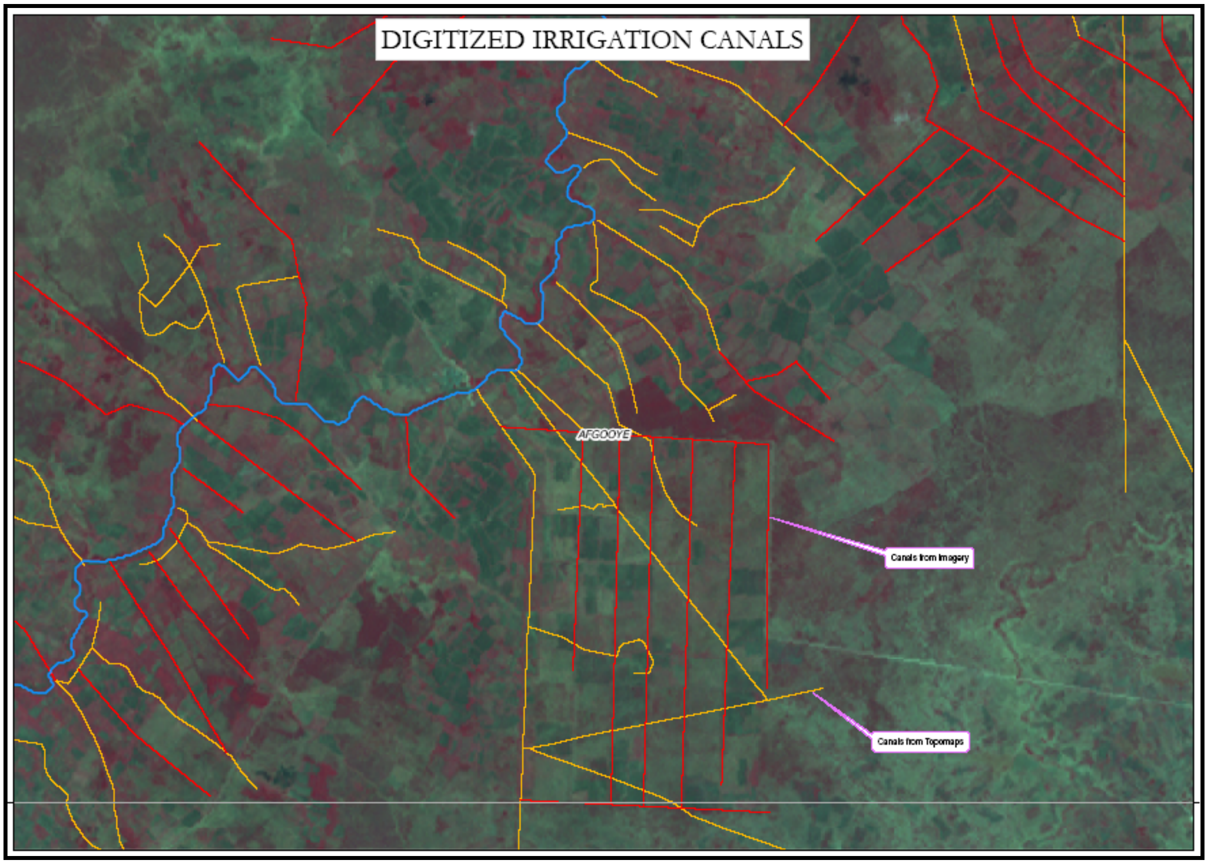


Figure 5.5: Digitized irrigation canals

All irrigation layers captured from the topographic maps and satellite imagery have been fully documented and the method of capture fully described. The details provided for each canal in the attribute table database includes the scheme served, crops grown and where available canal name, as shown in Table 5.1 below.

Table 5.1: Example of attribute table of canals digitized

Name	Topo/Image Check	Schemes/Projects	Crops grown
Afraad (Cessare Maria)	TOPO	Shalambood Project	Rice
Afraad (Cessare Maria)	TOPO	Wagaade Zone	Banana
Afraad (Cessare Maria)	TOPO	Shalambood Project	Rice
Afraad (Cessare Maria)	TOPO	Golweyn Project	Banana & Fruit trees
Bakooro	TOPO	Haduuman Zone	Banana & Fruit trees
Bakooro	TOPO	Jeerow Zone	Banana & Fruit trees
Bakooro	TOPO	Tahliil Zone	Banana & Fruit trees

Name	**Topo/Image Check**	**Schemes/Projects**	**Crops grown**
Busley	TOPO	Bandar Zone	Banana & Fruit trees
Caanoley	TOPO	Haduuman Zone	Banana & Fruit trees
Cabdi Abuukar	TOPO	Refugee Farm	Maize, Sorghum & Fruits
Cabdi Fadir Siidow	TOPO	Degwariiri Zone	Banana, Maize, Sesame & Fruits
Cabdi Keelow	TOPO	Asayle Project	Banana, Maize, Sesame & Fruits
Cabdilahi Mudey	TOPO	Degwariiri Zone	Banana, Maize, Sesame & Fruits
Canalow	TOPO	Jeerow Zone	Banana & Fruit trees
Ceel Wareegow	TOPO	Refugee Farm	Maize, Sorghum & Fruits
Ciise Cabdi Reerow	TOPO	Degwariiri Zone	Banana, Maize, Sesame & Fruits
Dhame Yasin (Bufow)	TOPO	Genale Zone	Banana
Dhame Yasin (Bufow)	TOPO	Shalambood Project	Rice

Agencies active in the agricultural sector in Somalia, including CEFA, UNDP, Agrosphere and CARE also provided SWALIM with data. Figure 5.6 shows the data obtained from partner organizations as compared to data digitized in SWALIM.

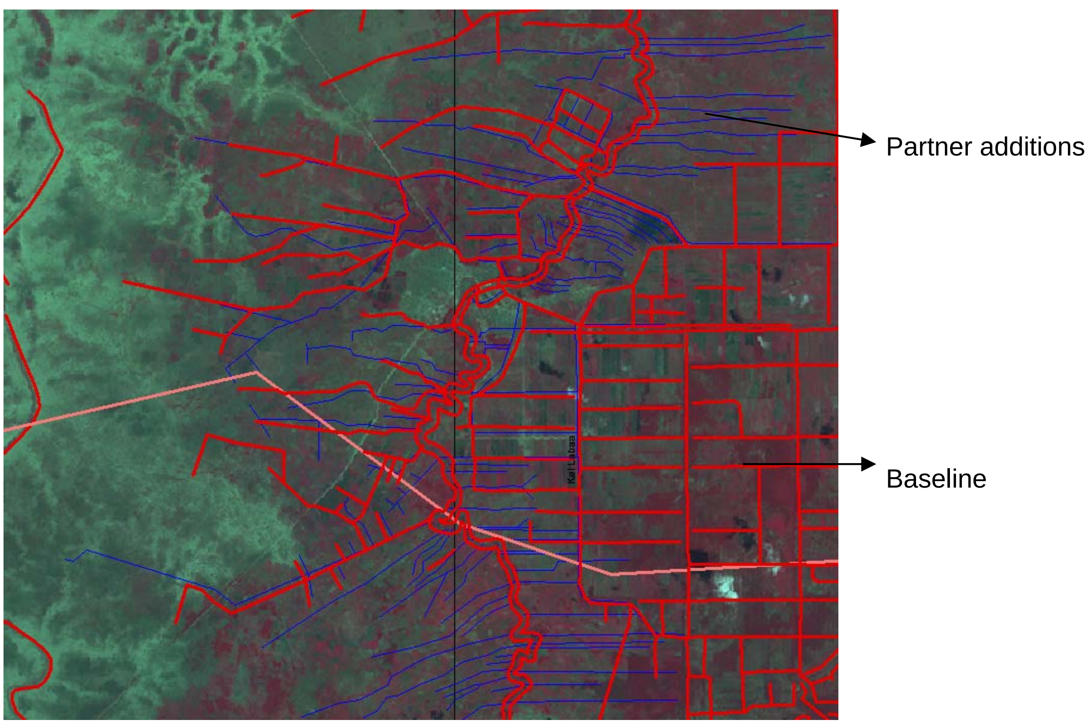


Figure 5.6: Partner data with baseline digitized canals

Partner data also shows that river embankments have been weakened by farmers in an attempt to access water since most of the canals are silted, barrages broken with vandalized gates and lack of coordination along the river basins by farmers.

Initial determination of operational status involved use of Normalized Difference Vegetative Index (NDVI) to identify whether irrigation infrastructure was fully, partially or not operational. This was also complemented by inputs received from the two irrigation workshops that were held in Nairobi and Baidoa. An example of the use of NDVI can be seen in Figure 5.7.

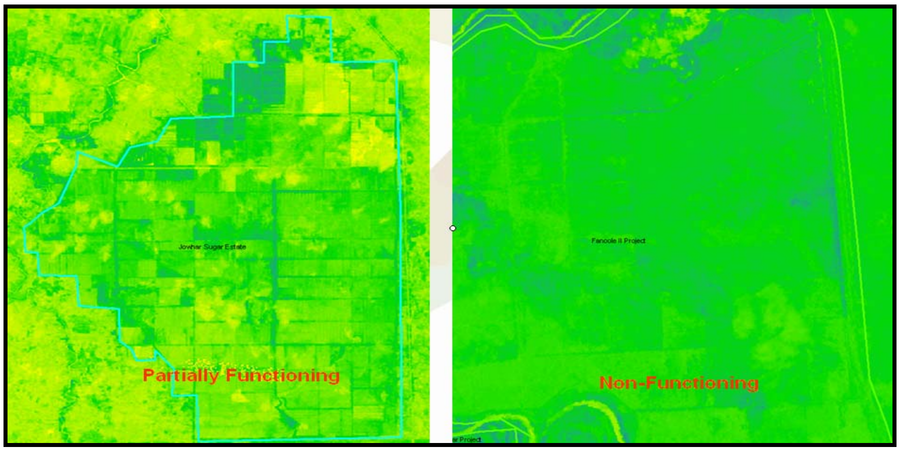


Figure 5.7: NDVI analysis

Verification of the spatial dataset was done through the two consultative workshops held in Nairobi and Baidoa. These workshops helped SWALIM in identifying priority areas for coordinated interventions within the irrigation sector (Refer to Workshop reports).

5.2 Results

From the assessment, SWALIM developed an irrigation database comprising of canals, barrages and irrigation schemes/projects in the riverine areas of Southern Somalia. At least 32 medium to large irrigation schemes were identified and mapped, and their command areas established based on pre-war studies or by use of GIS spatial techniques and in some cases experienced personnel.

Overview maps for the digitized irrigation schemes and infrastructure in Shabelle and Juba basins are shown in Figures 5.8a and 5.8b respectively. Detailed maps of individual irrigation schemes are provided in Annex 3 of this document. However, there is need to acknowledge that the project boundaries still await field verification. A summary of the identified schemes/ projects and their operational status is also provided in Tables 6.4a and b in Chapter 6.

This information is available in SWALIM for future rehabilitation/interventions to ensure alleviation of hunger through improvement in food security and production. To request for any of these maps, please contact SWALIM using the email enquiries@faoswalim.org.

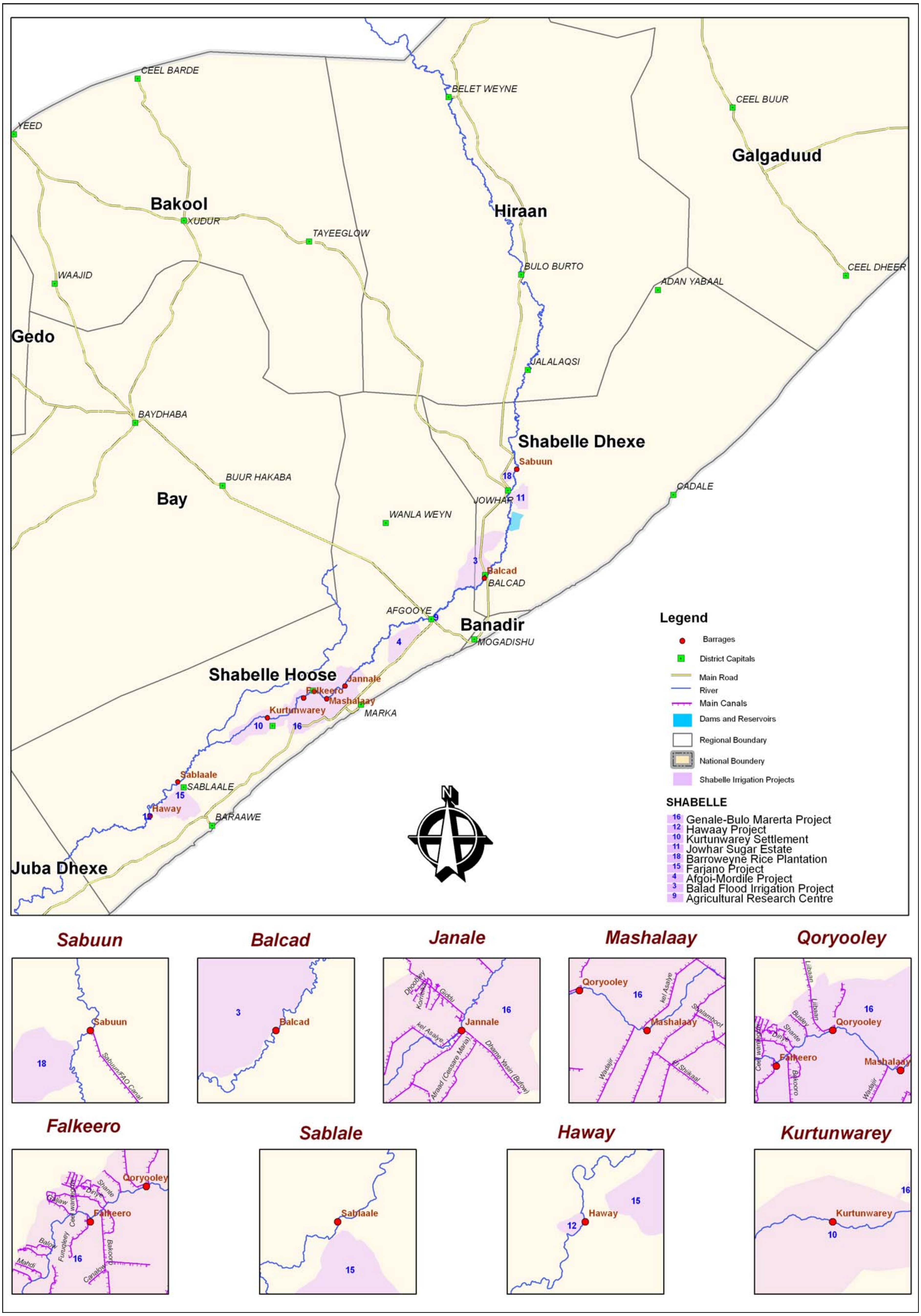


Figure 5.8a: Irrigation schemes and infrastructure in Shabelle River

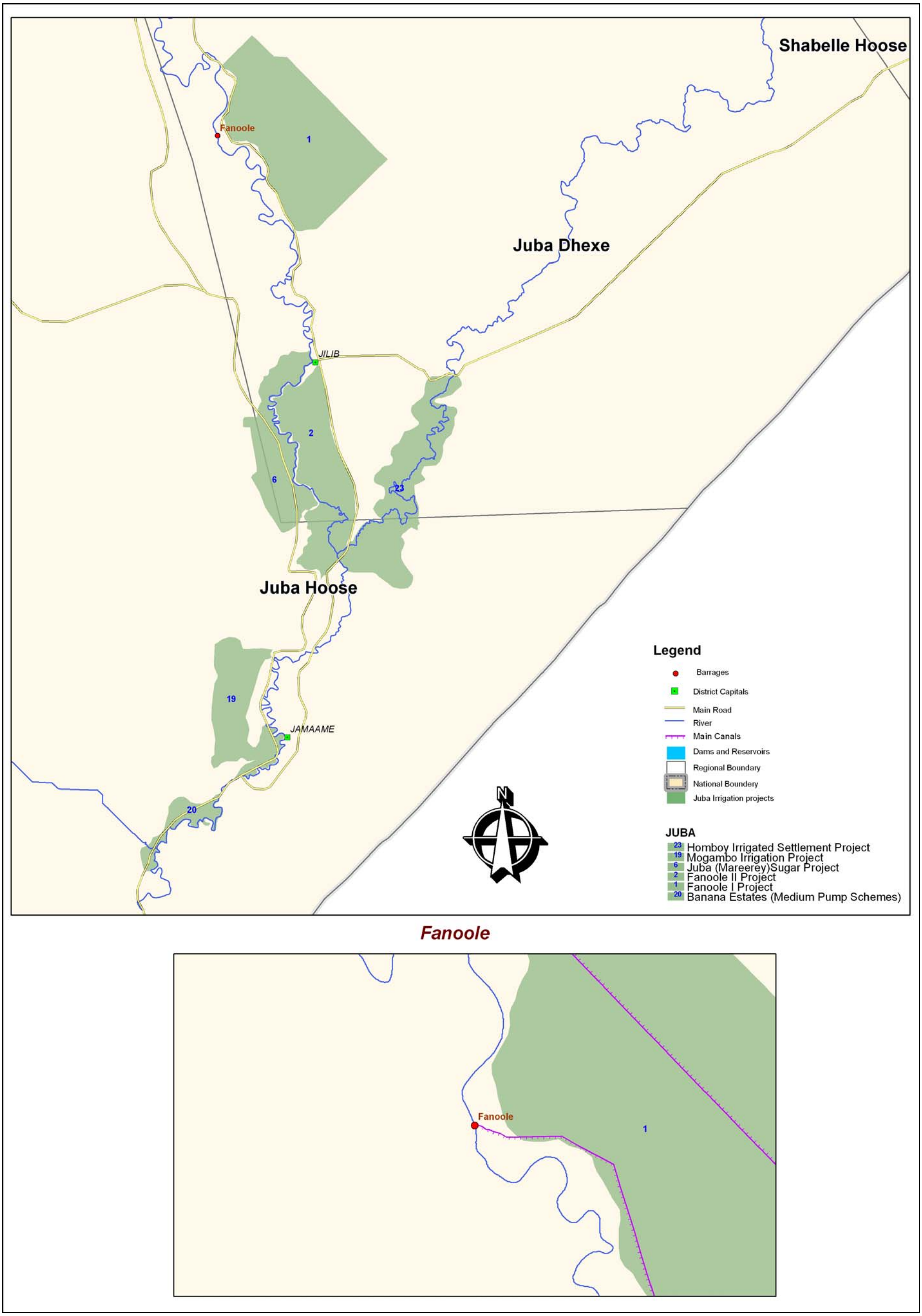


Figure 5.8b: Irrigation schemes and infrastructure in Juba River

6. Status of Irrigation Infrastructure / Schemes in Southern Somalia

6.1 Development of Irrigation in Southern Somalia

Southern Somalia is traversed by the Juba and Shabelle rivers, both of which originate in the Ethiopian highlands. The two rivers have for a long time been used for irrigation by farmers in the medium to large irrigation schemes in Southern Somalia. Irrigation water is abstracted either by barrages with weirs controlling water flow into primary canals, or by pumped intakes drawing water from the rivers into primary canals that commandeer water into secondary canals (EC, 2002).

The considerably high potential for irrigation in the two river basins led to the development of several schemes as early as 1920s to provide food security and alleviate poverty for the people living along the riverine areas. Both rivers experience frequent floods, depositing vast amounts of sediment which make the river valleys the most fertile areas in the country. The administrative regions endowed with this potential are Hiraan, Middle Shabelle, Lower Shabelle, Middle Juba, Lower Juba and Gedo Regions (Figure 1.1).

In 1920, during Italian colonization, certain areas were brought under controlled irrigation and a wide range of commercial crops tested by Italian concessionaires. Cotton and bananas were the main crops grown during this period. Between 1950 and 1960, further feasibility studies were carried out for pilot projects and more detailed soil and topographical surveys. As a result, a number of irrigation projects were designed and implemented (UNDP/FAO, 1969). In 1962, a study by Hunting Surveys Corporation Ltd recommended the establishment of an Agricultural Development Agency. In 1965 this agency was created and was responsible for the expansion of future irrigation developments in Southern Somalia.

In 1967, UNDP moved in and within the framework of earlier programmes undertook a feasibility study on the irrigation and flood water controls on the Shabelle River basin. The studies were focussed on cropping patterns, irrigation designs, water management and economic analyses to determine the viability of irrigated agriculture in the basin. The Agriculture and Water Surveys study established that, although the Italians had introduced controlled and pumped irrigation along the Juba, inundation irrigation (based on high floods) was developed in depressions of the floodplains where, as was the case along the Shabelle, canals were constructed to divert water from the river to low-lying tracts of land. Major crops grown included maize, sorghum, sesame, cotton and vegetables.

In 1976, controlled irrigation system was established at Jowhar in Middle Shabelle to provide irrigation water to sugar plantations, and at Genale, Lower Shabelle, controlled gravity-flow irrigation system was developed for banana plantations. A number of pumped irrigation systems from the Juba and Shabelle provided water to plantations growing bananas, vegetables, maize, cotton, sesame and groundnuts. Between 1980 and 1990 the irrigation areas largely benefited from a well-established network of canals and drains, allowing for a consistent supplement to the scarce and unreliable rains, with abundant waters from the Shabelle and Juba rivers. For many years, fertile soils and a favourable climate sustained a high performance of both cash and food crops under irrigated conditions, while extra water was used for leaching practices that kept salinity build-up under control (EC, 2002).

The break out of the civil war in 1991 led to rapid deterioration of the irrigation infrastructure in Southern Somalia. The operational status of the irrigation schemes, determined by the efficiency of water distribution system(s) for particular irrigation schemes, decreased drastically as a result of poorly managed intake and conveyance systems.

The status of the major irrigation infrastructure both before the break out of the civil war and at present are discussed below. The pre-war status of the irrigation schemes is determined mainly from literature, while the current status is determined from SWALIM's database created using GIS techniques, field engineering assessment carried out at the barrages and the irrigation expert workshops organized by SWALIM for the barrage operators and other stakeholders in the irrigation sector in Somalia.

6.2 Shabelle Valley Irrigation Infrastructure and Schemes

In the Shabelle valley, irrigation started as early as 1920s with the implementation of the Jowhar Sugar Estate. The scale of irrigation development shot up thereafter and at the end of 1980 some 60,000 ha were developed in the Shabelle River basin; half of these in Jowhar District in Middle Shabelle, and half in Balcad District in Lower Shabelle. Only one irrigation scheme, Military Farm/Cash Program was identified in Hiraan Region. The scheme (Annex 3.1) is located in Beletweyne district. It covers an area of 1,435 ha with the main crops grown being maize, sesame and sorghum. Part of the scheme is currently operational.

The barrages identified in Middle and Lower Shabelle and the associated canals and schemes served are discussed below.

Middle Shabelle Region

6.2.1 Sabuun barrage

Sabuun barrage is located in Jowhar district. The barrage was constructed in 1925 to regulate supply of irrigation water and to protect irrigated lands from flooding in Middle Shabelle. The barrage has an irrigable command area estimated at 50,942 ha (Sir Mott McDonald and Partners Ltd, 1984; SWALIM database).

The Sabuun barrage has nine gates and all are stuck and embedded in mud, making it completely non-operational. The upstream of the barrage is blocked by tree trunks, silted up and overlaid by a thick layer of sediment blocking the inlets to the flood relief canal and the Jowhar off-stream supply canal. The gears are broken and the walk rails are missing as a result of vandalism after the break out of the civil war.

Photographs taken in an assessment by SWALIM in the month of September 2007 are shown in Figure 6.1.

Figure 6.1: Photos showing the current status of Sabuun barrage

The main canals associated with this barrage are the Flood Relief (Chinese) canal and the Jowhar Off-stream supply canal.

6.2.2 Flood relief canal – Chinese/Duduble canal

The Flood Relief Canal at Duduble (the Chinese Canal) was initiated in 1969 and a detailed study for implementation started in 1983. The canal was intended to provide flood relief to the then-proposed Duduble Reservoir located 40 km north of Jowhar town. The site was suitable for flood relief works, being a natural spillage area. The canal was constructed for the following purposes:

- To abstract water from Upper section of Shabelle river;
- To reduce risk of flooding in the Shabelle valley;
- To convey floodwaters to the then-proposed Duduble Reservoir (dam) situated 40 km north of Jowhar.

Due to neglect and lack of maintenance, the canal became completely silted, not delivering any water.

Major rehabilitation work was done by UNDP Somalia in 2006. The gates were replaced, walk ways and barrage deck rehabilitated. Desilting of the main intake was also carried out. Although the canal was meant for flood relief, a number of tertiary canals were built by UNDP to assist the communities make use of diverted flood waters for irrigation. The rehabilitation was carried out through community mobilization and local authorities. Local structure for flood management and canal management committees were also established.

6.2.3 Jowhar off-stream supply and outlet canals

This canal, located in Jowhar district of Middle Shabelle region, has a design bed slope of 0.16 m/km; bed width of 2 m; internal side slopes of 2:1 and design capacity of 50 m^3/s. It was constructed in 1980 for the conveyance of floodwaters from the Shabelle River to Jowhar Off-stream Storage Reservoir during high floods. The Jowhar Off-Stream storage project was conceived in the late 1960s, planned in the mid-1970s and implemented in 1980 to facilitate a degree of regulation and control of Shabelle River water resources. The reservoir covers an area of approximately 100 km^2, with a design capacity of 200 million m^3. It makes use of a natural depression directly downstream of the Jowhar Sugar Estate on the left bank of the Shabelle River. It comprises two low earthen embankments closing against the left bank river levee to the west and a high ridge to the east.

From the recent SWALIM assessment, the Jowhar offstream canal was found to be completely buried, overgrown by trees and farms. The reservoir has a thick layer of sediment and does not contain any water.

An outlet canal to the reservoir is situated at the lowest point of a natural depression crossed by the south embankment 3.1 km from the Shabelle River flood bund. The structure comprises 4 x 4 metre-wide sluice gates with a total capacity of 25 m^3/s at full supply level (Sir Mott McDonald and Partners Ltd, 1984; SWALIM database). The canal is currently damaged, with no water outlet.

Two irrigation schemes, Baro Weyne rice plantation and Jowhar sugar estate benefited from water diverted using the Sabuun barrage.

(i) Barroweyne rice plantation

The Baro Weyne rice plantation is located upstream of Jowhar Sugar estate, on the Shabelle River in Jowhar district. The scheme was initiated in 1982 to grow rice and maize under a gravity-fed irrigation system. The irrigated area covered 180 ha and extension potential was estimated at 4,200 ha. Map for the Baro weyne rice plantation is attached in Annex 3.2. The scheme is currently operating partially.

(ii) Jowhar Sugar estate

The Jowhar Sugar estate (Annex 3.3) was irrigated from the 24.2 km Jowhar off-stream canal. The scheme, located in Jowhar/Balcad district, initially used to obtain water from the Luigi di Savoia and Duchess d`Aosta canals on the left bank of the Shabelle River. The initial canal was constructed in 1920 to irrigate sugarcane on 10,579 ha of low-lying floodplain through a gravity-fed irrigation system. Potential for scheme extension was estimated to be 32,357 ha.

6.2.4 Outfall into Shabelle River

The supply canal outfall comprises a 19 m-wide weir placed in the northern reservoir embankment, close to a high ridge to the east of the reservoir. The weir crest is set 0.75 m above the design level of the canal bed. The downstream face of the weir includes eight rows of baffle blocks, a gravel-filled basin and dry stone pitching providing protection against erosion up to 25 m downstream of the weir base. A bridge deck was provided directly above the weir (Sir Mott McDonald and Partners Ltd, 1984; SWALIM database).

At present, the weir crest is completely eroded and is inseparable from the canal bed. The downstream face of the weir has been eroded and does not provide protection against erosion as was intended.

6.2.5 Balcad Barrage

The Balcad barrage is located along the Shabelle River, in Balcad district. Little information is however available about the barrage.

Iraqsoma cotton project - Balcad cotton scheme

This scheme is located on the right bank of the Shabelle River, downstream of Balcad and west of the Balcad to Jowhar road in Balcad district. The scheme was initiated in 1967/1968 to grow cotton, sesame and maize crops through a gravity-fed irrigation system. The irrigated area covered 10,000 ha with expansion potential estimated at 14,700 ha. Map of the scheme is attached in Annex 3.4 (Sir Mott McDonald & Partners Ltd & Hunting Technical Services Ltd, 1969; SWALIM database). At present only part of the scheme is operational.

Lower Shabelle Region

Irrigation in Lower Shabelle is more developed than the other regions of Southern Somalia. Many barrages were constructed to control water for the irrigation fields. Afgoi irrigation scheme and the Agricultural Research Centre are the most upstream irrigation projects in the region.

(i) Afgoi/Mordille irrigation scheme

This scheme is located on the left bank of the Shabelle River about 19 km downstream of Afgoi between the Afgoi - Merka main road and the Afgoi - Barire earth road running close to the river in Afgoi district (see Annex 3.5 for scheme map). Irrigated area in the scheme is estimated to have been 1,560 ha with a potential for extension of 19,365 ha.

(ii) Agricultural Research Centre

The scheme (Annex 3.6) was initiated in 1967-1968 as an agricultural research centre where the following crops were considered for in-depth research and suitability investigations: bananas, grapefruit, sorghum, sugarcane, cotton, oilseeds (groundnuts, sesame) and vegetables, using a pump irrigation system. Irrigated area was 1,560 ha and the extension potential is estimated to have been 4,500 ha. (Sir Mott McDonald & Partners Ltd, 1969 and Hunting Technical Services, 1969; SWALIM database).

6.2.6 Genale barrage

The Genale barrage is located along the Shabelle River in Qorooley/Marka Districts. The barrage was commissioned in 1927 to:

- Regulate the river level at Genale.
- Divert water in the canals Cessare Maria (Primo Primario, also known as First Primary Canal) including Primo Secondario (First Secondary Canal) on the left bank and Asayle canal on the right bank.
- Control and reduce flooding downstream by diverting water through Cessare Maria to the dunes near Sinay and through Primo Secondario to the Shangaani basin through the Gofca channel (a remnant of the probable previous Shabelle riverbed).

The barrage, with a command area of 67,440 hectares used to serve approximately 75% of the former banana growing area in Lower Shabelle (Sir Mott McDonald and Partners Ltd, 1978; SWALIM database). In addition to the above mentioned canals, the barrage serves several other canals including Giddu, Sigaale East and West, Degwariri, Jiidow and Busley.

During the SWALIM assessment, all the 11 gates of the barrage were found to be corroded below water in the slide channels (Table 6.1). The screw spindles are equally corroded and embedded in the concrete cross walls and need replacement. The gates lifting mechanism (gear box) is completely run down and is not operational, rendering the barrage non functional at the moment (Table 6.2).

The barrage concrete deck is weak, the edge beam, the concrete column, the handrail beam concrete and all the reinforcements for the deck, beams and columns are damaged and broken.

The columns, the beams as well as the sawn form work to vertical sides of both upstream and downstream of the barrage, the riverbanks and the channel bed have substantial silt deposition. The gates located in the mid right section of the barrage are operational and allows desilting in the mid right section of the river while most of the gates in the mid left section of the river are not operational or only partially operational.

CARE has already established a barrage management committee for the operation of this barrage beside canal management committees for the primary canals taking water from the barrage.

Table 6.1: Condition of Genale barrage gates[3]

Gate No	Condition
1	Submerged and cannot be seen from bridge
2	Stuck
3	Stuck
4	Stuck
5	O.k.
6	In place but condition unknown as the gear box casing is broken
7	In place
8	In place
9	Stuck
10	In place
11	Stuck

Table 6.2: Condition of Genalle barrage lifting mechanism

Lifting mechanism number	Condition
1	Gear box not in place

[3] Source of Table 6.1 & 6.2: Stable Frames Services, September, 2007, work carried for CARE International under EC funding

2	**Gear box vandalized**
3	**Gear box in working order**
4	**Gear box missing**
5	**Gear box in working order but lacks lubrication**
6	**Gear box casing broken and cannot be operated**
7	**Gear box in good condition but difficult to operate; spindle bent**
8	**Gear box casing broken and cannot be operated**
9	**Gear box not functioning**
10	**Gear box o.k but spindle bent, hence cannot function not in place**
11	**Gear box not available**

Three primary canals (Cessare Maria, Primo Secondario and Asayle) take water from Genale Barrage. All the three canals have direct offtakes to farms from the main channels. (Sir Mott McDonald and Partners Ltd, 1978; SWALIM database). The canals, according to SWALIM's partner agencies, are currently partially operational and need desilting. Most of the regulators and off-takes are broken and in bad condition. Photographs taken from some of the canals are shown in Figure 6.2 below.

Figure 6.2: Status of some of the canals taking off Genale barrages[4]

6.2.7 Cessare Maria primary canal

The canal is 17 km long, draining via Kel Shekaal (6.9 km) into the coastal dunes. It has a design capacity of 1.9 m^3/s, with a command area of 12,000 ha. The canal is heavily silted and need rehabilitation.

6.2.8 Asayle primary canal

Asayle canal is 16 km long, and drains back to Shabelle River. The canal has a command area of 6,500 ha, with design capacity of 1.6 m^3/s. It feeds three secondary canals of 7.3, 4.5 and 4.0 km length, in addition to Kel Shekaal (Sir Mott McDonald and Partners Ltd, 1978; SWALIM database).

[4] photographs taken by SWALIM in September, 2007, tell a story of the status of the Genale barrage and the adjoining primary canals

Rehabilitation work of the Asayle Primary Canal is underway by CARE under EC funding. The rehabilitation will also include 40 tertiary canals and the Genale Barrage. The project will benefit more than 2000 families in Merka and Qoryole districts in Lower Shabelle Region.

6.2.9 Primo-Secondario canal

This canal is 36 km long with a discharge drain of 8 km into the coastal dunes. The command area is 12,000 – 15,000 hectares, while the design capacity is 2.65 m^3/s. It feeds 6.9 km Kel Shekaal secondary canal. The canal, together with Dhamme Yassin canal acted as flood relief diversion channels whenever the river was at risk of flooding. The canals reduced the river flow downstream of Genale passing water into the old storage reservoir or the old river channels at the tail of the system (Sir Mott McDonald and Partners Ltd, 1978; SWALIM database).

In 2006, the canal was rehabilitated by the community and local administration of lower Shabelle. Recently, CEFA also did some rehabilitation, but the canal is still in bad condition due to siltation

6.2.10 Genale Secondary canals

Beside the three primary canals, a number of other canals take water from the Genale barrage. However, few of the secondary canals are functional. These canals normally receive water at high river levels. Table 6.3 lists some of the major secondary canals associated to Genale barrage.

Table 6.3: Other major canals associated to Genale barrage

Canal	Location of off take	Scheme served	Gross area irrigated (ha)
Sigaale	6.4 km upstream of Genale		290
Giddu	1.7 km upstream of Genale		600
Wadajir/Fomari	8.2 km upstream of Qoryooley		2,890
Liiban	Qoryooley	Farahaane Irrigation Project	1,230
Bokore	Felkeerow	Genale-Bulo Marerta Irrigation Scheme	5,730

Genale Bulo-Marerta irrigation schemes

The Genale Bulo-Marerta irrigation schemes (Annex 3.7) benefits from water diverted from the Genale barrage. Comprehensive development of the Genale irrigation schemes started in early 1925 and went on until 1930. During this period, the Genale barrage and its associated canal system were being constructed. At first, cotton was grown in the area but in 1930 bananas were introduced as the major crop, using gravity-fed irrigation from the Genale barrage. In 1955 work started on the Bulo-Marerta project, which included the Qoryooley and Ferkerow barrages and the Wadajir, Liban and Bokoro canals. After modifications, the Primo

Secondario became the most important supply canal from the Dhamme Yaasin. The Wadajir canal joins this; which in turn flows into the Shangaani basin at the tail of Bokoro canal.

The Genale Bulo-Marerta schemes are located about 100 km south west of Mogadishu, on the left bank of the Shabelle River floodplain and are almost the last area of cultivable land before the river enters a swampy area. They occupy a large portion of the Lower Shabelle region in Southern Somalia. In 1978 the gross irrigated area in the scheme was 54,180 ha and the expansion potential was estimated to be 67,410 ha. (Sir Mott McDonald & Partners Ltd, 1978; SWALIM database). Map of the schemes is attached in Annex 3.7 at the end of this document.

The Genale Bulo-Mareta project area was divided into specific projects and development zones. The area was broadly sub-divided into three areas: area north of the Shabelle, area between the Shabelle and Primo Secondario canal; and the remaining area, which was predominantly south-east of Primo Secondario. The specific projects are discussed below, and summarised in Table 6.4b.

(i) *Asayle Project* (Annex 3.7.1)
The Asayle project is located in Qoryooley district. The area used to be irrigated by the Asayle canal, with 4,563 ha estimated to have been under irrigation in 1978.

(ii) *Genale Develoment zone* (Annex 3.7.2)
This project is located in Qoryooley/Marka districts on the eastern edge and left bank of the river. The area used to be irrigated from two secondary canals of the Dhamme Yaasin system. 9,221 ha is estimated to have been irrigated in 1978.

(iii) *Degwariiri zon* (Annex 3.7.3)
This zone is located in Qoryooley district, north of the Shabelle River. Before the break out of the civil war, the zone contained banana plantations and was predominantly irrigated from the Sigaale and Giddu canals. In 1978, the actual irrigated area was 6 748 ha, Sir Mott McDonald & Partners Ltd (1978) obtained from SWALIM digital library).

(iv) *Bandar Development zone* (Annex 3.7.4)
This zone is located in Qoryooley district and lies in the north-west corner of the area between the Liibaan canal and the river. In 1955 under the Bokoro project, the area was to be irrigated by the Liibaan canal; however land surface slope was flat and could not allow gravity irrigation and the proposal was abandoned. In 1978 area of 2,929 ha was irrigated using small canals from the river.

(v) *Banana Drainage project* (Annex 3.7.5)
This project is located in Qoryooley/Marka districts. The first area to be irrigated was on the left bank of the river between the river and the Primo Secondario canal, while later developments covered land on the other bank of the Primo Secondario canal downstream. In 1978 the area under banana cultivation is estimated to have been 3,884 ha, mainly by gravity-fed irrigation system.

(vi) *Der Flood Project* (Annex 3.7.6)

This project is located in Qoryooley district, and lay near the junction of the Sisab and Bokoro canals. In 1978, irrigated area under this project is estimated to have been 862 ha.

(vii) *Grapefruit Production Scheme* (Annex 3.7.7)
This project is located in Marka district and was funded by the EDF. In 1978, the area of irrigated bananas in the scheme is estimated to have been 2,065 ha.

(viii) *Farahane Project* (Annex 3.7.8)
This project is located in Qoryooley/Marka districts on the left bank of the river. It used to be irrigated by small canals directly from the river. 4 883 ha is estimated to be the irrigated area in 1978.

(ix) *Golweyn project* (Annex 3.7.9)
This project is located in Marka district, west of the Shaambood project and is fed from the Primo Secondario canal. In 1978, the irrigated area is estimated to have been 3,313 ha.

(x) *Harduuman Development zone* (Annex 3.7.10)
This project is located in Qoryooley district. The zone lies between Farahane project area and the river and cannot be reliably fed by gravity from the new Gayweerow barrage. By 1978, the area was intensively irrigated from the river, with an estimated irrigation area of 1,960 ha.

(xi) *Jeerow Development zone* (Annex 3.7.11)
This project is located in Kurtunwareey/Qoryooley districts west of the Bokoro canal. In 1978 the gross area of approximately 2,325 ha was irrigated from the Bokoro canal and the expansion potential was estimated at 9,686 ha.

(xii) *Majebto Development zone* (Annex 3.7.12)
The zone is located in Qoryooley district, between the downstream reach and the river. It used to be irrigated from both sides of the channel. The zone is narrow, forming a basin with considerable flooded areas caused by seepage from the Asayle canal and the river. In 1978 the irrigated area was 1,628 ha.

(xiii) *Mukoy Dumis project* (Annex 3.7.13)
This project is located in Kurtunwareey/Marka districts. In 1978 irrigated area of bananas is estimated to have been 9,132 ha and was irrigated from the Bakoro canal system offtake at Ferkerow barrage.

(xiv) *Primo Secondario Banana zone* (Annex 3.7.14)
This project is located in Qoryooley/Marka districts, and was previously used fro banana production. The lower reach was however remodelled to take water to a grapefruit project. In 1978 the area under irrigation is estimated to have been 3,956 ha.

(xv) *Qoryooley project* (Annex 3.7.15)
This project is located in Qoryooley district. It was designed to be irrigated from the Geyweerow barrage, but 90% of the area required low head pumping. The Asayle canal could however irrigate about half the area by gravity. In 1978 approximately 6,379 ha were under irrigation.

(xiv) *Shalambood project* (Annex 3.7.16)
This project is located in Marka district and was first identified in 1969 by Hunting Technical Services Limited. The project area was considered for a rice irrigation project (State Planning Commission, 1977) and was transferred to the Golweyn project. In 1978, irrigated area is estimated at to have been 6,993 ha.

(xvii) *Tahliil Development zone* (Annex 3.7.17)
This project is located in Qoryooley/Marka districts between Farahane and the Der Flood project. In 1978 the area irrigated from the Wadajir and Bokoro canal systems is estimated at 2,903 ha.

(xviii) *Wagaade Development zone* (Annex 3.7.18)
This project is located in Marka district, between the Dhamme Yaasin and Primo Secondario canals. In 1978, the irrigated area of bananas is estimated at 3,461 ha.

6.2.11 Mashallay barrage

The Mashallay barrage is located in Qoryooley/Marka Districts and is 15.7 km downstream of the Genale barrage. It was commissioned in 1986 mainly to:

- Regulate river levels so as to divert water into a 3.0 km canal emptying into Primo Secondario at chainage 13.7 km downstream from its Genale head regulator.
- Provide water to the Qoryooley Irrigation Scheme through a pump lift into a remodelled Asayle canal.

On the date of commissioning the effective water flow in the link canal is reported to have been in the opposite direction, from Primo Secondario to the river Shabelle. The link canal therefore became a drain for the Primo Secondario rather than providing the support flow for which it was designed.

The structure of Mashallay barrage was found to be better than all other barrages assessed during SWALIM survey. The deck is fairly good, as can be seen from Figure 6.3. The reason for the good structure is that there is no provision for traffic on the barrage, as it never functioned due to the above mentioned abnormality of reverse flow. Though, some of the eight gates are stuck in the substructure of the barrage, corroded and not functioning. The walk rails are missing from plunder during the break out of civil war. The lifting gears are rusted and corroded. The lifting gear and electric motors were also looted.

The majority of the canals around the barrage are non-functional since the barrage never operated.

Figure 6.3: Current status of Mashalay barrage

6.2.12 Qoryooley barrage

The Qoryooley barrage is located in Qoryooley District, approximately 26.3 km downstream of the Genale barrage. It was commissioned in 1955 for the purpose of regulating the river level so as to divert water into Fomari (Wadajir) and Liban canals, as well as a number of small canals irrigating farms neighbouring the Shabelle River. Approximately 20 small canals benefit from raised river levels from closing of the barrage gates. The command irrigation area is 4,120 ha, of which 2,890 ha are in Qoryooley Irrigation scheme.

The barrage has a design retention level of 67.16 m^3, and a normal fall through structure of 1.05 m. In most cases, when the Farkeerow barrage is closed the barrage water level downstream is almost equal to the upstream water level. There is evidence that construction on part of the Qoryooley Irrigation Scheme may have started. However there has been no confirmation whether it worked or not.

Since the commissioning of the barrage and testing against its ability to provide water through the link to Primo, it can be assumed that the link to the sump for the Qoryooley Irrigation Scheme was not completed.

Qoryooley barrage is currently in bad condition. The barrage structure is weak with the superstructure made of steel being corroded. The top surface of the deck is irregular as a result of weathered concrete. The deck slab spans across reinforced concrete wall piers which are found to be in good condition. However, the barrage deck is in bad condition and need replacement. The guardrails on the upstream side of the deck are missing while on the downstream side, they are loosely held on to the deck and some sections missing.

The gates are supported by steel stanchions comprising of vertical angle sections and braced angle sections. The gates slide along steel U-channel sections which are welded on the steel stanchions. The vertical spindle that raise the gates is supported at the top of the U-channel sections bolted onto the stanchions. All these elements are in bad condition and need replacement.

An elevated steel walkway runs at the top of the stanchions from where the gates operator rests during operation. The structural steel cantilever members and the steel plate are heavily corroded and require urgent replacement.

There are nine gates mounted in slides fixed into steel structural columns. The first and the last gates are smaller than the rest. The gates are made of thick mild steel plates and reinforced U-channels. The gate plates and reinforcements are heavily rusted and require to be replaced. The slides are either missing or worn out and all of them need to be replaced. The lifting mechanisms are comprised of main gear rack and pinion type, turning wheel connected to the main gear directly. Only one gear is functioning, with three others missing. The rest of the gears are defective, as shown in Figure 6.4.

Structural steel for gate support stanchions in serviceable condition.	Steel walkway atop the stanchions for the gate operator are corroded and require replacement during rehabilitation

Figure 6.4: Status of gates, superstructure and lifting mechanisms in Qoryooley barrage

In general, siltation problem was observed in the upstream side of the river but on a larger scale in the eastern bank between the barrage and Farhano canal off take. In the immediate downstream of the barrage, serious bank erosion has occurred, creating a large whirl pole on both sides of the river which the locals reported to be rapidly growing, Figure 6.5.

Erosion on the left hand side bank downstream of the barrage

Siltation upstream of the barrage

Figure 6.5: Siltation and erosion of Qoryooley barrage

There are two primary canals that take water from the upstream of this barrage. These are: Fomari primary canal, which originates 8.2 km upstream of Qoryooley barrage with a command area of 2,890 ha, and Liban primary canal with a command area of 1,230 serving mainly Farahane irrigation project. The condition of these canals is best described by the photos in Figure 6.6 below.

Figure 6.6: Status of some of the primary canals in Qoryooley barrage area

The famous Liban canal is totally buried with its off-take overgrown by bushes and trees. Part of the canal along the main road to the barrage did not exist at the time of the assessment.

6.2.13 Falkerow barrage

The Falkeroow barrage is located in Qoryooley District and is approximately 39.7 km downstream of Genale barrage. It was commissioned in 1955. The barrage was constructed to regulate the river levels and divert water into Bakooro and other canals, including large canals such as Furuqulay and Barawaqo and small canals irrigating areas adjacent to the river. The barrage has a design retention level of 66.11 m^3.

As Figure 6.7 shows, the barrage deck is poor and weak. There are up stand beams on either side of the slab. The slab is not provided with side spouts for drainage and water stagnates on the top of the deck when it rains. The slab appears to have been done in two layers at varying times but there are cracks on top and below the slab, and the reinforcement steel is exposed. The existing slab deck is structurally unsound All the piers are in good structural condition and don't require rehabilitation.

The barrage abutments have been eroded on the downstream side of the barrage and urgent measures need to be taken to reinstate the river banks and ensure the stability of the whole barrage.

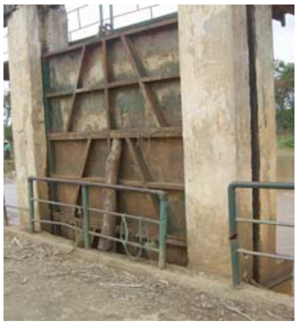
Part of the abutment walling is broken on the Abdi Ali village side of the barrage and this too needs reconstruction. It was noted that plaster has peeled off from various parts of the whole structure and this requires reinstatement.

The barrage has nine gates in total with U-channel slides. About half of them have been submerged in silt. Some repairs on the gates were done in 2002. However the repairs did not achieve much, as all the gates are rusted, and need re-painting. The gate slides are rusty and new ones will require to be installed. There is only one gear to operate the functional gates, which require eight men to carry from one gate to another. Closing and opening of a gate requires three hours.

There exists an elevated steel walkway spanning across the R.C. columns. A new walkway will have to be installed to replace the old one.

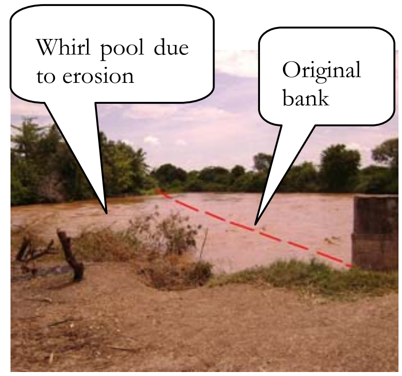
In this barrage, the main problem in the downstream is bank erosion, Figure 6.7. A big semicircular whirl pool has formed on the western side of the river while a triangular one is formed and rapidly advancing.

On the upstream, the river channel is constrained due to siltation on both banks. In the Western bank between the barrage and a nearby culvert crossing located about 50m away is a depressed and eroded area which was reported by the locals to have been caused by river banks overtopping at the immediate upstream of the barrage.



The body of the concrete gate support columns are in generally good condition.

Most of the lifting gears are defective while others are totally missing



The red line indicate the original bank line and all the left of the line has been eroded

Figure 6.7: Current status of Falkerow barrage

Three primary canals take off from the barrage. These are Bakooro, Furuqulay and Barwaqo. The canals provide water to the Farahaane Irrigation project. However, they are silted and overgrown by vegetation. Bakooro is currently under rehabilitation by FAO and CEFA, but the other two remain in bad state. The heavy siltation, vegetation and malfunctioning off-take structure greatly affect the efficiency of the canals.

Figure 6.8: Status of primary canals taking off Falkerow barrage[5]

[5] The top left photo show Furuqulay canal overgrown by vegetation with no gates and regulators, while the other photos show the Bakooro canal under desilting by FAO/CEFA. There is clear evidence of damage in cross regulators

Refugee farms

The scheme (Annex 3.8) is located in Qoryooley/Kurtunwareey districts, and was initiated to grow maize, sorghum and fruits using a direct intake irrigation system. The actual irrigated area covered 5,487 hectares with the potential for expansion estimated at 6,060 ha.

6.2.14 Kurtunwareey barrage

The Kurtunwareey barrage is located in Kurtunwareey District in Lower Shabelle Region, Southern Somalia, and was constructed in 1986. The barrage was constructed to abstract water through canals that supported irrigation by farmers in the villages of Garawlay, Uran-urow, Sheikh Bananey and Afgoi Yare, all of which are located on the right bank. Canals benefiting from water levels raised by the barrage include 1st, 2nd, 3rd, 4th and 5th canals, as well as Dabaray, Faraday, Qarafow, Keli Bahar, Keli Khalif Muse, Keli Abdulahi Shikhal, Canal Ghedi, and Ido Godho canals. The irrigation command area is 5,000 ha, mainly growing maize, sesame, water melon, beans and peas.

The main barrage deck and structure are generally in good condition. The barrage deck slab is also in reasonably good condition except for some worn out sections on the top of the slab and the edges where the reinforcement steel is exposed, Figure 6.9.

The Barrage deck slab in relatively good condition

Parts of Barrage deck slab with Exposed Reinforcement steel

The off take structure of canal no 5 is in good condition but concrete is broken on the underside exposing the steel reinforcement, no gates and lifting mechanisms

Exposed reinforcement of side Walk-way with loosely held Guard rails

Side walk way with cracked concrete

Figure 6.9: A photo gallery showing current status of Kurtunwareey barrage

The walk way slab is badly cracked with the reinforcement steel exposed in most areas. The quality of concrete used to construct the walkway appears to have been very poor. The steel guard rails on the side of the walkway are loosely held due to the failure of the concrete. The walkway slab will require to be demolished and cast a fresh.

Each of the eight barrage gates is supported by two U-channel columns anchored on either side of the concrete piers. The two steel columns are joined at the top by two U-channel steel beams which support the gate lifting mechanism. The steel is in good condition.

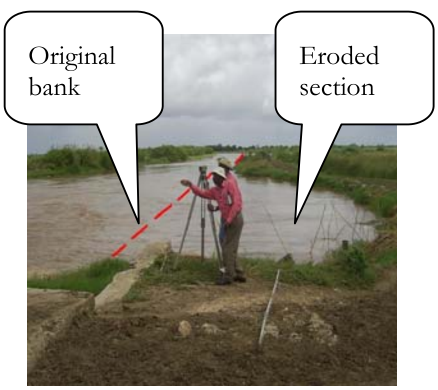
There is also an elevated steel walk way mounted near the top of the steel columns and on which the gate operator steps during gate operation. The walkway structural members and the steel plate are heavily corroded and need to be replaced.

The off-take structure for canal number 5 has double gates with one gate functional while the other is heavily silted and non-functional. The off take structure is in good condition with the exception of the concrete walkway whose concrete is broken on the underside exposing the steel reinforcement.

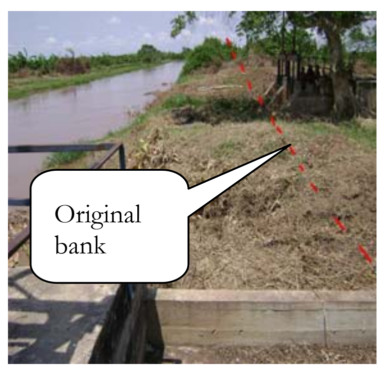
There are 8 gates mounted slides on steel structures. About half of the gates are submerged in silt. The slides are in good condition at the exposed areas but rusted in the submerged sections. The submerged sections require replacement while the exposed ones require minor repairs.

The upstream river reach is very constrained due to siltation on both sides of the banks over a length of about 300m. On the downstream side of the barrage, a big whirling pool of water forms and is progressively eroding the sides. On the East bank, the erosion is eating backwards around the barrage and if not quickly arrested may open up a by-pass of the river around the barrage, causing it to fail completely (Figure 6.10).

Interviews with the barrage operations revealed that the river occasionally overflows the bank at the barrage and has caused a large swamp on the western side of the barrage.



The east banks are eroded on the downstream of the barrage forming a whirl pool.



Siltation of upstream banks leaving the off take structure away from the river reach.

Figure 6.10: Erosion and siltation in Kurtunwareey barrage

Water abstraction through canals that supported irrigation by farmers in the villages of Garowlay, Uran-urow, Sheikh Bananey and Afgoi Yare, all of which are located on the right bank has stopped and canals carry no water. The canals are heavily silted and grown with bushes and tree trunk.

Kurtunwareey Irrigation scheme

The Kurtunwareey Irrigation scheme (Annex 3.9) benefits from water from the Kurtunwareey barrage. The scheme is located in Kurtunwareey District, and was initiated in 1986 to grow maize, sesame and sunflower using a gravity-fed irrigation system off the Kurtunwareey barrage. The irrigated area before the break out of the civil war was 4,900 ha and the potential for scheme extension was estimated to be 29,742 ha. (ADORPIS, 2006; SWALIM digital library).

6.2.15 Sablaale barrage

The Sabaale barrage is located in Sabaale District, downstream of Kurtunwareey Barrage. It was constructed in 1987 to divert water into Sablaale Irrigation Settlement scheme. It would serve small canals irrigating farms neighbouring river Shabelle. The barrage serves Sablaale Irrigation Settlement scheme, where maize, sesame, water melon, beans and peas are grown.

This barrage (Figure 6.11) is considered the best among the barrages surveyed during this assessment. It consists of reinforced concrete structure and incorporates a bridge deck. The barrage has a single main gate and four weirs. The concrete is solid and sound and shows good workmanship. The approach and exit end show neglect and continued erosion over time. The gate is rusty but stable. Though, it requires sanding, priming and painting.

The access to the barrage is clear except for the erosion over time as mentioned above. The earth embankment and road which also acts as retaining wall to the swamp storage area is failing with two main breaks approximately 1.6 km from barrage and several small breaks approximately 3.5 km from the barrage. The water is diverted into swamps leaving little water for feeding the canals. During the assessment, the following was noted:

- A lot of water is flowing outside the barrage point
- The villagers have been cut off and use boats/canoes to get to their homes
- Continuous water flow this direction will result in swamp water level going down to a point that canals served by this barrage will not receive any water.
- The swamp both upstream and down stream is extending rapidly and will soon eat into the arable land
- The irrigation canals are of poor conditions.

Figure 6.11: Snap shots from Sablale barrage[6]

Farjano Settlement irrigation Project

This scheme is located in Sablaale/Barawe districts. It was planned in 1985 as a settlement for refuges to grow their own food, especially sorghum, maize and sesame, using a gravity-fed irrigation system. In 1985 the irrigated area stood at 16,000 ha. The potential for expansion is estimated at 28,740 ha. A map of the scheme is attached in Annex 3.10.

6.2.16 Haway barrage

The Haway barrage (Figure 6.12) is located on the downstream side of the Sablale barrage on the Shabelle River. Proper operation of this barrage is critical to the successful irrigation of the Lower Shabelle region. This is the last barrage in River Shabelle, and was constructed in 1926 to divert water into Haway Irrigation Settlement scheme. It serves small canals irrigating farms neighbouring river Shabelle. The irrigation command area is 3,000 ha, and crops grown are maize, sesame, vegetables, water melon and tobacco.

The current status of the barrage is relatively unstable with the river having changed its course in the vicinity by passing barrage hydraulic structure. The barrage has one side main gate and a number of sluice gates.

A 2004 assessment report recorded that heavy rains in the area eroded and breached river banks resulting in the current river diversion. This has also rendered the barrage sitting on a dry river bed. Consequently the canal diversion headworks were left without enough head to divert water into the existing canals.

Erosion, scouring and undermining are evident in the barrage vicinity. This consists of bush, rubbish, or debris as well as thick silt depositions.

[6] Photos provided by CARE during one of their previous assessment

The structural arrangement of the sluice gates for the barrage consists of several features with the lifting mechanism being the integral part. The lifting mechanism is are of 700mm diameter with single start square threads of pitch. One end of spindle is attached to the gate via sheer through holes drilled for this purpose.

The operating handles are in the form of a rim for the facilitation of lifting the sluice gates. They work with lots of difficulty, though there was no water at the time of the visit. The gates are set high up above the water level. These are two in number and are of vertical sliding type, consisting of double wall plates. They are in good shape but rusty due to the harsh environment. There are four vertical slides and are still in good shape.

The weir is hanging with all the foundations breached. The superstructure consisting of concrete, form work, hardcore fill and scour sluices are all broken and need fills and a new river course diversion.

Figure 6.12: Current status of Haway barrage and its canalization system

(i) Haway Irrigation Project

The barrage is the main source of water for Haway irrigation scheme (Annex 3.11). The scheme is located in Barawe district, and was initiated as part of Farjano prison custody farms built to grow food crops, especially sesame, maize and sorghum to feed prisoners, using a gravity-fed irrigation system. The area previously under irrigation area was 395 ha, with a potential for scheme extension estimated to be 400 ha.

6.3 Juba Valley Irrigation Infrastructure and Schemes

The most important water resource in the Juba Valley is the Juba River, which determines the riverine area ecosystem. The river itself is a habitat for fish and wildlife and interacts with the riparian lands through the regular seasonal floods. In addition, it charges groundwater storage, although not much detail is known about these mechanisms. People make use of the river for domestic and animal watering needs, and for cultivating crops using flood recession techniques. During the 1970s, water of the Juba was used for generating electricity through the Fanoole barrage and provided a basis for modern irrigated agriculture, which is the primary water consumer.

The potential for irrigated agriculture in the Juba valley in 1999 was tentatively put at 160,000 ha. (State Planning Commission). By then, only 14,000 ha were being cultivated under controlled irrigation, while significantly large areas were partly irrigated by uncontrolled flooding (Agrar-Und Hydrotechnic GMBH, 1990).

6.3.1 Pumped Irrigation in Juba valley

(i) Homboy Settlement Project

The Homboy settlement project in Annex 3.12 was proposed, but there are do documents to show that it was actually implemented.

(ii) Mogambo irrigation scheme

The scheme is located in the south-western part of Somalia, on the Shabelle/Juba floodplain in Jamame District. The scheme was initiated in 1986 to grow rice (2,204 ha of surface irrigation and 160 ha. of sprinkler irrigation). Irrigation water was provided using pumping stations and irrigation was achieved with basins of 2 ha each with individual inlets and outlets (Agrar-Und Hydrotechnic GMBH, 1990; SWALIM database). Map for the scheme is attached in Annex 3.13.

(iii) Mareerey sugarcane irrigation scheme-Juba sugar project

This is located in Afmado/Jilib/Jamame districts. The scheme was initiated in 1980 to grow sugarcane irrigated mainly by overhead sprinklers using a pumped irrigation system supplied by two large and two minor pumping stations from Barheere dam. The irrigated area in 1987 was 7,000 ha and the potential for scheme expansion was estimated at 10,720 ha (Agrar-Und Hydrotechnic GMBH, 1990). Map for the scheme is attached in Annex 3.14.

(iii) Banana plantations irrigation schemes

Medium-scale pump schemes supplied primarily banana estates of 30-70 ha with a total area of some 3,400 ha. Between 1986 and 1990 about 140 pumps with an average capacity of 170 litres/second (equivalent to approximately $25m^3/s$) were in operation mainly in the Lower Juba reach below Kamsuma. Medium-scale irrigation for banana production required standard land preparation and irrigation practices comparable to large-scale schemes, as the crop was fixed on the field for at least three to four years, and irrigation layouts could only be changed at great cost. The relative success of this form of irrigated crop production system was only possible with considerable support. Banana farmers were most-affected by the combination of low river flow during the *Jilaal* and uncontrolled water abstraction by upstream farmers. Seawater intrusion constituted an additional peril during this time (Agrar-Und Hydrotechnic GMBH, 1990; SWALIM database).

6.3.2 Fanoole barrage and its canal system

Fanoole barrage is the only barrage in Juba river. It is located in Buaale/Jilib Districts, and was constructed between 1977 and 1982 to divert 33.4 m^3/s of flow to a command area of 15 250 ha. The net irrigable area is 7 750 ha, where two crops of rice used to be grown annually.

Fanoole Rice Irrigation Schemes

The Fanoole barrage and canal system provided water for the Fanoole rice irrigation schemes located in Jilib district. The schemes were initiated in 1977 to produce electricity and to grow rice, maize and sesame crops using gravity-fed irrigation systems off the Fanoole barrage (constructed between 1977 and 1982). The irrigated area in 1987 was 1,800 ha comprising 800 ha under rice and 200 ha under sesame. The potential for scheme expansion is estimated at 8 200 ha. The project was not fully implemented. Maps for these schemes are available in Annexes 3.15 and 3.16. The combined command area for the Fanoole barrage is estimated at 120,000 ha. (Agrar-Und Hydrotechnic GMBH, 1990).

6.3.3 Flood protection works

Reduction of flood damage in the Juba Valley was achieved through an integrated approach involving:

(i) Effective flood storage by the Baardheere reservoir, which would decrease the flood discharges to 700 m^3 or more depending on their size, duration, period of occurrence and reservoir operation.
(ii) Construction of flood protection bunds wherever the river overtopped its banks.
(iii) Increasing the discharge capacity of the Juba river channel (regular dredging of silt deposits in the channel, straightening of river oxbows especially in the Lower Juba).
(iv) By-passing floodwater and storing of floodwater in natural depressions and reservoirs wherever terrain morphology permitted.
(v) Construction of flood relief structures, and gates in bunds wherever a diversion channel was constructed to reduce discharge during floods and efficient operation from these sluices.
(vi) Improving drainage systems in areas where they were insufficiently developed, or disturbed by man-made obstacles such as roads, irrigation canals, flood protection bunds, river embankments, etc.
(vii) An effective flood warning system based on efficient monitoring and interpretation of rainfall and river-flow data, consisting of a signalling, decision-making and operation system (permanent observers, shortwave transmitters).
(viii) Resettling affected dwelling areas and houses.
(ix) Efficient emergency and rescue services equipped by adequate quantities of relevant equipment and machinery.

Application of individual protective measures and their combination/s depended on local conditions such as:

- Terrain morphology and altitude in relation to flood level.
- Size and importance of the area (economic and other losses) affecting decision on the degree of protection required..

- Distance from the planned Bardheere reservoir and its operation (impact of reservoir operation decreases with the size of the intermediate catchments).
- Local infrastructure.

6.3.4 Drainage systems

Drainage was required in the Juba irrigation schemes to:

- Prevent long-term flooding of the irrigated area after heavy rains and floods
- Drain excess irrigation water and water used for leaching

In the large-scale projects, unit drains discharged into branch collector and main collector drains which were trapezoidal in section. Drainage water moved southwards following the natural slope of the ground. Saline water discharged into the river from drains increased river water salinity which was not acceptable in the period February/April. During this period salinity of river water was already high, endangering water quality for abstraction downstream.

In flat depression soils, trapezoidal surface field drains (minimum depth 0.5 m, nominal discharge about 50 l/s) diverted water to escape and collector drains. Elsewhere drainage water flowed to the lower end of fields. The drainage system was designed for rainfall with a return period of 10 years. Deeper drains were required locally to keep the groundwater table at an acceptable depth so that neither water logging nor salinisation of the root zone occurred.

It was observed that the water level in the greater part of the area rose to within 3 to 4 m of the soil surface during the irrigation seasons. The natural sub-surface drainage could not cope with the high percolation losses. Therefore it was necessary to construct control structures (each for 20 - 30 km drainage unit) with dual purpose of throttling the flow to avoid surcharging the main drainage system, and preventing erosion due to the head drop into the main drains. The other drain structures comprised outfalls, canal underpasses, junction and road culverts. Outfall structures discharged drainage flow to the Juba River or to outcropped natural depressions. They were equipped with return gates in order to prevent the river backing up into the drainage system during times of high flow

In depressions, pumping stations were required (or irrigation pumps were used) to divert collected water. A monitoring system to record the movement of groundwater table levels were installed prior to commencement of large-scale irrigation. A systematic checking of irrigation intensities was required. Over-irrigation caused the water table to rise to dangerous levels, requiring a deep, local sub-surface drainage system.

6.3.5 Summary of Schemes under Controlled Irrigation in Southern Somalia and Associated Infrastructure

A summary of the irrigation schemes and infrastructure discussed in chapters 5 and 6 is presented in Tables 6.4a and 6.4b below. The figures in both tables only reflect controlled irrigation. Although *deshek* irrigation is known to exist in Southern Somalia, there was limited literature available during this study to determine the full extent. Records from the Ministry of Water indicate that 110,000 ha of land were under flood recession irrigation in 1987/88 cropping year. It is not clear though whether the figure applies only to the indicated year or it was the total figure across the area.

Table 6.4a gives a summary of the irrigation infrastructure in Juba and Shabelle rivers. The table gives the names of barrages and years of construction, river and district where the barrage is located. The command area determined from both literature and GIS is also given in the table. The command area, in hectares, refers to the extent of land which can be irrigated by water from the particular barrage. During this study, the literature values of the command area where determined from reports, project documents, designs etc, while the GIS values were calculated from digitised project areas/boundaries. The same method was used to determine the actual irrigated area, which indicates the area under irrigated crop. The actual irrigated area indicates the portion of the command area which was developed for crop growing. In many cases the not all the command area was fully developed. The table also shows the primary canals related to the barrage and the irrigation schemes served. The last column of the table indicates the status of the barrages and canals in time of the field assessment in 2007.

Even though literature and GIS values for both the command area and the actual irrigated area compare fairly well for some barrages, there are some cases where the difference is quite pronounced, extending to over 20,000 ha. This is to a large extent as a result of missing literature. In some cases like for Balcad, Mashalley and Sablaale barrages, there is no literature available to indicate the size of the command area and actual irrigated area. The missing information makes it difficult to compare the literature and GIS values. The GIS values were also calculated from maps and no field verification was made, hence there could be over- or under estimation of the area as well.

Table 6.4b gives a summary of the irrigation schemes in Juba and Shabelle rivers. The irrigation schemes are classified by regions and district where they are located. The table gives the irrigated area in hectares, which reflects the area under irrigated agriculture before the break out of the civil war in Somalia. From literature, the total area under irrigation is estimated to be 161,583 ha. This does not however indicate that all this area was under irrigation at the same time, as the only available information is when the schemes were incepted. It could not be established whether after inception the schemes continued to operate fully. Records from the Ministry of Agriculture indicate that in 1987/88 cropping year there were 112,950 ha of irrigated agriculture in Southern Somalia. FEWS (1988) also reported almost a similar figure (109,350 ha) of irrigated agriculture in the same period. This clearly indicates that not all the established irrigation schemes were under crop.

The table gives the crops grown for each scheme. However, there is no literature indicating the crops grown in some of the schemes. Generally, banana, rice, maize cotton, sesame and fruit trees dominated the schemes. Also indicated in the table is the current functioning status of the schemes, based on the field surveys and information from the key players in the irrigation sector during workshops. The schemes are classified as “functioning” if all the area irrigated before the break out of civil war is currently under irrigation. The “partially operating” schemes are those with only a percentage of the originally irrigated area currently under crop, while the “not functioning” schemes are those where no irrigation is going on at present.

The “potential for extension” refers to the area not developed for irrigation before the break out of the civil war, but which under the prevailing conditions was suitable for irrigation. Again, from the available literature it is not possible to find the figure for every scheme.

Table 6.4a: Summary of irrigation infrastructure in Juba and Shabelle Rivers

Barrage Name (Year of Construction)	Location (River/ District)	Command Area (ha)		Actual Irrigated Area (ha)		Primary Canals and Schemes Served (in brackets)	Current Status
		Lit	GIS	Lit	GIS		
Sabuun (1925)	Shabelle/Jowhar	50,942	60,747	7,950	10,579	Duduble/Chinese Canal (Duduble Reservoir) Jowhar Offstream canal (Offstream Reservoir, Jowhar Sugar Scheme) Sabuun/FAO canal	▪ Barrage non-operational: all nine gates stuck and embedded in mud, gears are broken and walk rails missing, upstream blocked by tree trunks, canal inlets blocked by sediment. ▪ UNDP did some rehabilitation on the gates, walk ways and barrage deck in 2006 ▪ Canals completely silted and overgrown by vegetation.
Balcad	Shabelle/Jowhar					(Iraqsoma Cotton Project / Balcad Cotton Irrigation Project	▪
Genale (1927)	Shabelle/Qorooley & Marka	67,440	47,532	54,180	67,410	Cessario Maria, Asayle and Primo Secondario canals (Genale Bulo-Marerta Irrigation Schemes)	▪ Barrage non-functioning: all 11 gates corroded, screw spindles corroded and embedded in concrete walls, lifting mechanism completely run down, concrete deck, edge beam, beams and columns damaged/broken, channel bed silted. ▪ Canals partially operational, but need desilting, regulators and off-takes broken. ▪ CARE Somalia doing some rehabilitation on Asayle, and CEFA on Primo-Secondario canal.
Mashaley (1986)	Shabelle/Qorooley & Marka		27,000			Link to Asayle and Primo Secondario canals (Genale Bulo-Marerta Irrigation Schemes)	▪ Barrage deck fairly good, 8 gates stuck and not functioning, walk rails missing, lifting gears rusted and corroded, electric motor missing. ▪ Canals not functioning
Qoryooley (1955)	Shabelle/Qoryooley	4,120	17,713	2,890	17,713	Fomari and Liban canals (Farahane/ Bandar zone, Genale Bulo-Marerta Irrigation Schemes)	▪ Barrage structure weak, steel structure corroded, deck concrete weathered, guardrails on the upstream side of deck missing and loose on the downstream, gates damaged, one lifting gear functioning and 3 are missing, heavy siltation upstream and serious bank erosion downstream ▪ Canals overgrown with bushes
Felkeerow (1955)	Shabelle/Qorooley		26,800	4,900	26,800	Bakoro, Furuqulay, Barawaqo (Genale Bulo-Marerta Irrigation Schemes)	▪ Barrage slab cracked exposing reinforcement steel, piers in good structural condition, plaster peeled off from various parts of the structure, half of the gates sub-merged in silt, gate slides rusty, only one gear operational, slides are missing, upstream silted on both banks. ▪ Canals silted and overgrown by vegetation, off-take structure not functioning. ▪ Bakooro canal under rehabilitation by FAO and CEFA

Kurtunwareey (1986)	**Shabelle/Kurtunwareey**	**5,000**	**29,137**		**29,743**	**Dabaray, Faraday, Ghedi, Godho (Kurtunwareey settlement, Flood irrigation)**	▪ **Barrage deck and structure fairly good, deck slap reasonably good except few worn out sections on top of slab and edges, walkway badly cracked, steel guard rails loose, half of gates submerged in silt, upstream constrained due to siltation, erosion eating backwards of east bank**
Sablaale (1987)	**Shabelle/Sablaale**		**940**		**28,740**	**(Farjano/Sablaale Settlement Scheme)**	▪ **Barrage in good condition of all, concrete sound and solid, gate rusty but stable, access clear though upstream eroded** ▪ **Canals in poor state**
Haway (1926)	**Shabelle/Barawe**	**3,000**	**395**			**Haway Project**	▪ **Barrage unstable, river changed course, weir hanging with all foundations breached**
Fanoole (1977/82)	**Juba/Buaale & Jilib**	**15,250**	**120,568**	**7,750**	**83,814**	**Fanoole (Fanoole rice irrigation)**	

Pumped Irrigation

Name	**Location (River/ District)**	**Pumping Points**	**Capacity (l/s)**	**Irrigated Area**		**Primary Canals and Schemes Served**	**Current Status**
				Lit	**GIS**		
-	**Juba/Jamame**	**140**	**170**	**3,400**	**9,297**	**-**	**-**

Table 6.4b: Summary of irrigation schemes in Juba and Shabelle Rivers

Region	Project name & Inception Date	District	Irrigated Area (Hectares)	Crops Grown	Functioning Status	Potential for extension
Hiraan	Military Farm/Crash Program	Beletweyn	1,435	Maize, sesame, sorghum	Partial	
Middle Shabelle	Barroweyne (1982)	Jowhar	180	Rice, maize	Partial	4,200
	Jowhar Sugar Estate (1920)	Jowhar/Balcad	10,579	Sugarcane	Partial	32,357
Middle/Lower Shabelle	Balcad Flood Irrigation Project (1967)	Balcad/Afgoi	10,000	Cotton, sesame, maize	Partial	14,700
Lower Shabelle	Afgoi-Mordile Project (1967)	Afgoi	1,560	Bananas, sugar cane, cotton	Partial	19,365
	Agricultural Research Centre (1967)	Afgoi	1,560	Bananas, maize, fruit trees, sugar cane	Partial	4,500
	Asayle Project	Qoryooley	4,563		Partial	
	Genale Development Zone	Qoryooley/Merka	9,221			
	Degwariiri Zone	Qoryooley	6,748		Partial	
	Bandar Development Zone	Qoryooley	2,929		Not Functioning	
	Banana Drainage Project	Qoryooley/Merka	3,884		Functional	
	Der Flood Project	Qoryooley	862		Not Functioning	
	Grapefruit Production Scheme (EDF)	Merka	2,065	Bananas, grapefruit	Not Functioning	2,065
	Farahane Project (1978)	Qoryooley/Merka	4,883	Sesame, maize	Not Functioning	
	Golweyn Project	Merka	3,313		Partial	
	Harduuman Development Project	Qoryooley	1,960		Partial	
	Jeerow Development Zone	Kurtunwarey/Qoryooley	2,325		Partial	9,686
	Majebto Development Zone	Qoryooley	1,628		Partial	
	Mukoy Dumis Project	Kurtunwarey/Merka	9,132		Partial	
	Primo Secondario Banana Zone	Qoryooley/Merka	3,956		Functional	
	Qoryooley Project	Qoryooley	6,379		Partial	
	Shalambood Project	Merka	6,993		Partial	
	Tahliil Development Zone	Qoryooley/Merka	2,903		Partial	
	Waagade Development Zone	Merka	3,461		Functional	
	Refugee Farm	Kurtunwarey/Qoryooley	5,487	Maize, sorghum, fruit trees	Partial	6,060

Region	**Project name & Inception Date**	**District**	**Irrigated Area (Hectares)**	**Crops Grown**	**Functioning Status**	**Potential for extension**
	Kurtunwarey Irrigation Scheme (1986)	Kurtunwarey	4,900	Maize, sesame, sunflower	Partial	29,742
	Farjano Project (1985)	Sablale/Barawe	16,000	Bananas, fruit trees	Partial	28,740
	Haway Project	Barawe	395		Partial with extension	400
Middle Juba	Fanoole Rice Irrigation Scheme Projects I & II	Jilib / Buale	1,800		Not Functioning	8,200
Middle/Lower Juba	Homboy Settlement Project	Jamaame/Jilib	14,318		Not Functioning	
	Juba (Mareerey) Sugar Project (1987)	Afmadow/Jamaame/Jilib	7,000	Sugar cane	Partial with extension	10,720
Lower Juba	Mogambo Irrigation Project (1986)	Jamaame	2,364	Rice, bananas	Not Functioning	9,800
	Banana Plantations Irrigation Scheme (Medium Pump Schemes)	Jamaame/Kismayo	3,400		Partial	
Name	**Location** (River/ District)	**Pumping Points**	**Capacity (l/s)**	**Irrigated Area**		**Primary Canals and Schemes Served**
				Lit	**GIS**	
-	Juba/Jamame	140	170	3,400	9,297	-

6.4 Identified Needs in Irrigation Management

Irrigation water control requires management improvement in Southern Somalia. Three general areas where improvement is needed are as follows:

(i) Strengthening and expanding the Land and Water Department functions to include functions of irrigation water control including water rights, diversions, canal system management and on-farm water control.
(ii) Strengthening personnel of the Department through policies that will accomplish recruitment and retention of the engineering personnel and provide on-job training to improve capability.
(iii) Initiating an action research effort to improve management of irrigation water deliveries and accomplish water control, thereby increasing efficiency and productivity of water.

6.4.1 On-farm water control service

In 1990 an on-farm water control service was absent from all programmes for irrigated agriculture in the Ministry of Agriculture. This was reflected in serious deficiencies such as unreliable water supplies, inappropriate field irrigation systems, ineffective water use and lack of surface and sub-surface drainage. Farmer knowledge in each of the areas was seriously deficient, resulting in substantial reductions in crop yields and low irrigation efficiencies.

Recommendations for improvement are as follows:
(i) Add the function of on-farm water control to the Land and Water Department
(ii) Initiate and evolve field irrigation systems through an action research programme
(iii) Initiate a research programme to establish national criteria for appropriate design of needed farm water control technologies, such as precision land levelling, appropriate field irrigation systems, amount and timing of irrigation and surface and subsurface drainage.

6.4.2 Crop production

Crop production has a high potential for improvement and research is needed to achieve this. Specific areas were identified as follows:

(i) Establishment of on-farm water control research components in ongoing research activities.
(ii) Emphases of key constraints of farmers in formulating experiment station research such as water stress, tillage methods and costs, and appropriate practices for use of suboptimal inputs.
(iii) Initiation of an action research programme that systematically defines key constraints, solves problems directly, or feeds information to other units for action or further research.

6.4.3 Socio-economic constraints

Socio-economic constraints are related to the organizational needs of irrigated agriculture. Recommendations to meet these needs are as follows:

(i) Strengthening of the Land and Water Department by defining functions and improving personnel skills.
(ii) Strengthening programmes of other departments, based on priority constraints and improved personnel skills.
(iii) Initiating a monitoring and evaluation cell to implement an action research programme and improve management.
(iv) Initiating farmer organizations for effective involvement of farmers to improve management of irrigated agriculture (Agrar-Und Hydrotechnic GMBH, 1990).

7. Conclusions and Recommendations

7.1 Conclusions

This assessment has concluded that the pre-war irrigation schemes and their infrastructure were intact and delivered the required irrigation water to the pre-war irrigation schemes as were planned and executed, up to the time the war broke out in 1990. Nearly 90% of the medium to large irrigation schemes were operational before the war and majority of them in Lower and Middle Shabelle as well as Lower Juba produced large quantities of bananas that were sold to the EC market. It is clear that, there exists high natural potential of the irrigation sector, but since the start of the war the system has been in disrepair and progressive degradation.

The two rivers, Shabelle and Juba, are already silted up and have caused the river beds to rise; forcing canal off takes to be higher than their original design. The period over which these rivers flow at high levels are short and therefore less time and less water is available for irrigation. Silting of these rivers contribute to flooding, damaging canals, roads and crops and hindering transport. The flat gradient of the rivers course natural results in flooding, if the rivers are not regularly managed by dredging and bank reinforcement. Silting in the rivers also slows the flow of water, resulting in a faster rate of silt deposit, exacerbating the problem.

Most of the irrigation canals are silted up and choked with vegetation and only operate when the rivers are at their highest levels and this greatly reduces the area under crops. The most damaging consequence of the non-functioning canal system is the breaching of riverbanks by farmers to obtain irrigation water, which is resulting in uncontrolled flooding and wastage. Shortage of water also leads to the conflict when farmers block the canals and breach the banks or irrigation, thus depriving farmers further downstream of water.

Other conclusions include:

i) A high percentage of medium to large irrigation schemes were operational before the civil conflict and the majority were located in the Lower and Middle Shabelle and Lower Juba areas.

ii) In the 1987/88 cropping year the estimated irrigated area was approximately 222 950 ha consisting of 112 950 ha irrigated agriculture and 110 000 ha of *desheks*.

iii) Crops cultivated in the 1987/88 cropping season included food crops such as maize, sorghum and commercial banana and grape fruit plantations, as well as cotton, sesame and groundnuts.

iv) Irrigation water supply consisted of gravity diversions (barrages and weirs) constructed along the two rivers and pumped intakes.

v) River regulation infrastructure consisted of barrages and weirs constructed along the Juba and Shabelle rivers between 1925 and 1988.

vi) Nine barrages, namely: Sabuun, Balcad, Genale, Qoryooley; Felkerow, Kurtunwareey, Mashalley Sablaale and Haway were constructed on the Shabelle River. Only one barrage (Fanoole) was constructed on the Juba River. The ten barrages delivered adequate irrigation water to the gravity-fed irrigation systems in Southern Somalia.

vii) The irrigation infrastructure provided a reliable water supply to the gravity fed irrigations system and protection of irrigated lands from flooding.

viii) In project areas, management and administration of irrigation schemes were organized under specific project management units and organizational structures for each project or scheme was developed specific to each separately (FEWS, 1988; SWALIM database).

ix) The management and administration of irrigation schemes was the responsibility of Lands and Water Department in the Ministry of Agriculture.

7.2 Recommendations

7.2.1 Irrigation infrastructure

Based on the conclusions of this assessment, critical rehabilitation is needed to restore the irrigation schemes in Southern Somalia and their infrastructure. Rehabilitation for long term sustainability might require huge investment, which might not be available before peace is restored in the country; however restoring critical parts of these infrastructures is necessary for improving livelihoods of the communities. The following is recommended:

1) Thorough engineering assessments for all barrages to determine their stability and strength. Engineering assessment of primary canals' intakes around the barrages is also recommended.
2) Replacement of barrages gates and lifting mechanisms to allow controlled water for irrigation and flood protection purposes.
3) Protection works for all barrages in terms of erosion control and desilting. In some cases wall protection works is needed since most of the barrages developed large pools of water that are endangering the barrage structure.
4) Re-directing the river course around Sablale and Haway barrages, since the river has changed its course leaving the barrages structures sitting on dry river beds with no water getting into primary canals.
5) Bush clearance activities and desilting of the primary and secondary canals for irrigation water to get into the fields.
6) Re-designing of the Mashalay barrage to correct the abnormality of water flowing back to Shabelle River from Primo Secondario canal.

7.2.2 Irrigation schemes

None of the irrigation schemes identified by this assessment is currently operational as planned before the civil war. This is due to absence of a central authority to operate and mange these schemes. It was found during this assessment all barrages and primary canals have community management committees.

Through agencies active in agriculture and irrigation sectors in Somalia, barrage and canal level management committees have been established. Strengthening the capacity of these management structures will be a prerequisite in managing the water resource for irrigation purposes. Training and education is a critical component to the success of these committees. The recommendation will therefore be, to build adequate capacity to handle and manage the irrigation infrastructure.

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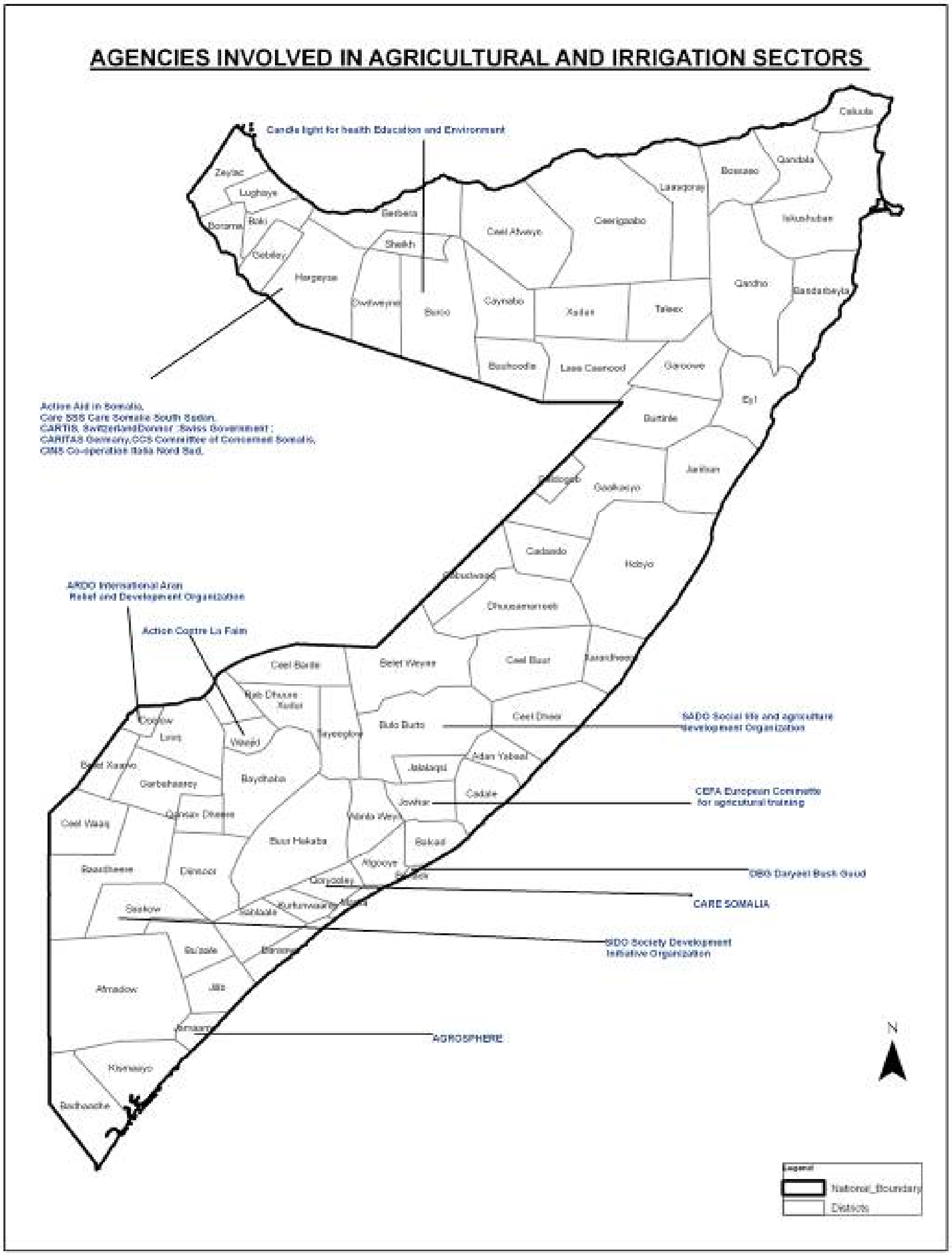
Annexes

Annex 1: Agencies involved in agricultural and irrigation sectors



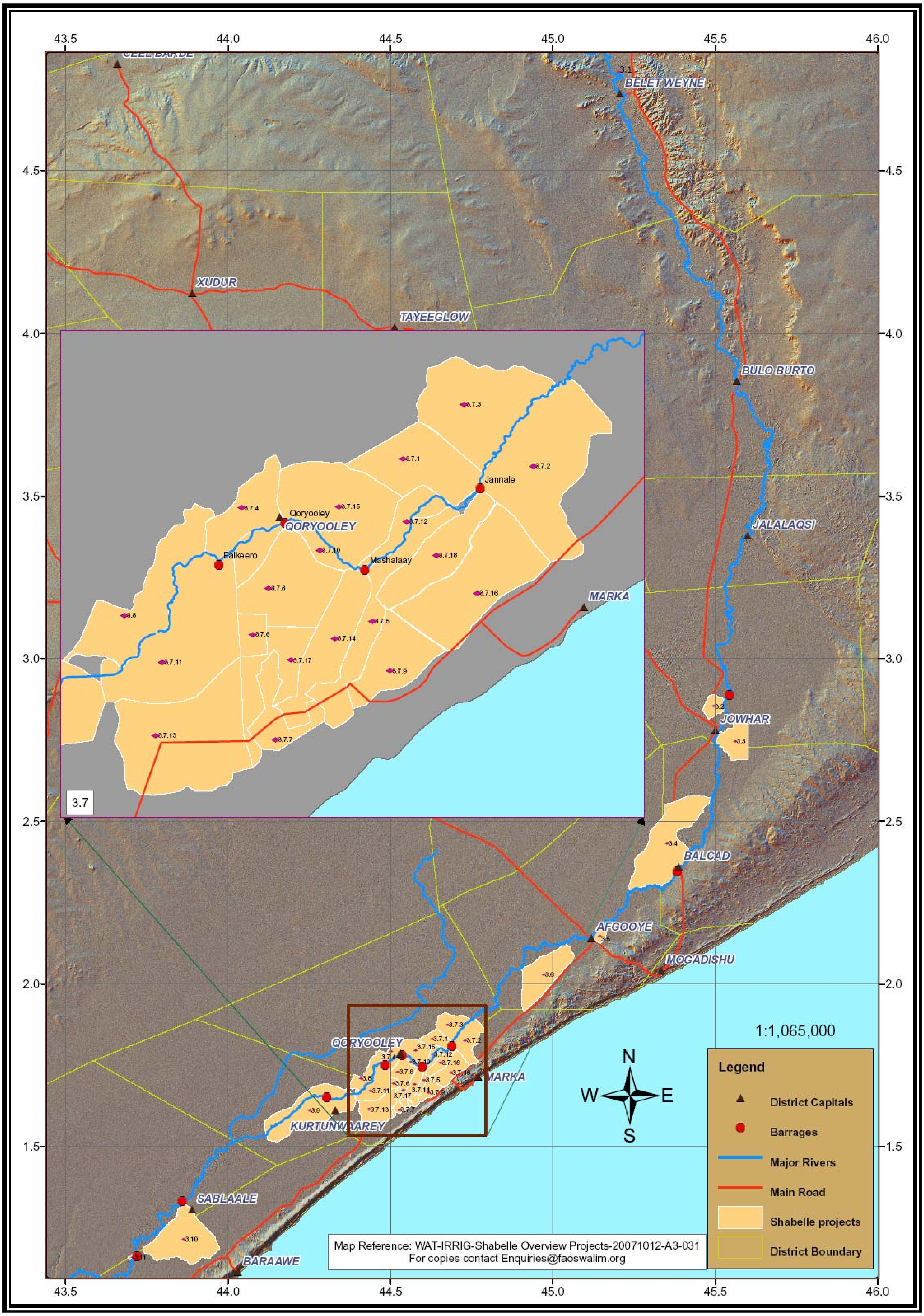
Annex 2: List of agencies active in irrigation sector in Southern Somalia

No	AGENCY	(FIELD OFFICE)	LOCATION	SECTOR	ACTIVITIES	DONOR	REMARKS
1	Action Contre la Faim	Wajid	Mogadishu North	Agriculture	Water catchments rehabilitation Agricultural assessment Agricultural training	Echo	Start: June, 2004
2	Action Aid Somalia	Djibouti Acton Aid – Hargeisa-Somaliland	Hargeisa	Agriculture	Soil and Water conservation	Comic Relief-UK and Action Aid	Start: May, 1992
3	ARDO International Aaran Relief and Development Organisation	Dollow-Gedo	Gedo	Agriculture	Agricultural development and Research Project	SSHDA in USA	Start date: Jan, 2004
4	AGROSPHERE	Jamama Lower Juba	Juba/Jamama District	Irrigation	Food security Water resource management Rehabilitation of irrigation and flood control infrastructures Seed security Vegetable production Community vegetable gardens	AGROSPHERE	Start: April, 2002`
5	Candlelight Candlelight for Health Education and Environment	Burao-Somaliland	Hargeisa	Rural agriculture	Strengthening rural women in development projects	International Republican Institute	Start:March, 2005
6	Care SSS Care Somalia South Sudan	Care Hargeisa Care Mogadishu	Hargeisa and Mogadishu	Agriculture	Food Security Programme	USAID	Start: April, 2004
7	CARITAS, Switzerland CARITAS, Germany	Swiss Group Hargeisa Somaliland	Hargeisa	Rural Water infrastructure	Water for livestock	CARITAS	Start: March, 2006

No	AGENCY	(FIELD OFFICE)	LOCATION	SECTOR	ACTIVITIES	DONOR	REMARKS
8	CEFA European Committee for Agricultural Training	Jowhar, Somalia	Jowhar	Irrigation	Rehabilitation and development of irrigation infrastructure	European Commission	Start: December 2002
9	CCS Committee of Concerned Somalis	Hargeisa	Hargeisa	Agriculture	Rehabilitation of agricultural infrastructure	UNDP	Start: 2005
10	CINS CINS Co-operazion Italia Nord Sud	CINS Hargeisa	Hargeisa	Agriculture	Agricultural field survey		
11	CIDRI International Cooperation for an integrated rural development	Hiraan	Lower Shabelle	Irrigation	Irrigation canal rehabilitation	CIDA	Start: December, 2004
12	DBG Daryeel Bulsho Guud	Mogadishu, DBG Mogadishu Office	Yaqshiid District ,Sasha Commercial Centre	Irrigation	Increase flow of water in four primary canals		
13	SADO Social Life and Agriculture Development Organization	Burdhubo, Gedo Region	Gedo Region	Irrigation	Daily data information on Juba river.		
14	SDIO Society Development Initiative Organization	Sakow District	Sakow District	Irrigation	Irrigation Canal rehabilitation	SACO-Somali Agriculture and Commercial Operation	Start: December, 2001

Annex 3: Irrigation schemes/projects

Barrages and Irrigation schemes in Shabelle River



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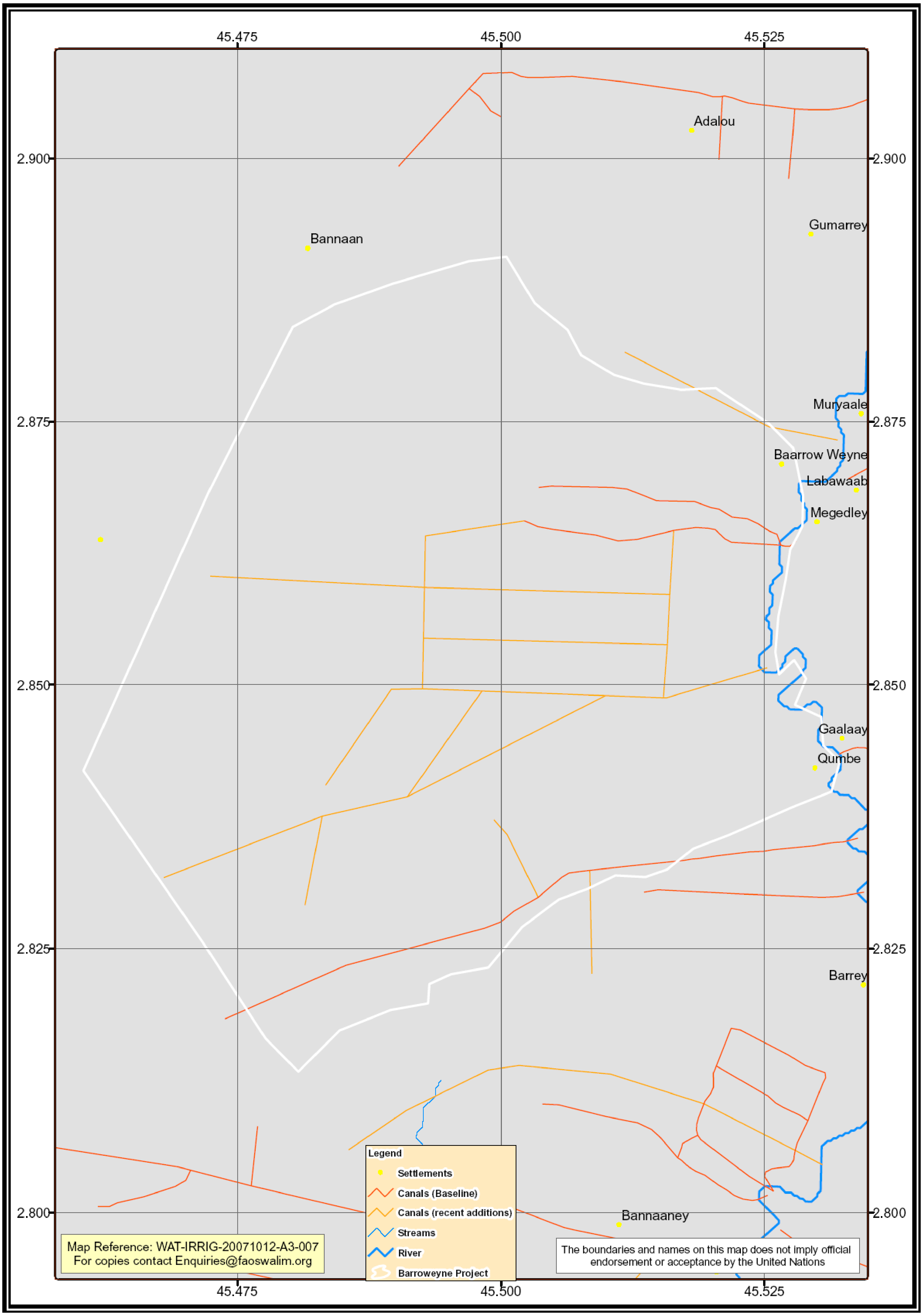
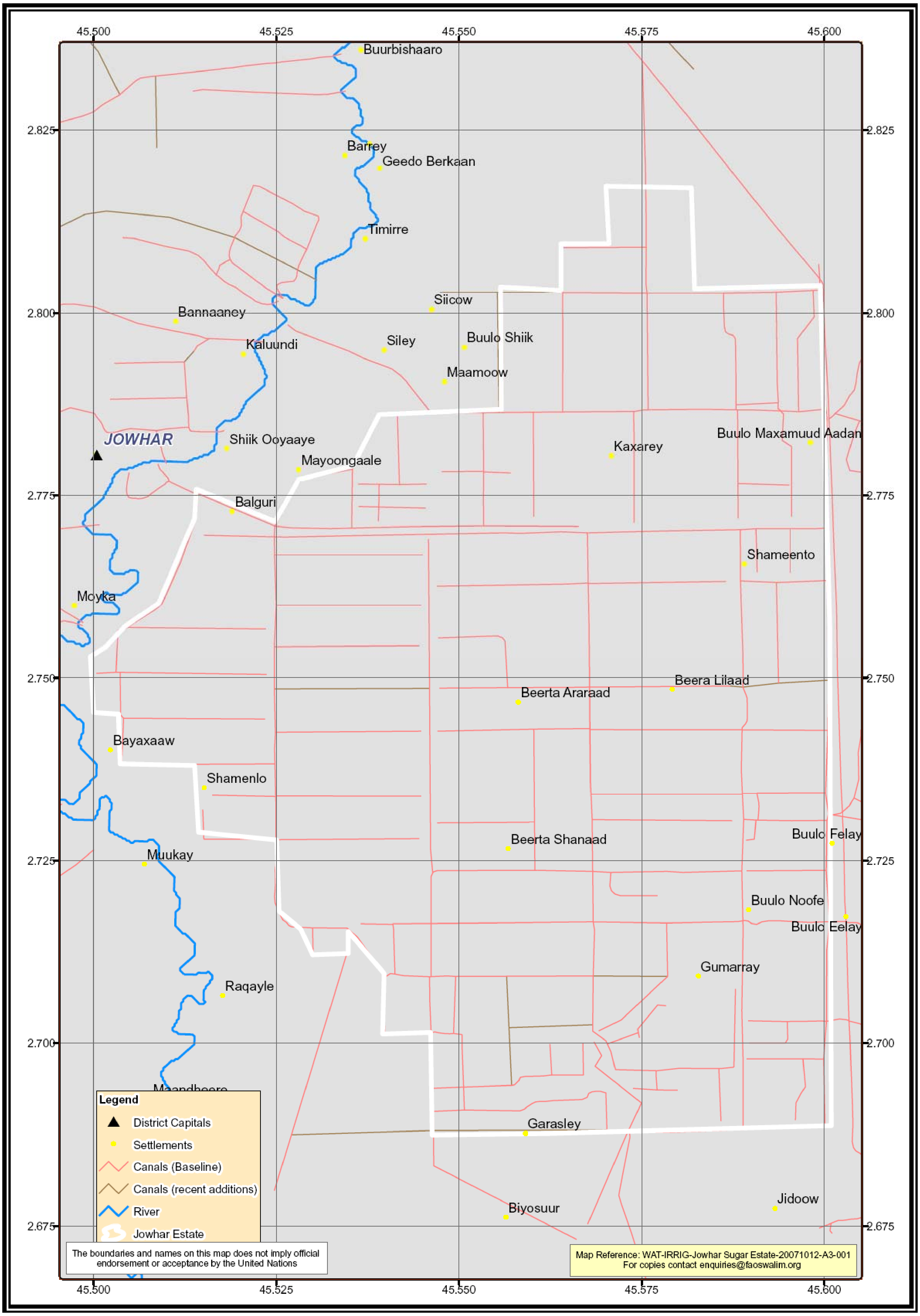
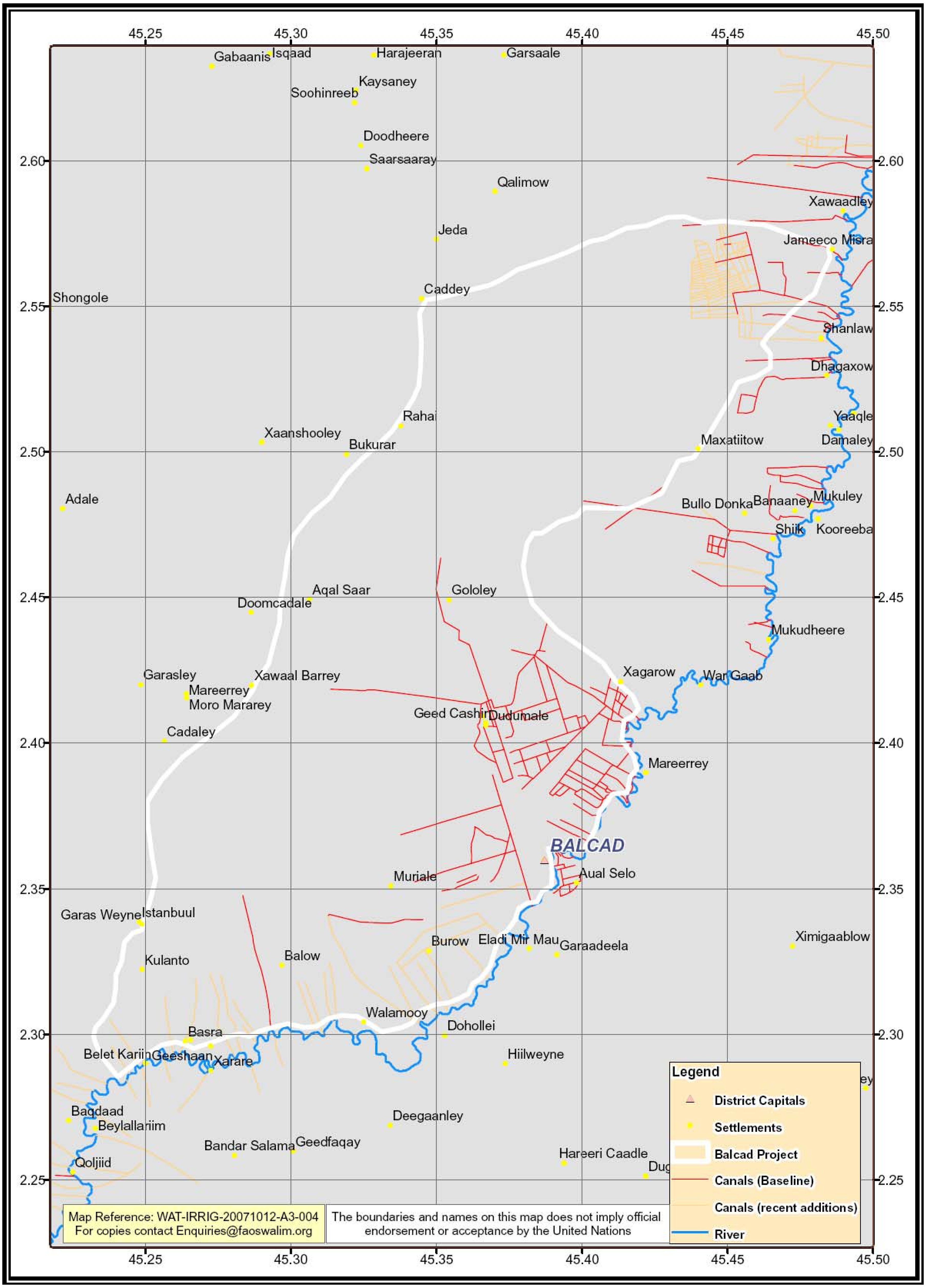


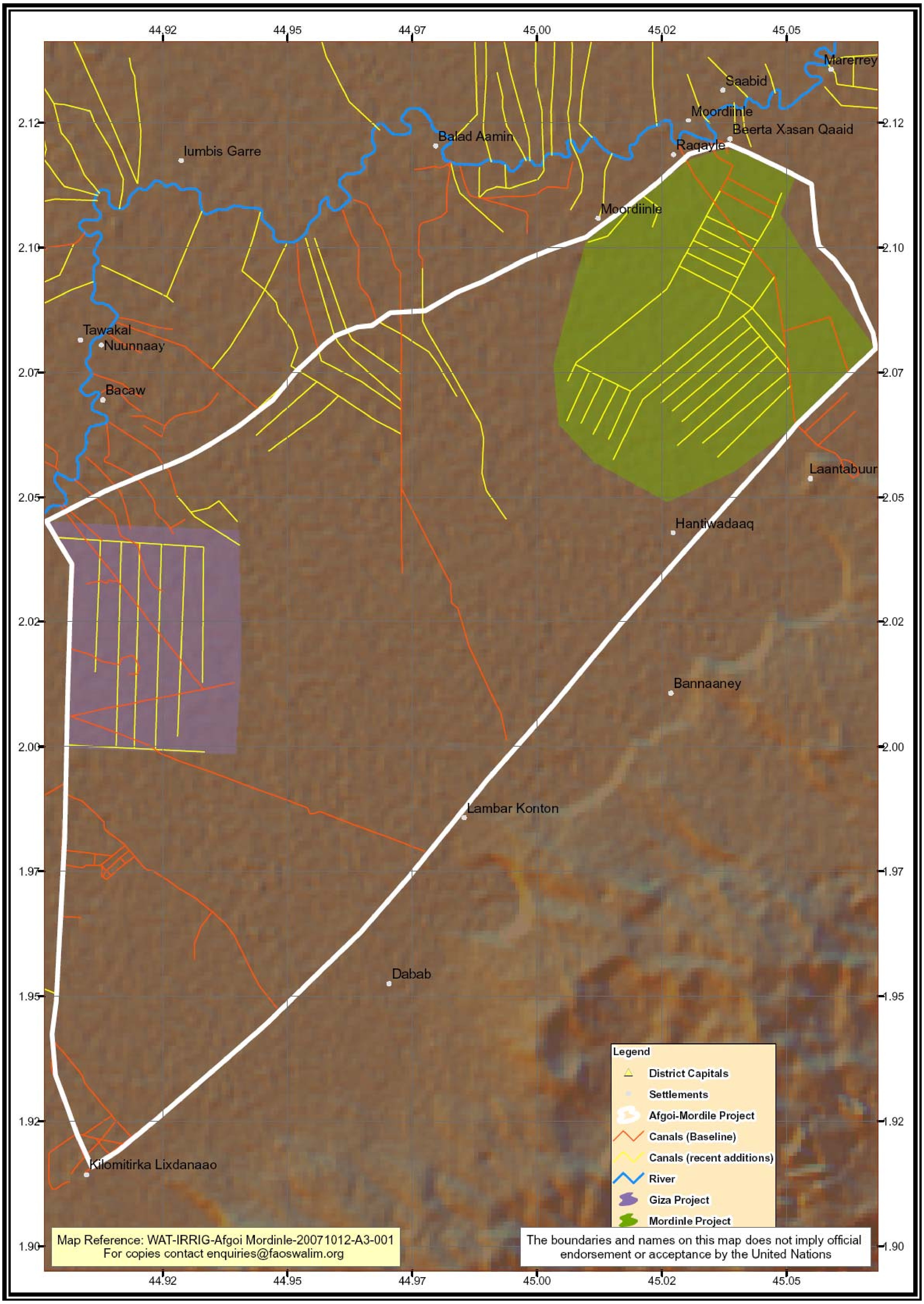
3.2 Barroweyne Rice Project



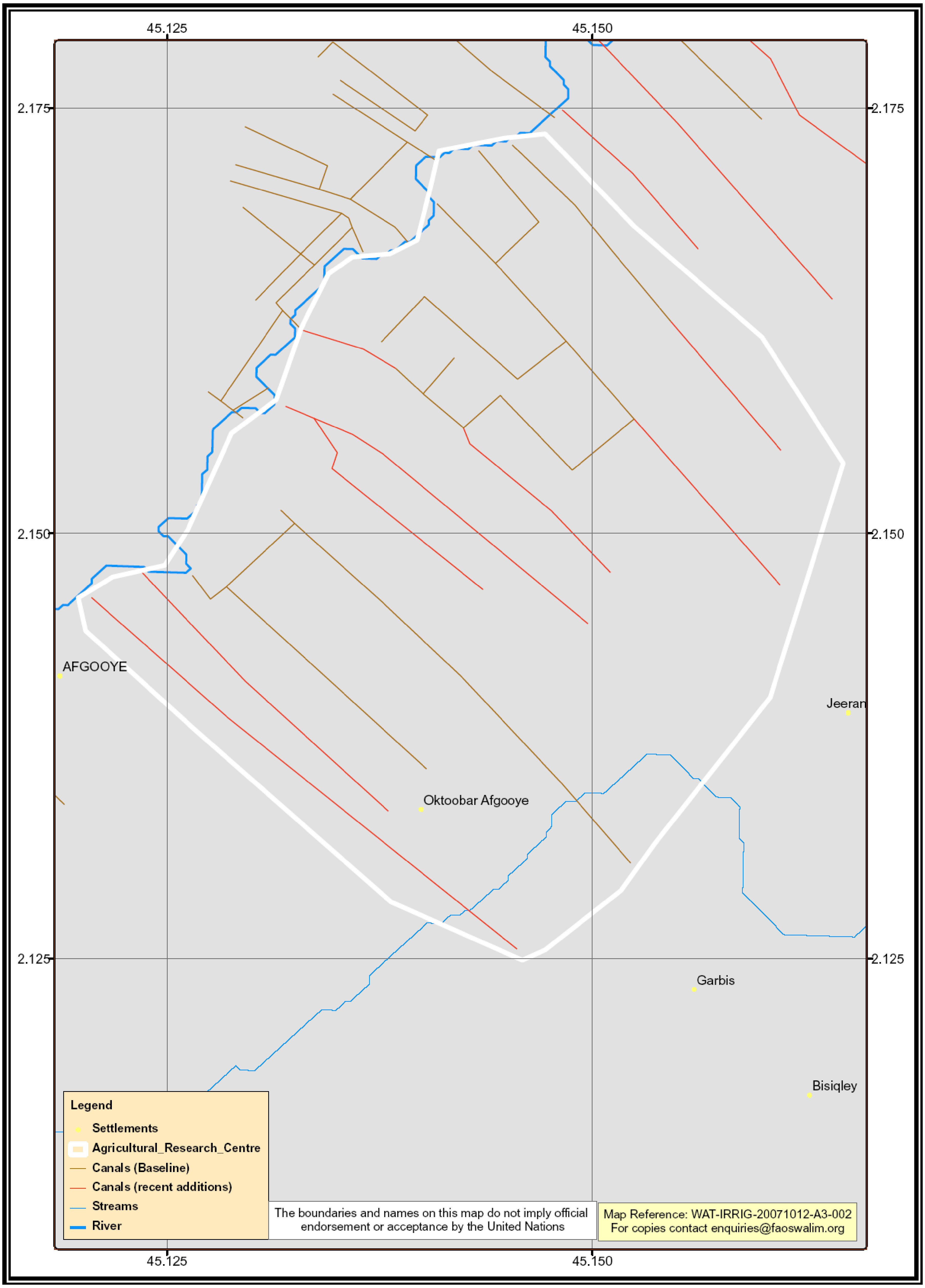
3.3 Jowhar Sugar Estate



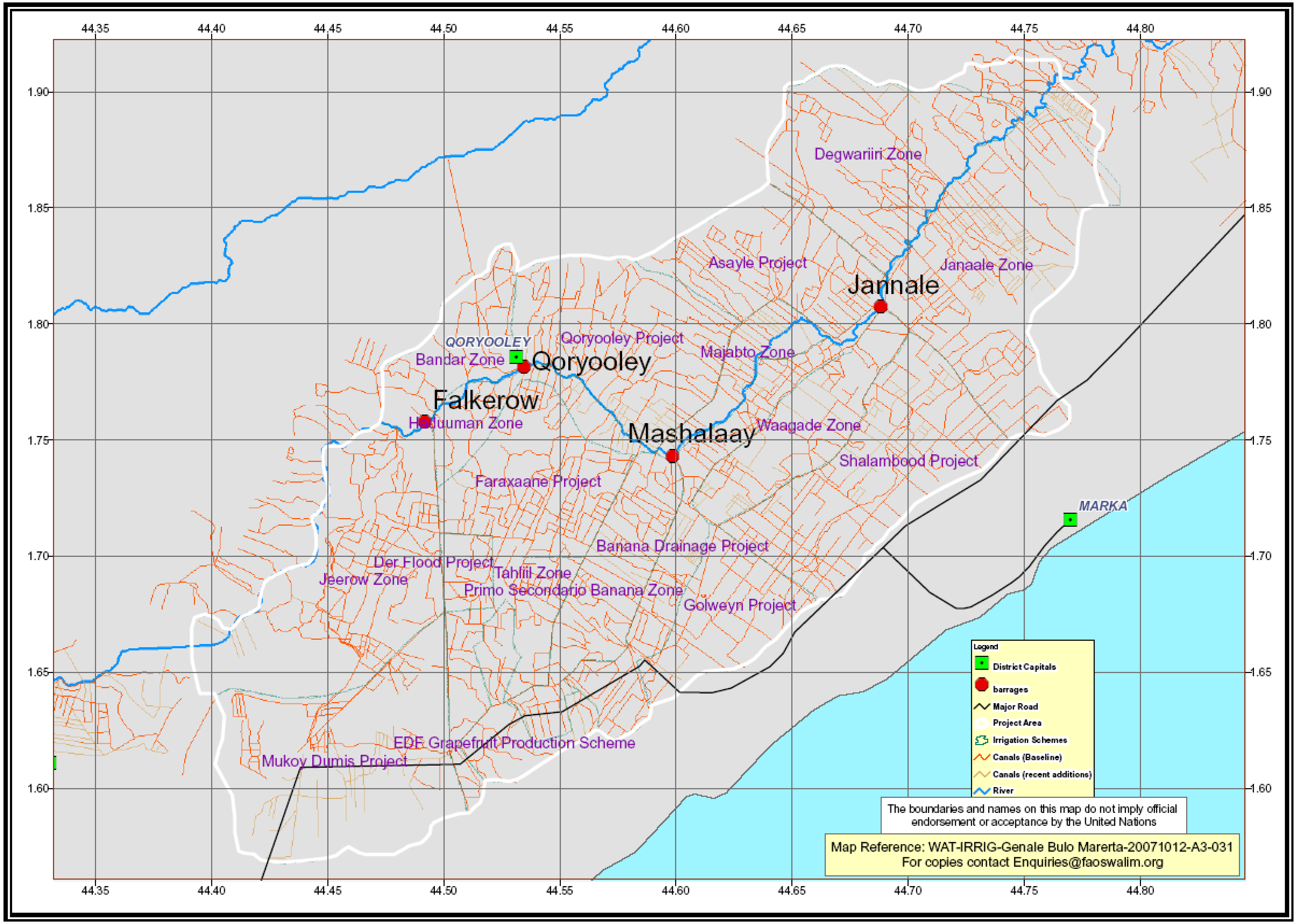
3.4 Balcad Flood Control



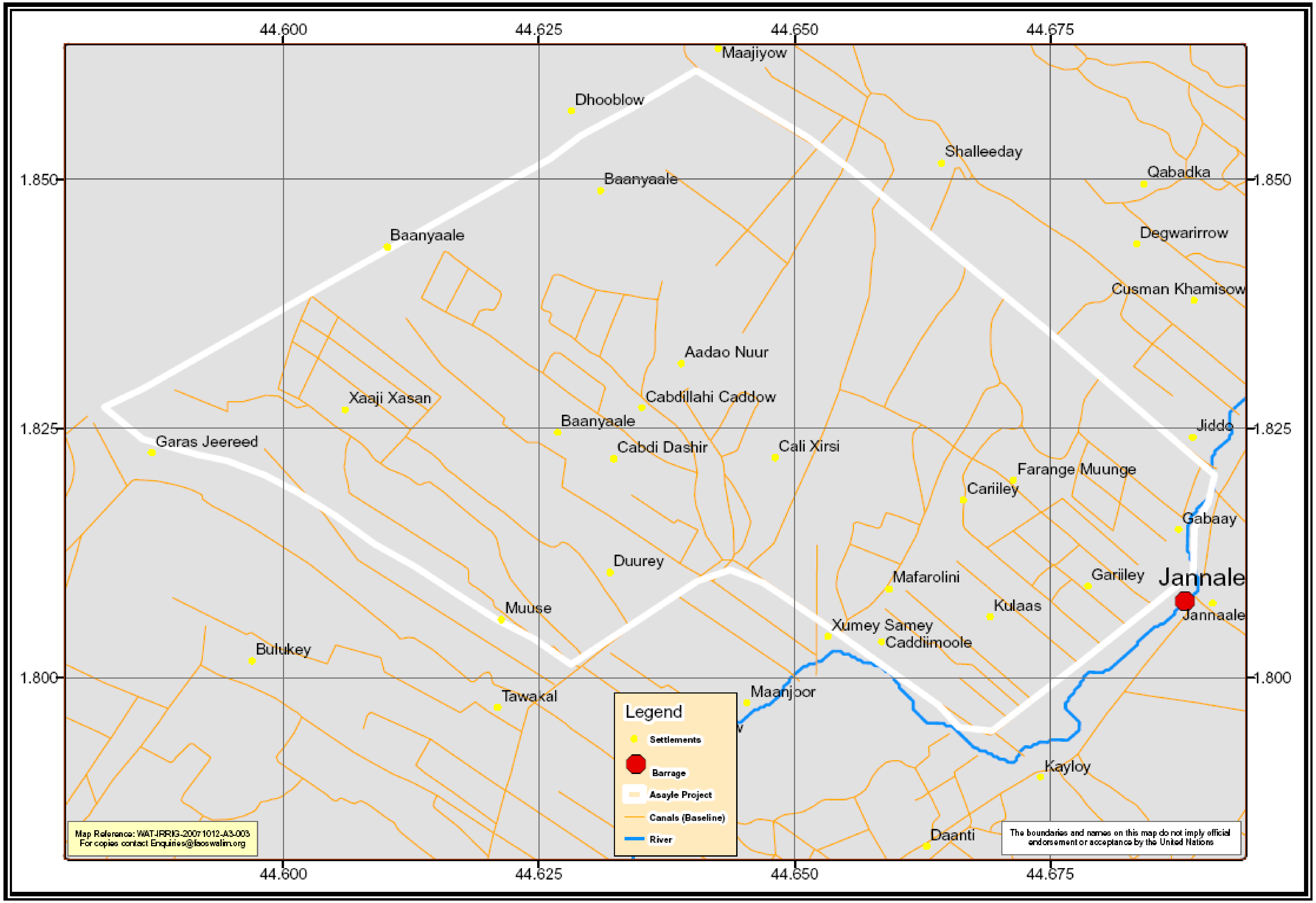
3.5 Afgoi-Mordinle Project



3.6 Agricultural Research Centre



3.7 Genale Bulo-Marerta Project



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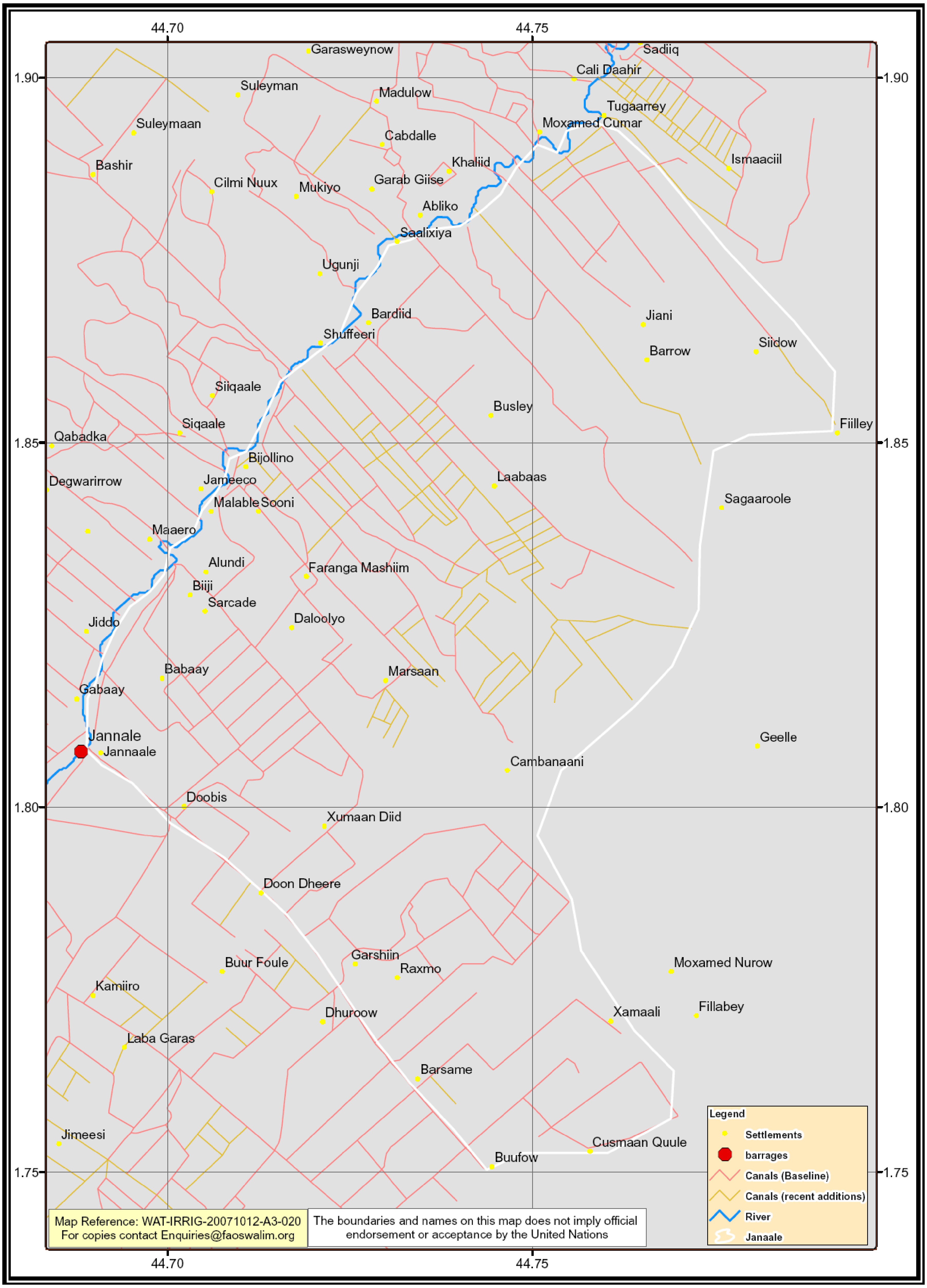
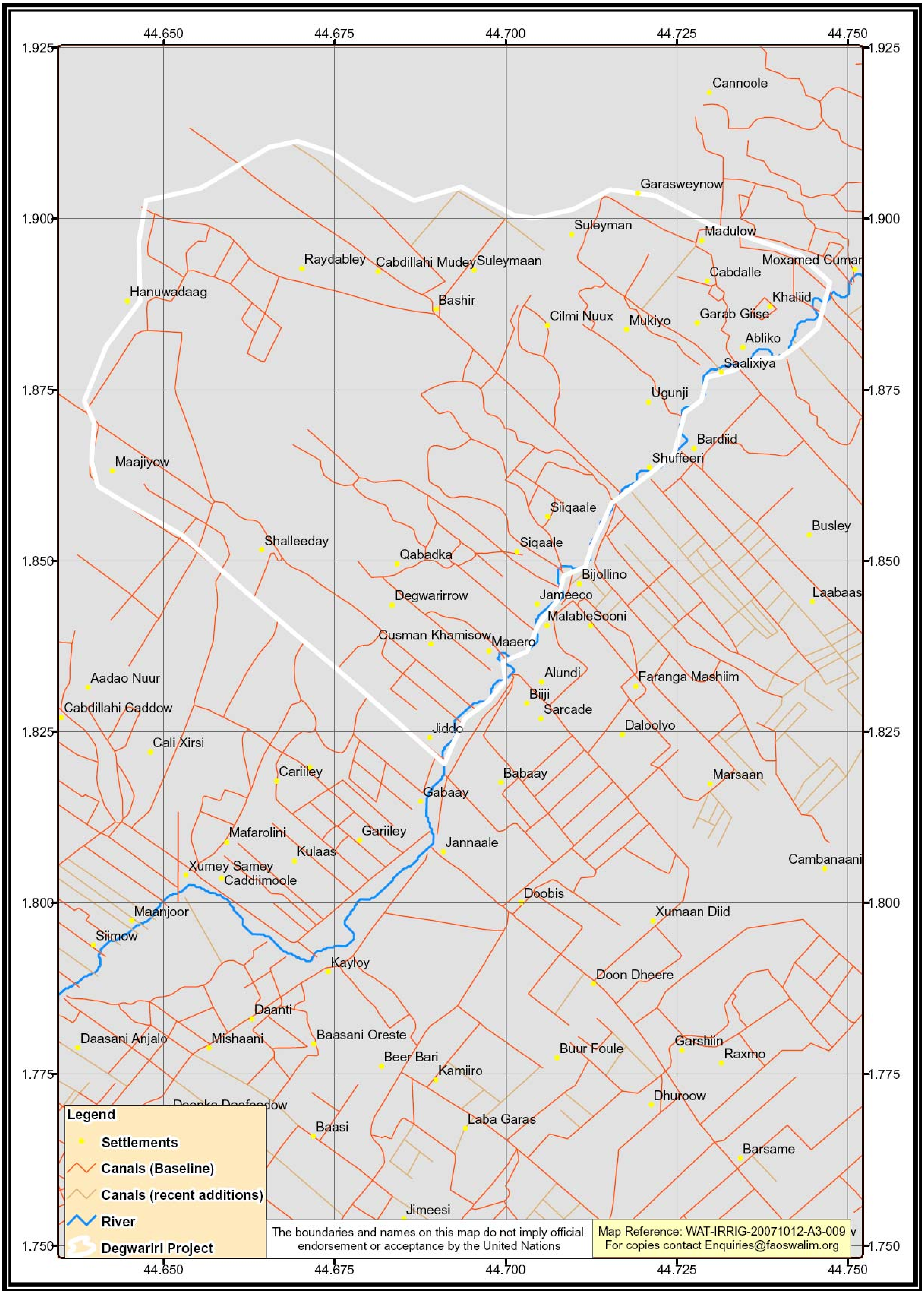


3.7.2 Genale Zone



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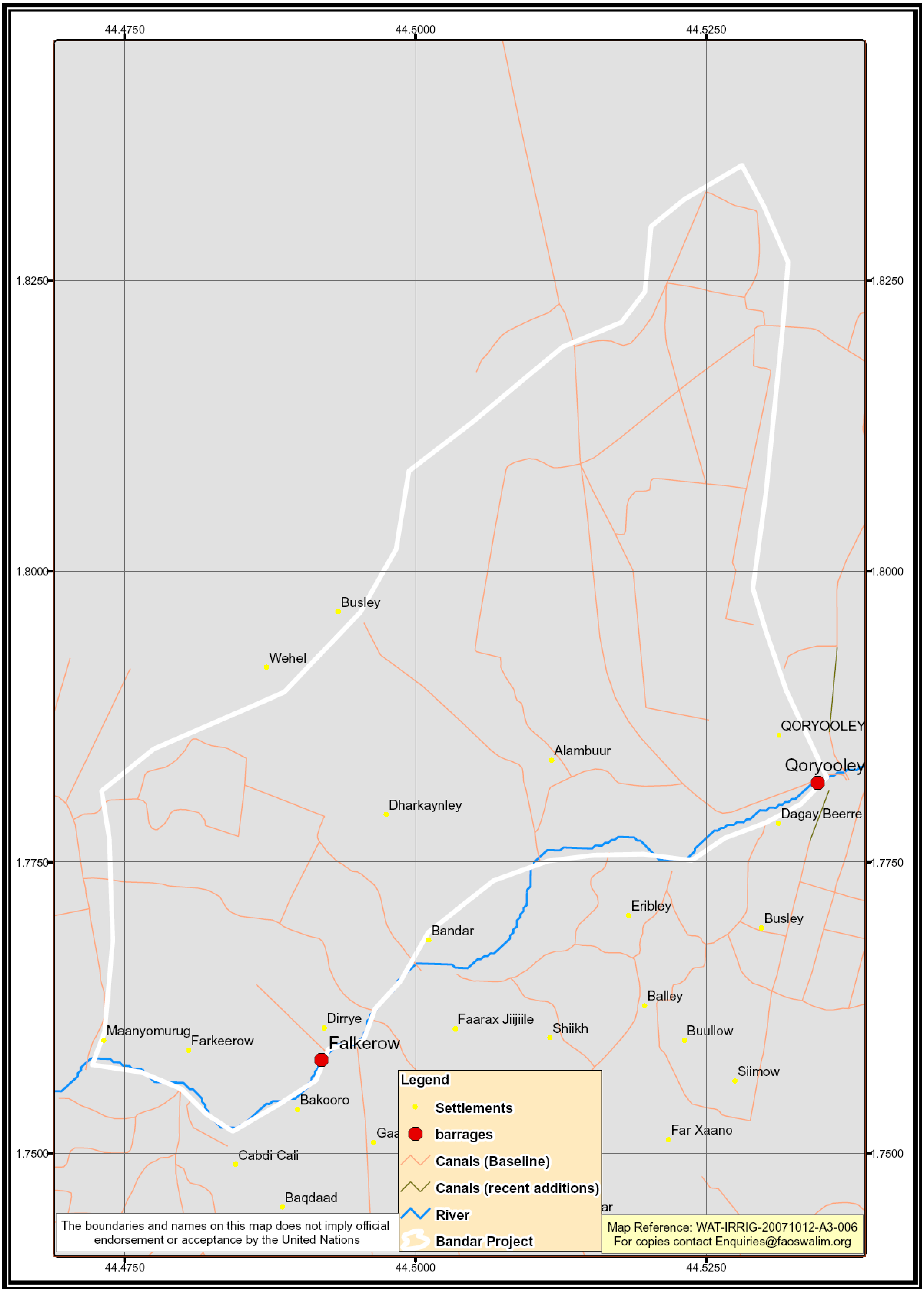
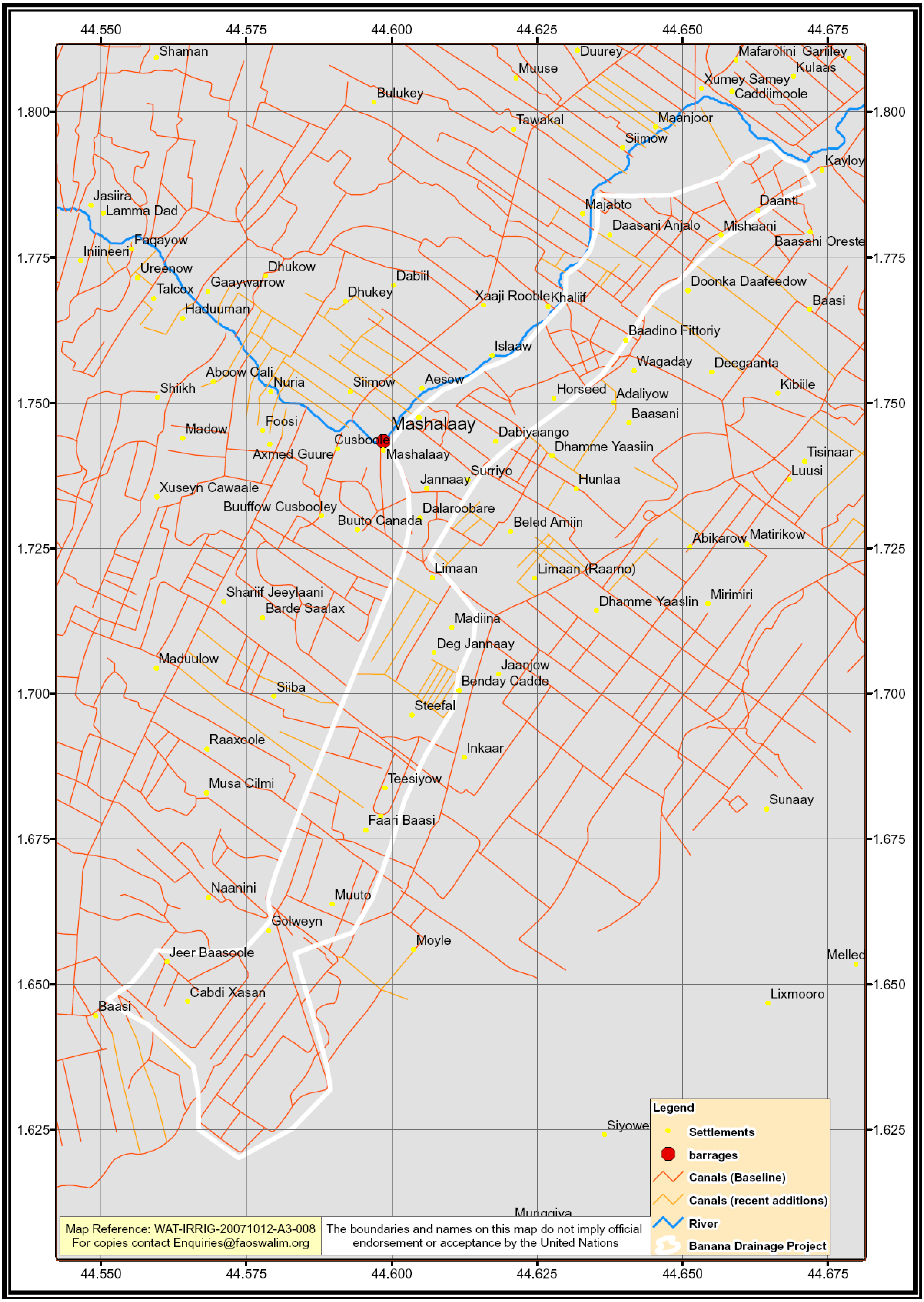
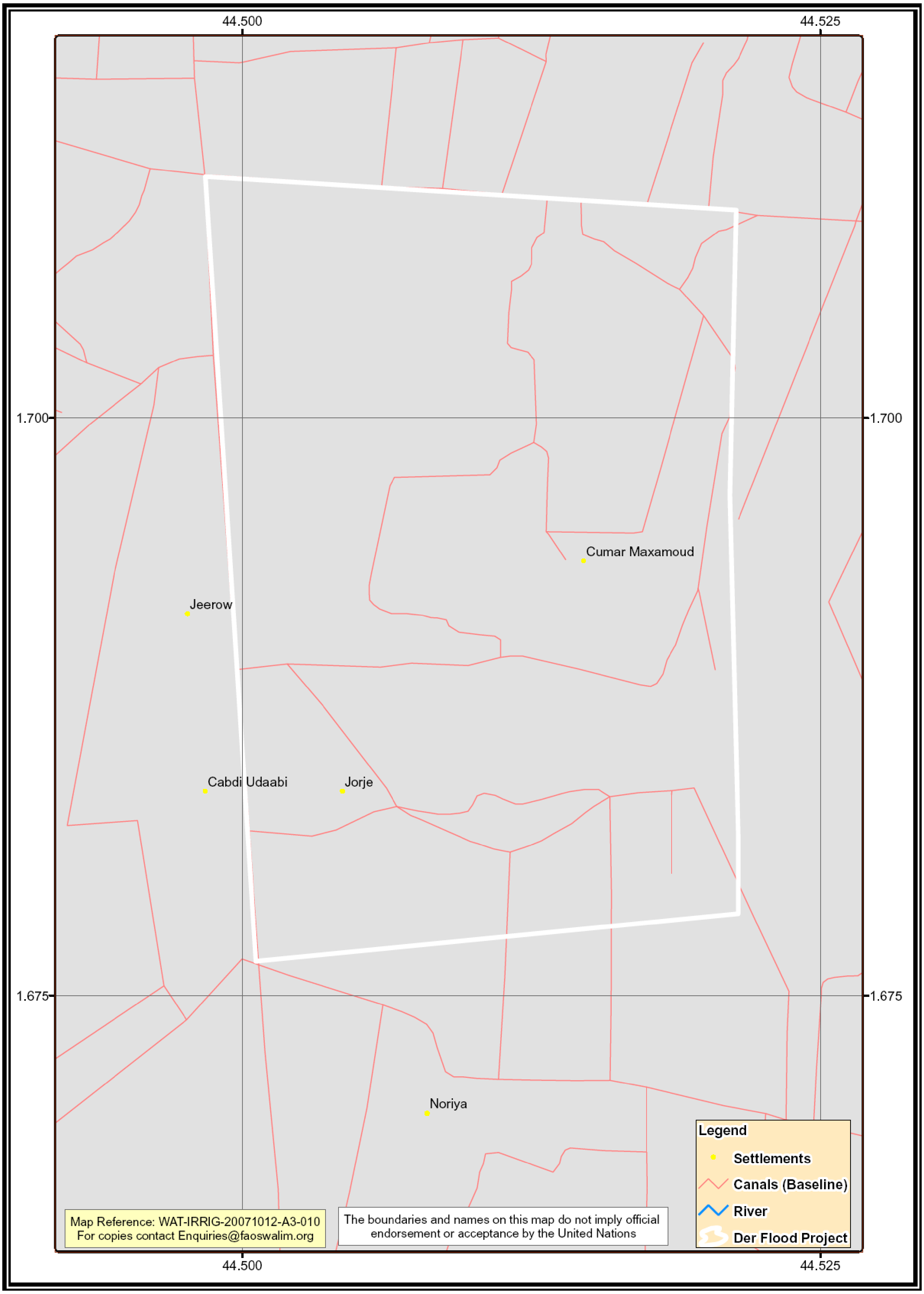


3.7.4 Bandar Zone



3.7.5 Banana Drainage Project



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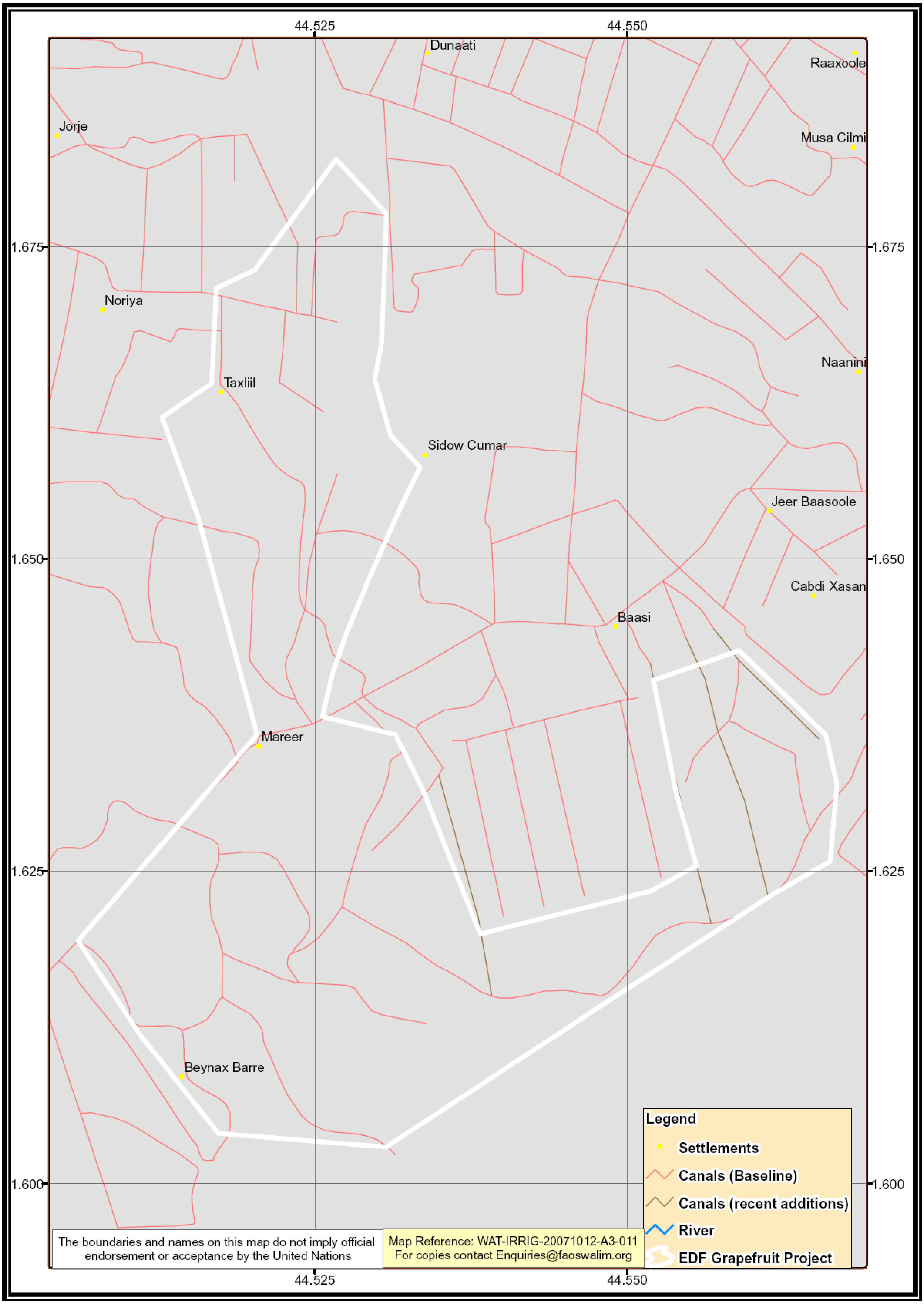
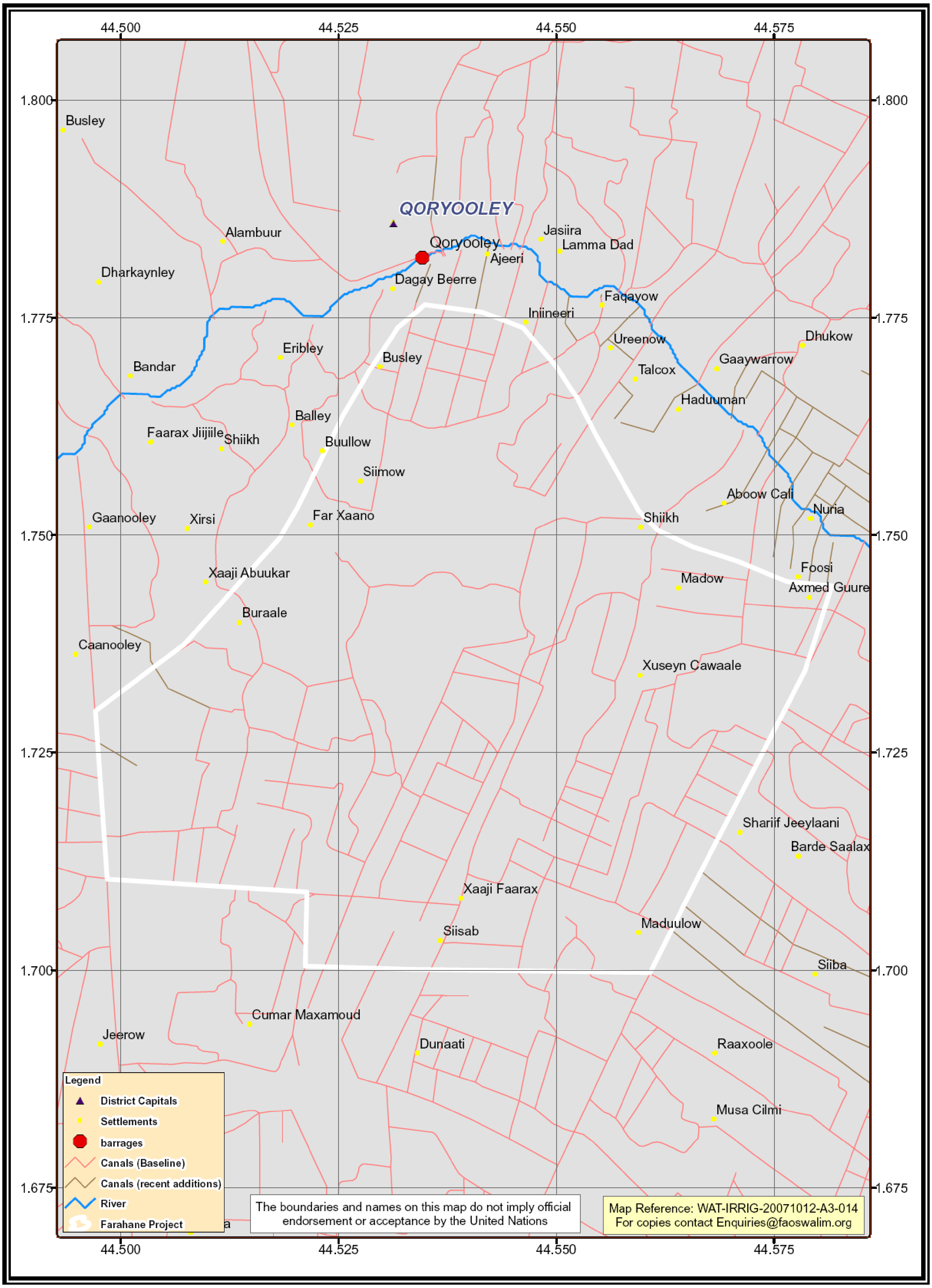
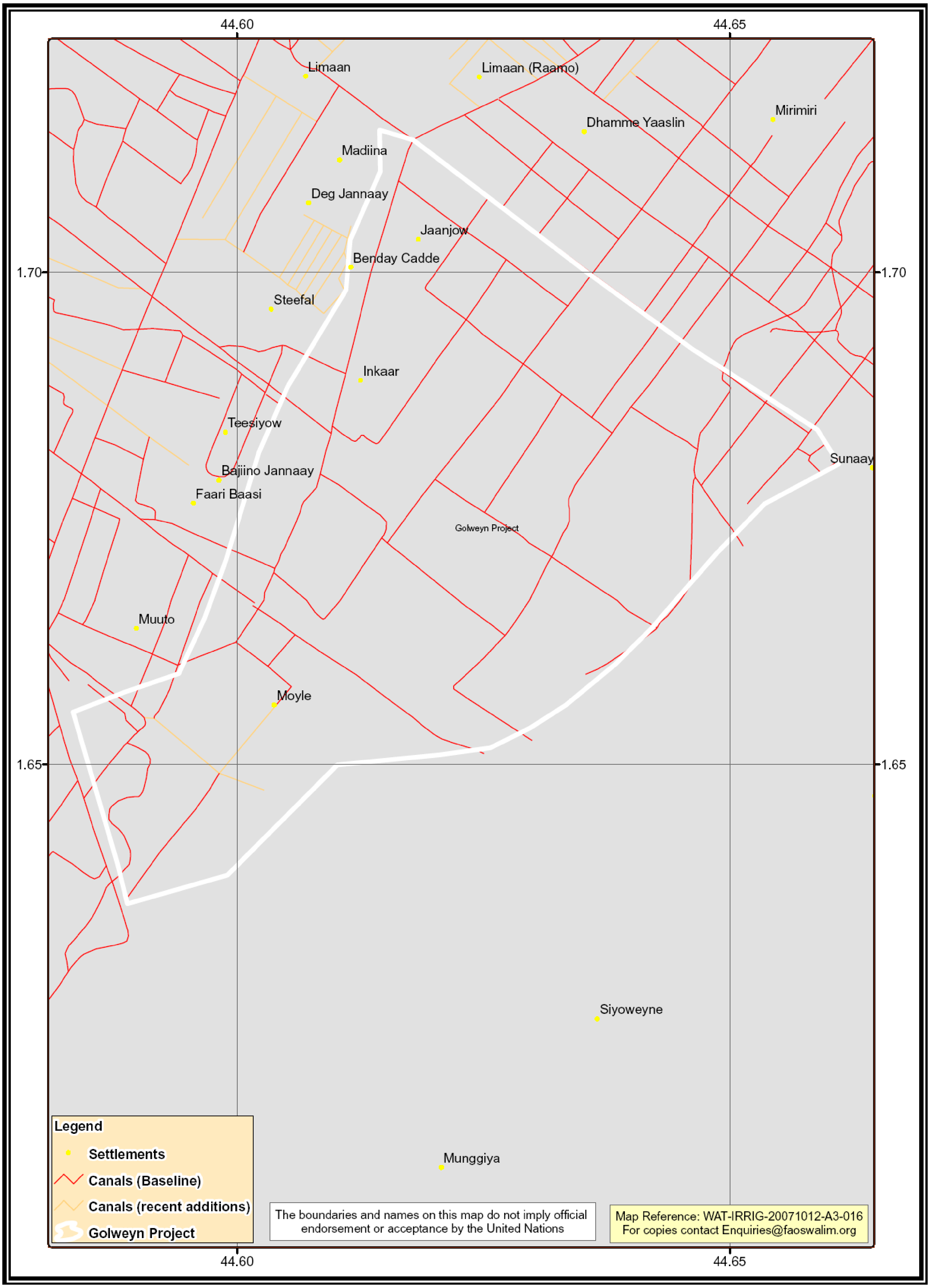


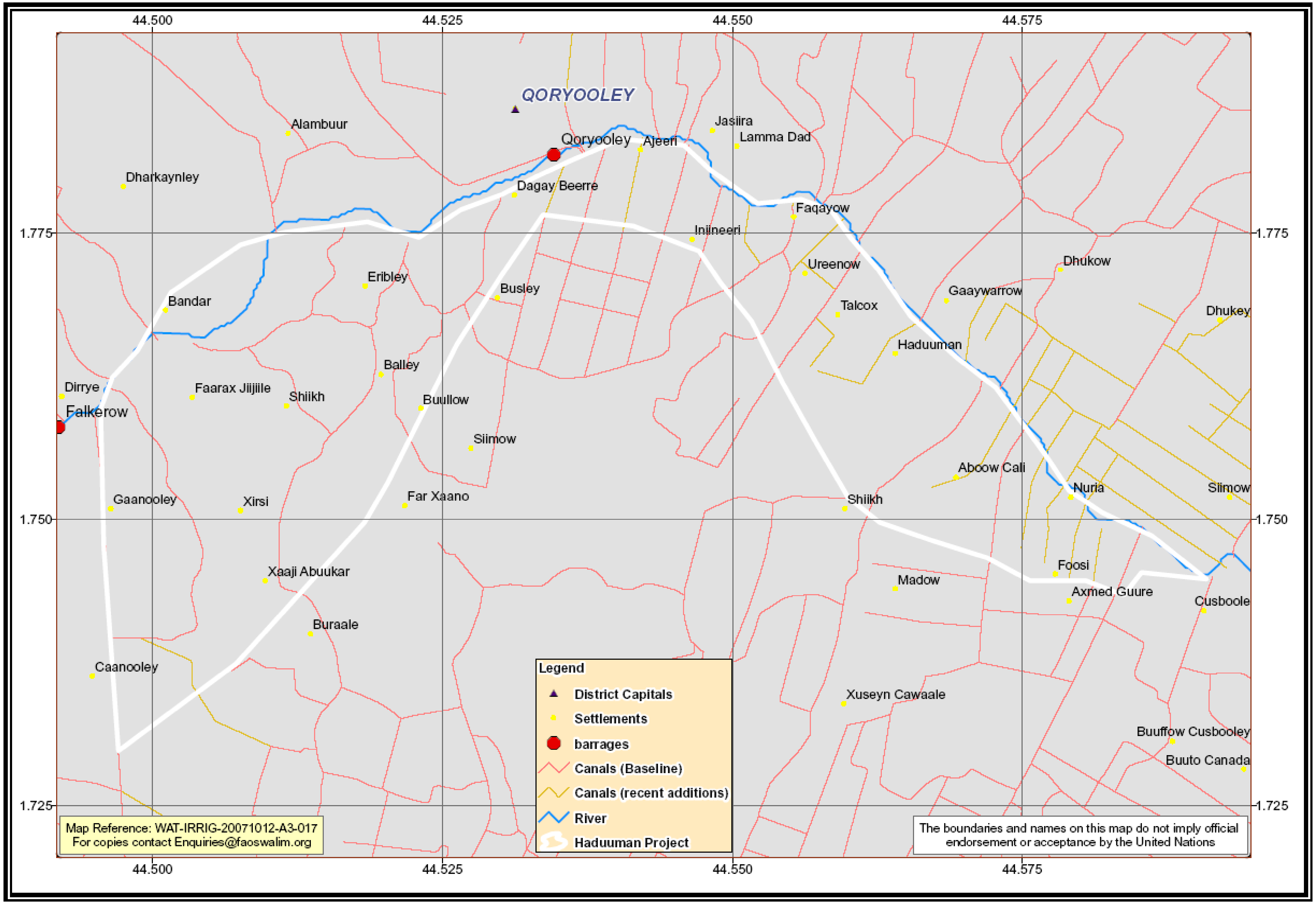
3.7.7 EDF Grapefruit Project



3.7.8 Farahane Project



3.7.9 Golweyn Zone



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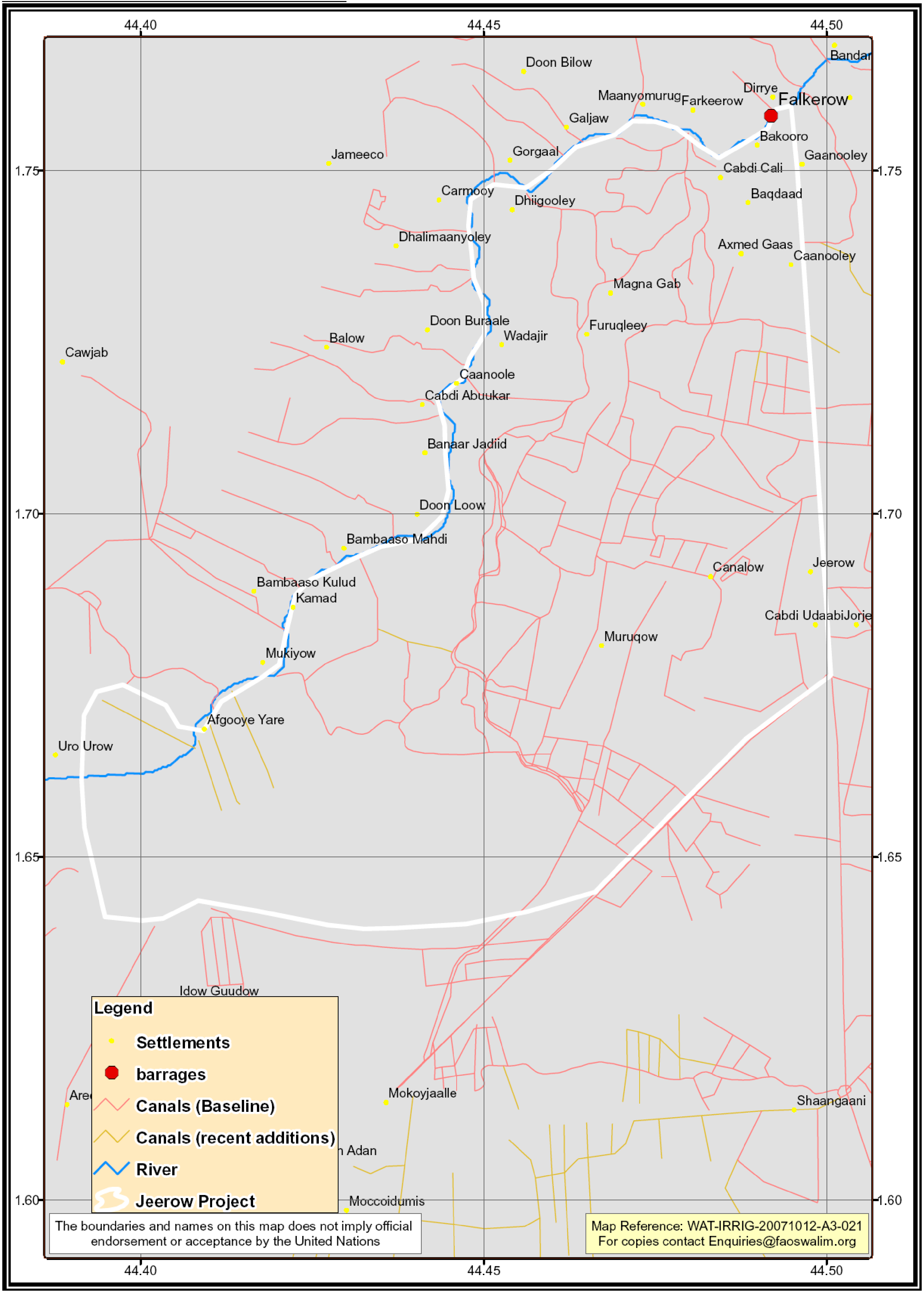

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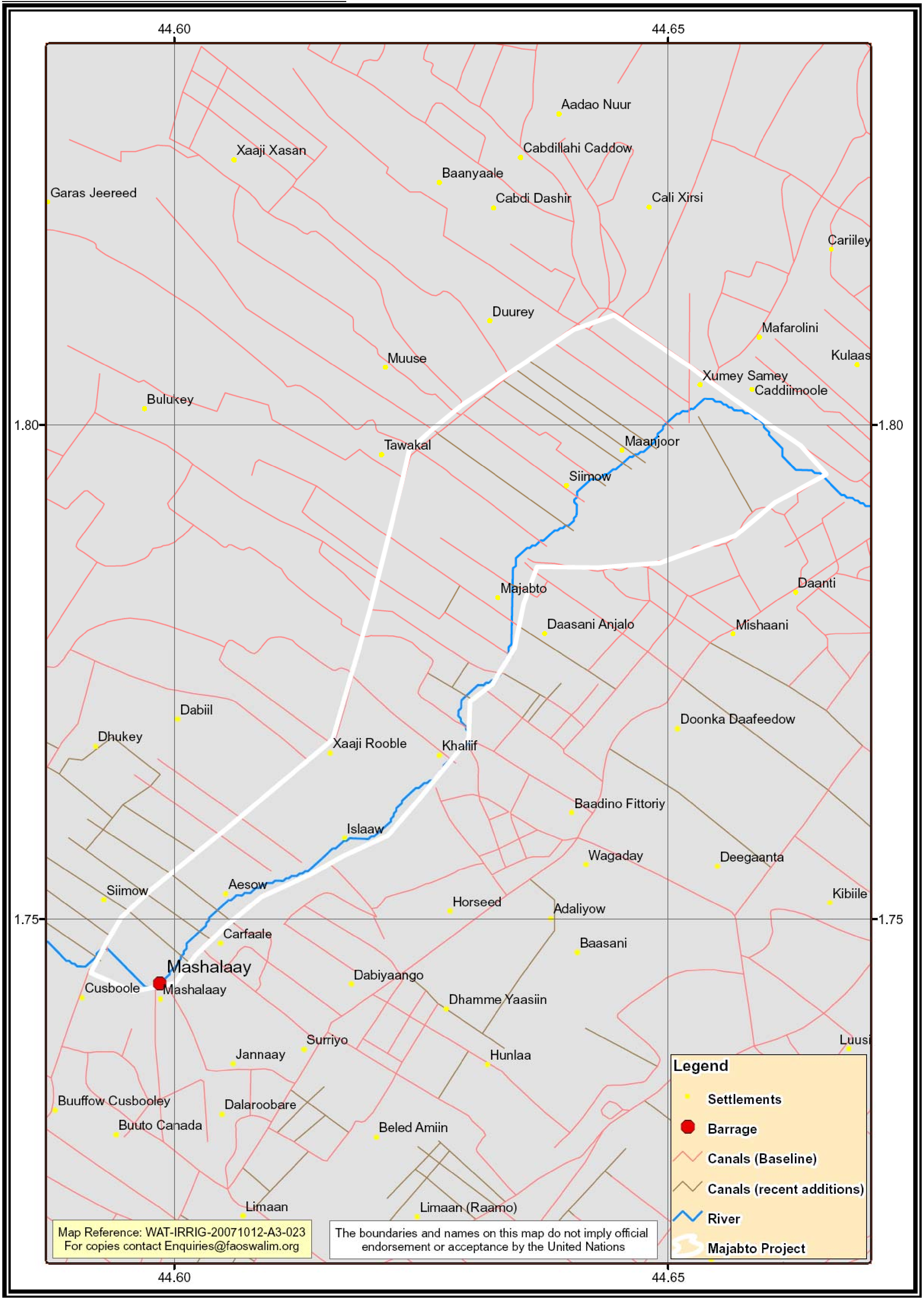

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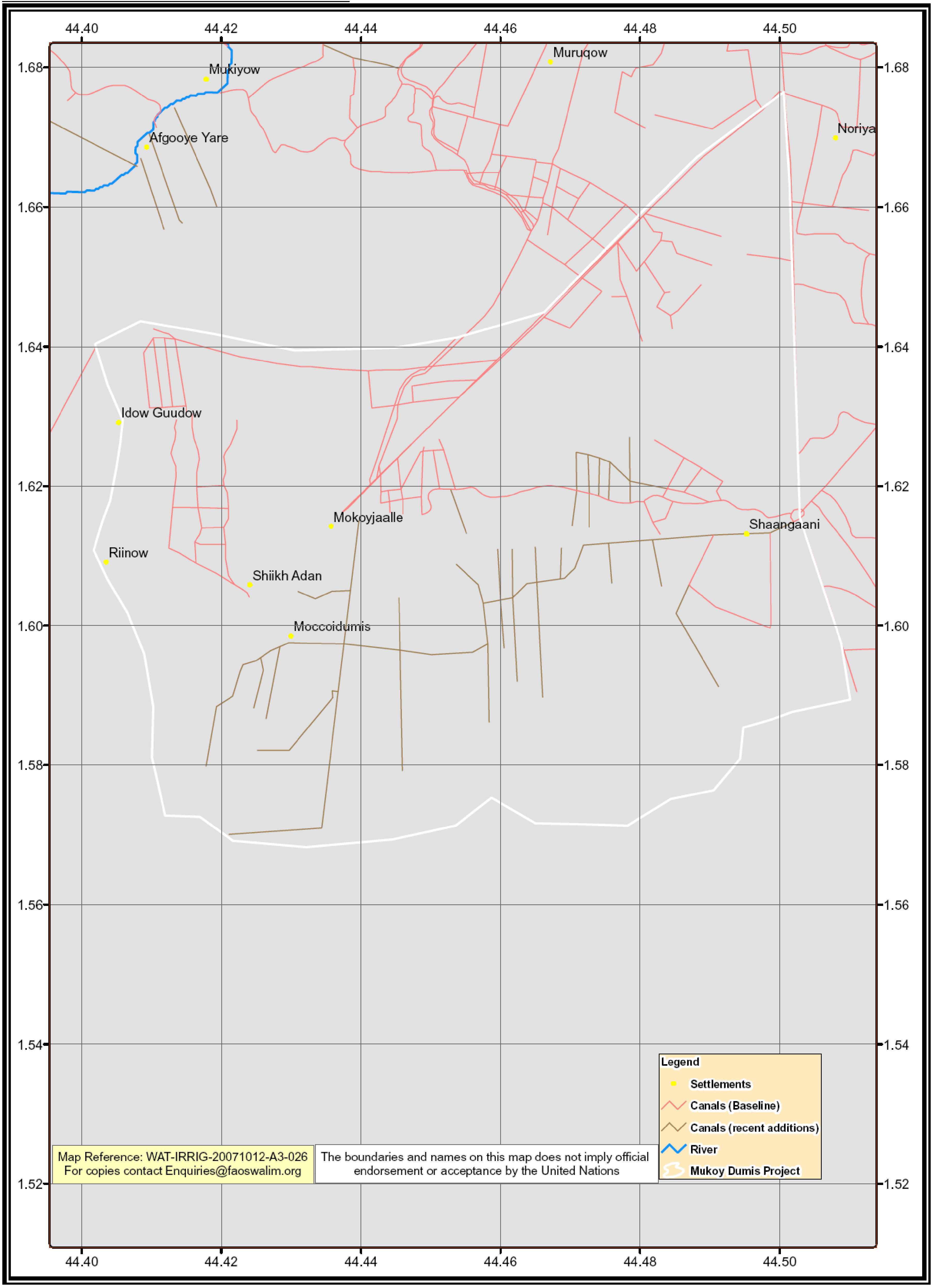

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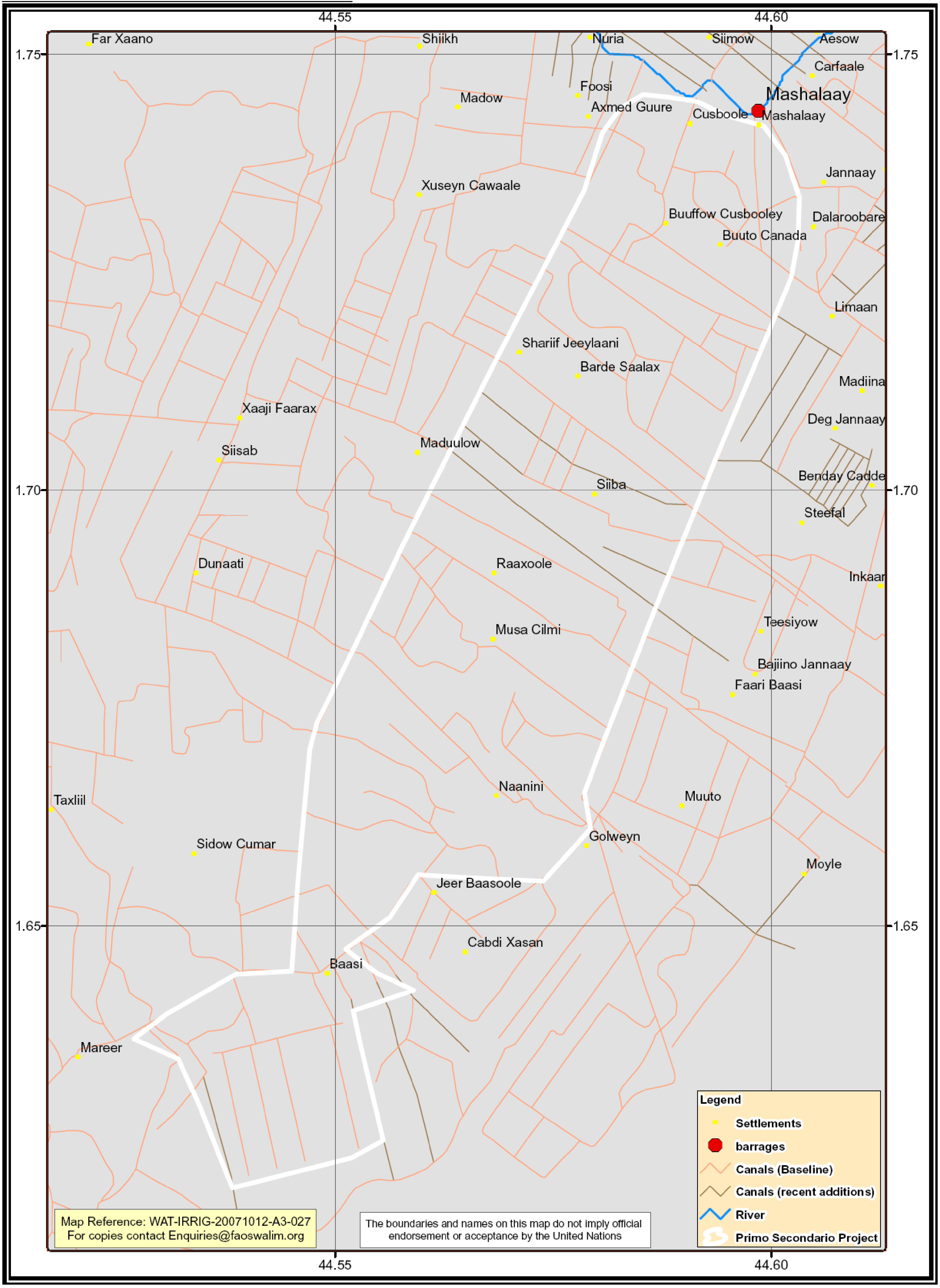
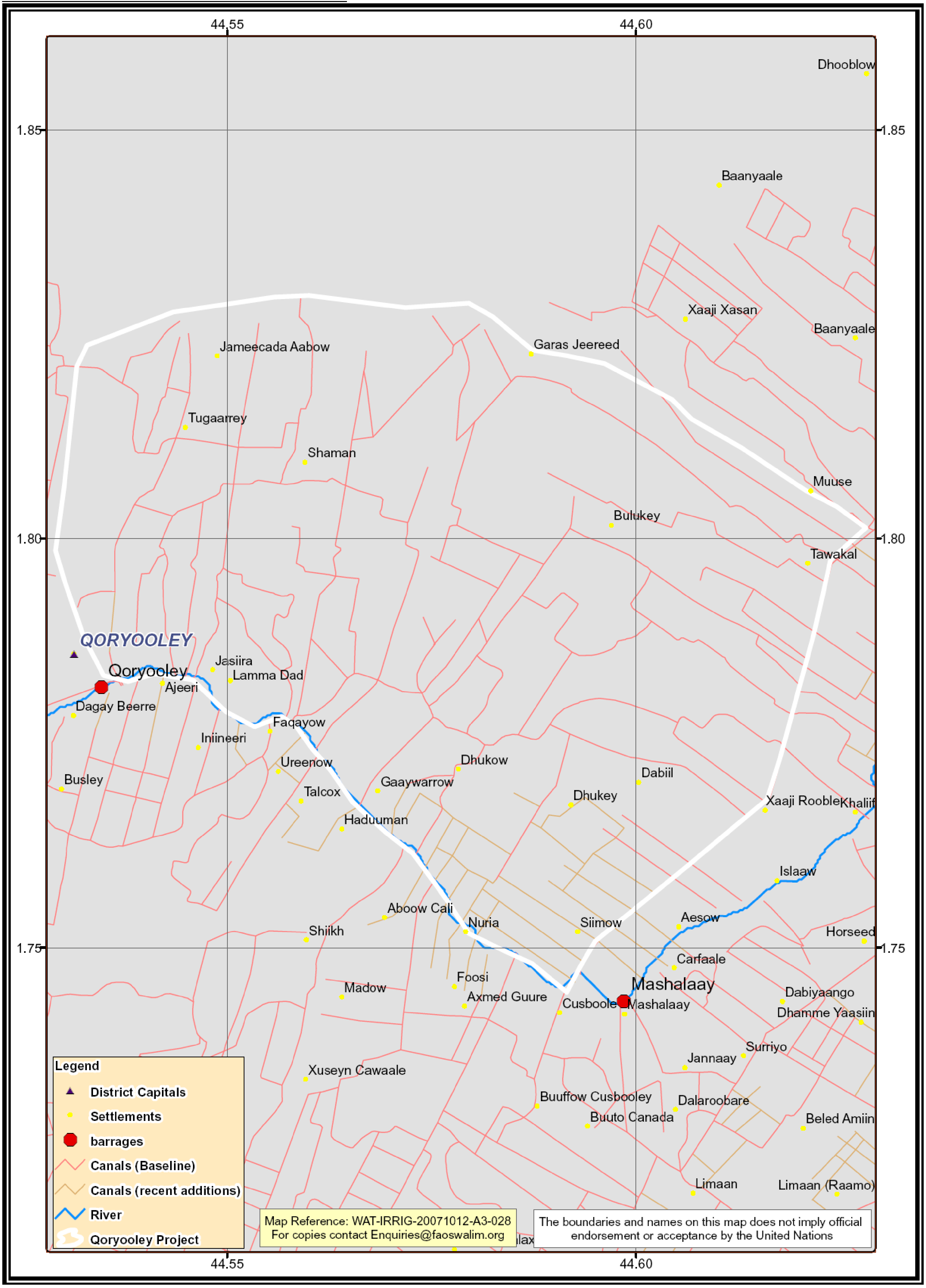


3.7.14 Primo Secondario Project



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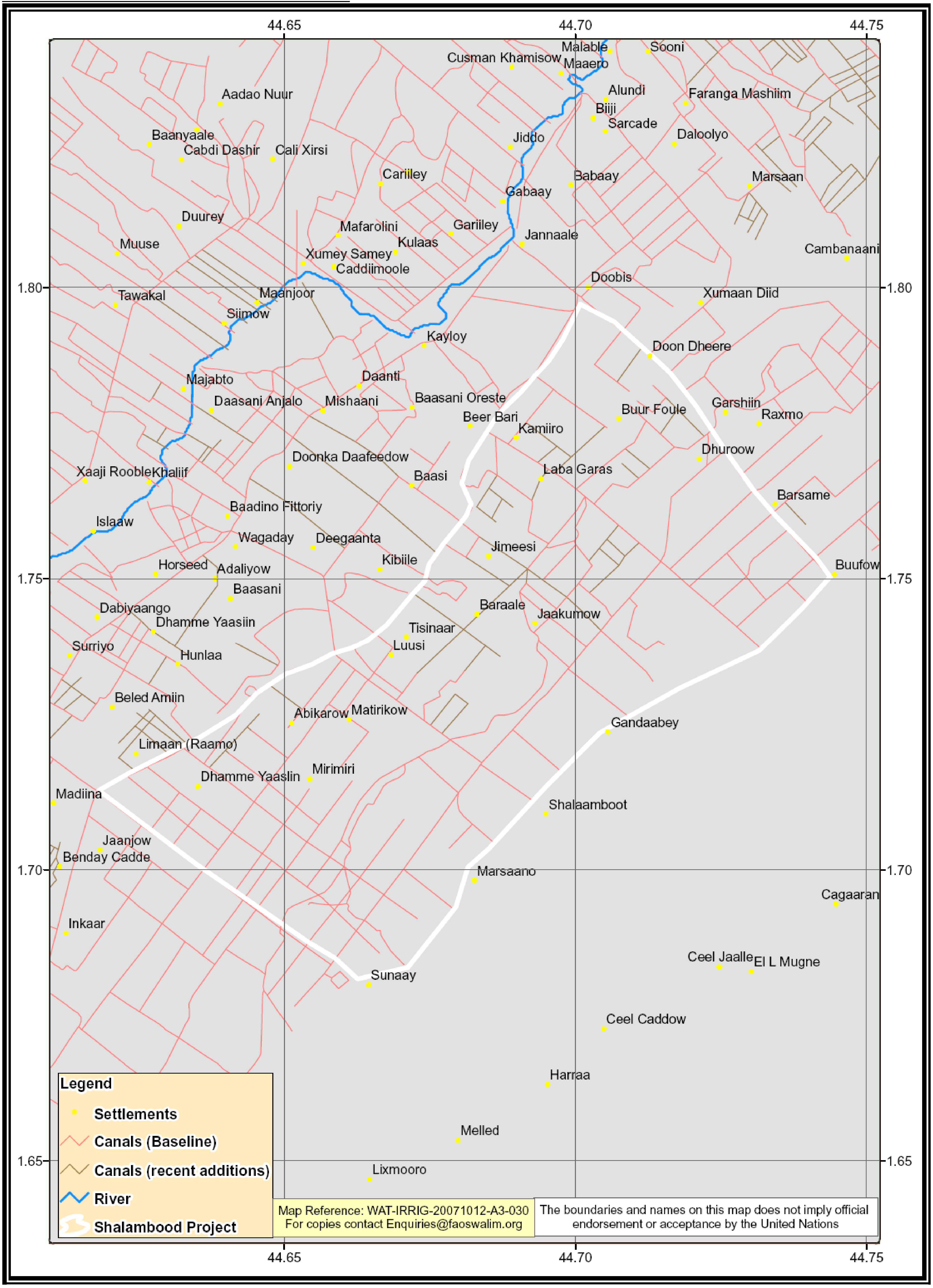
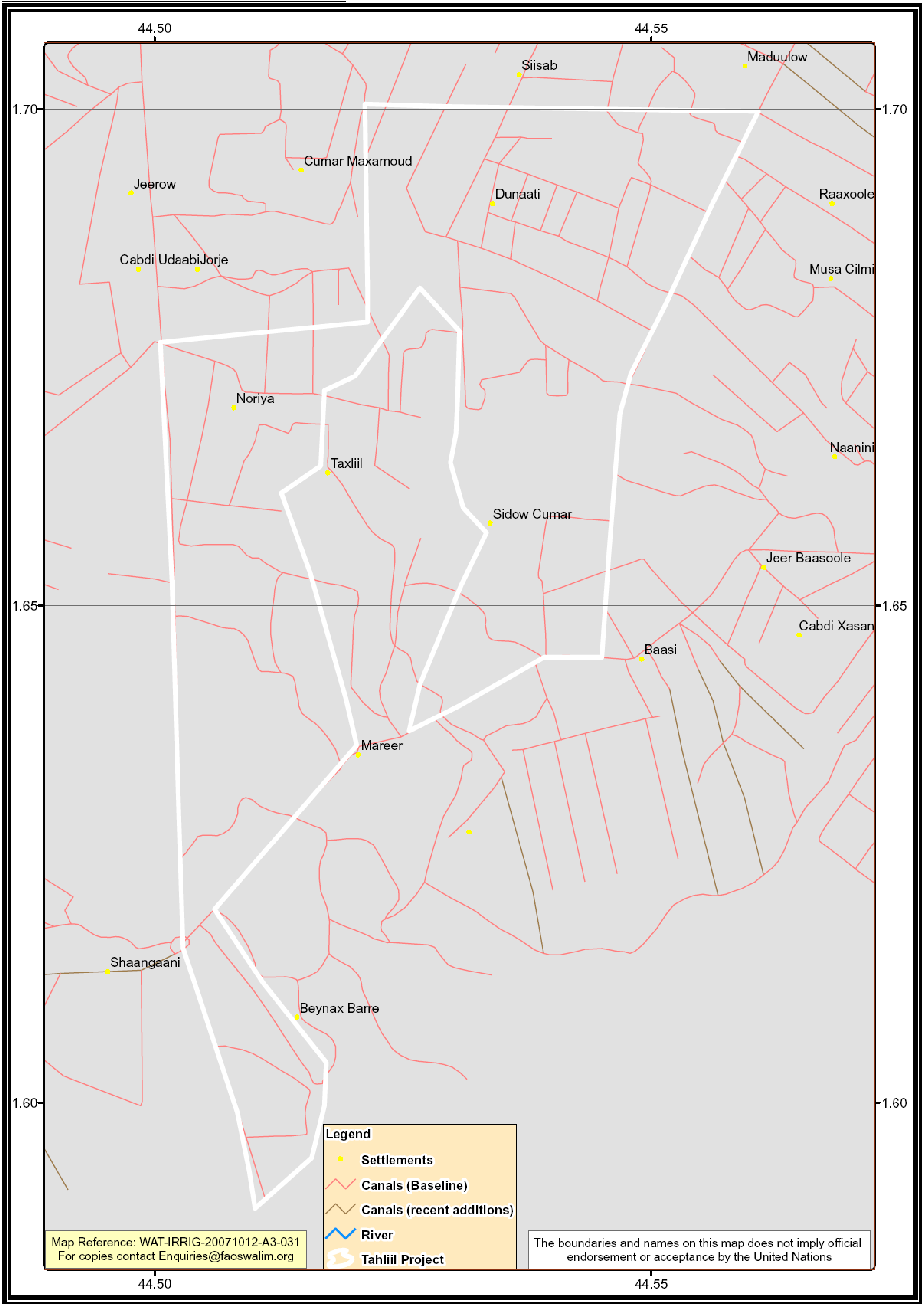
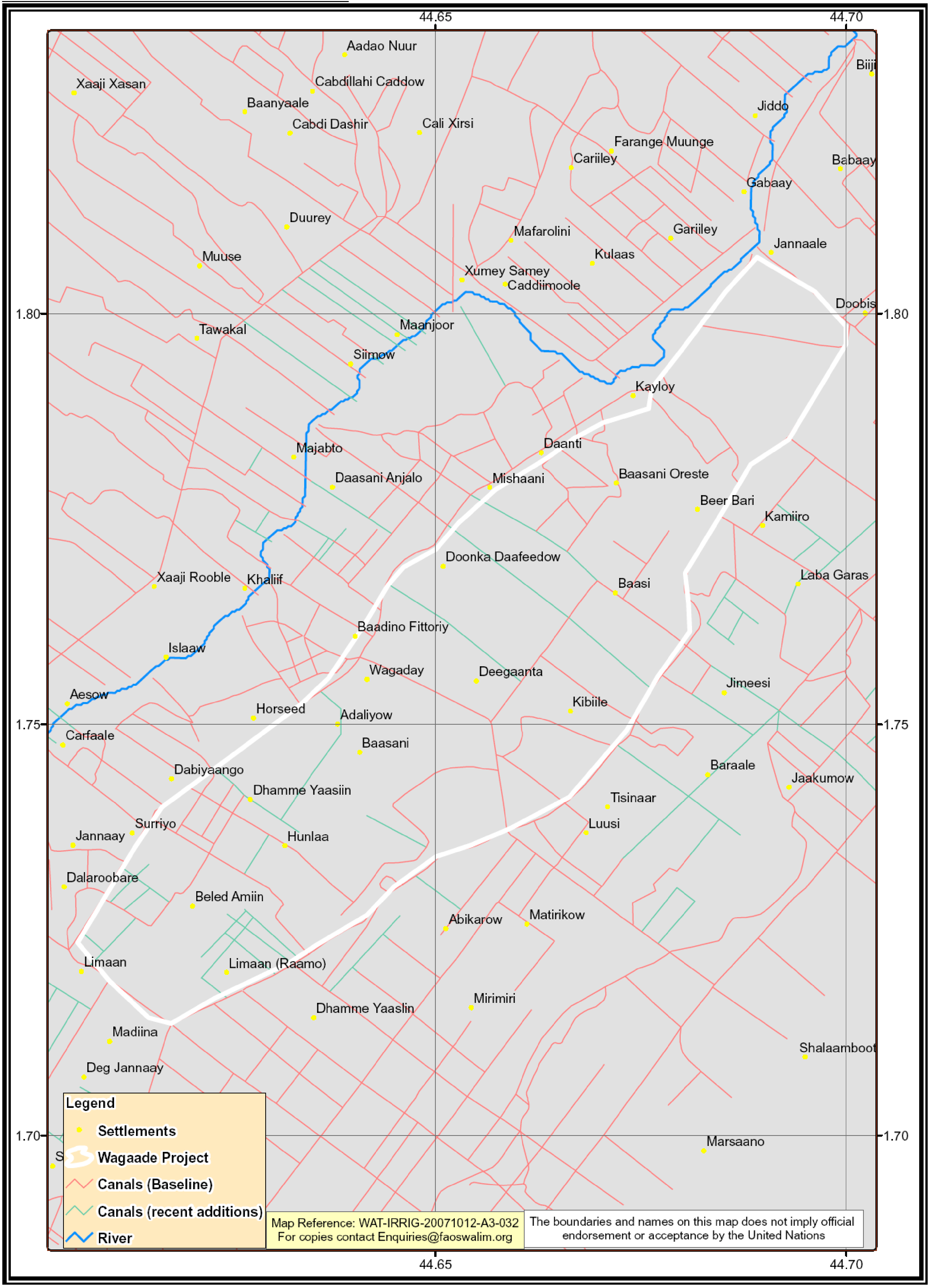


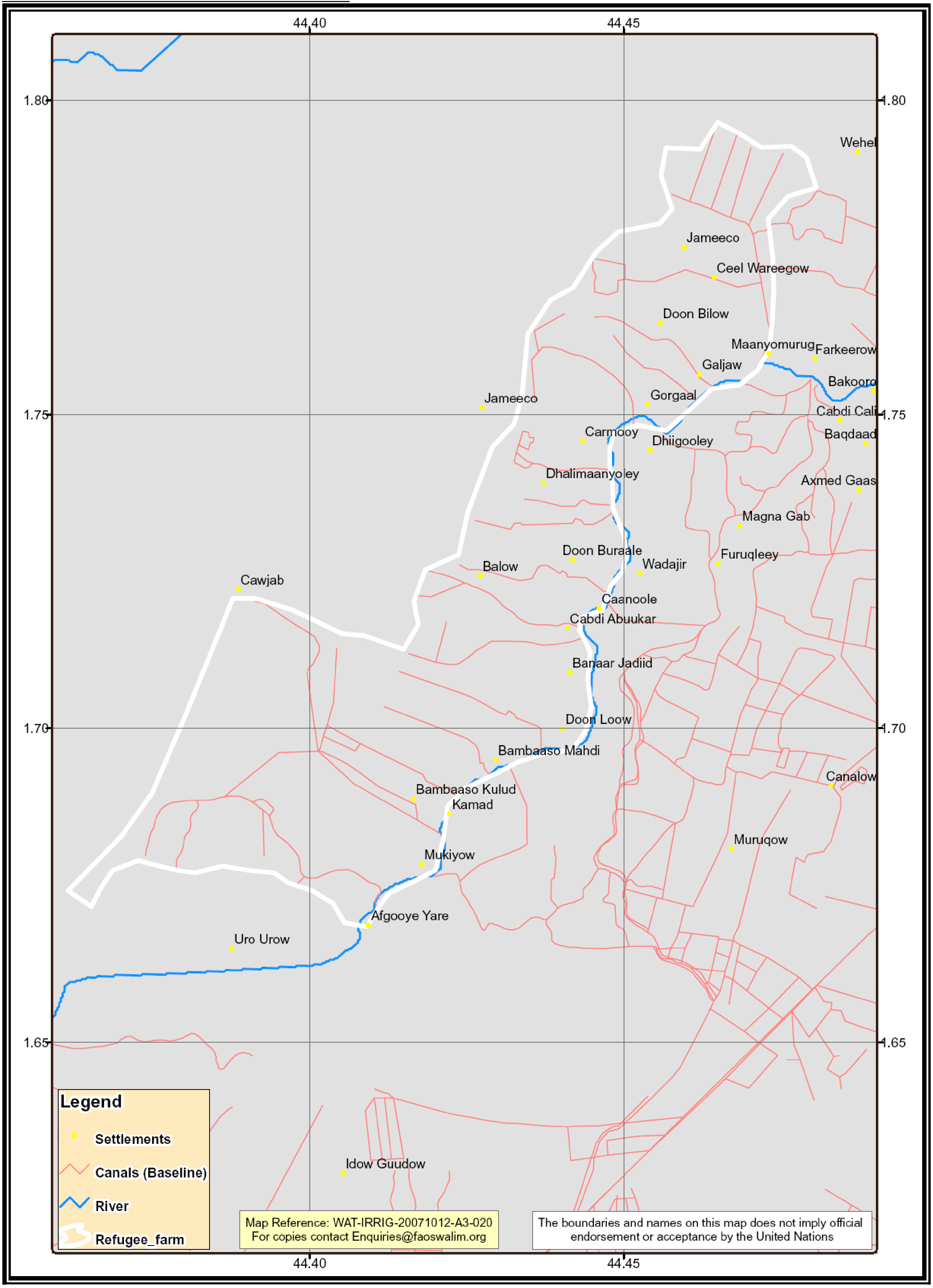
3.7.16 Shalambood Project



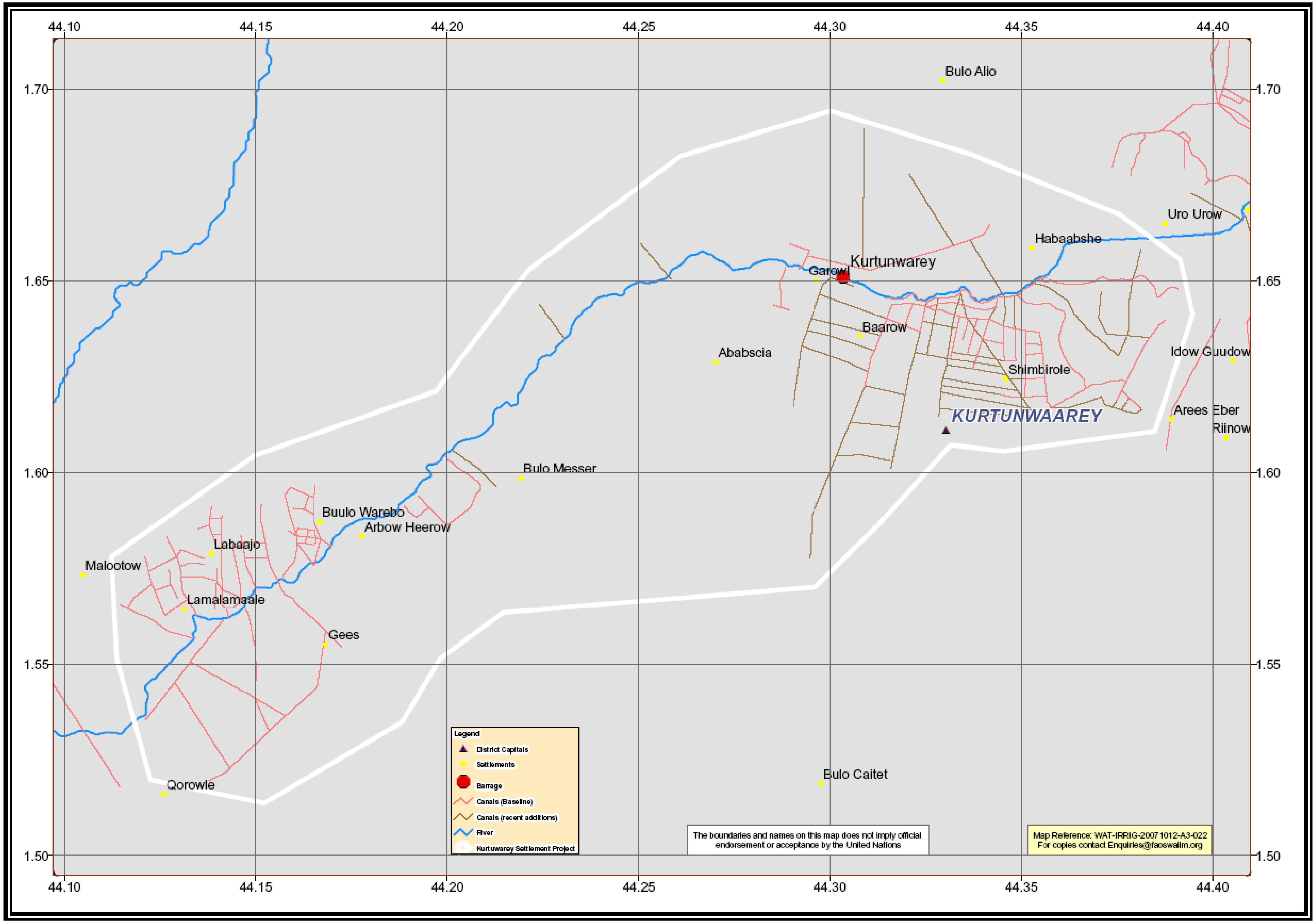
3.7.17 Tahliil Project



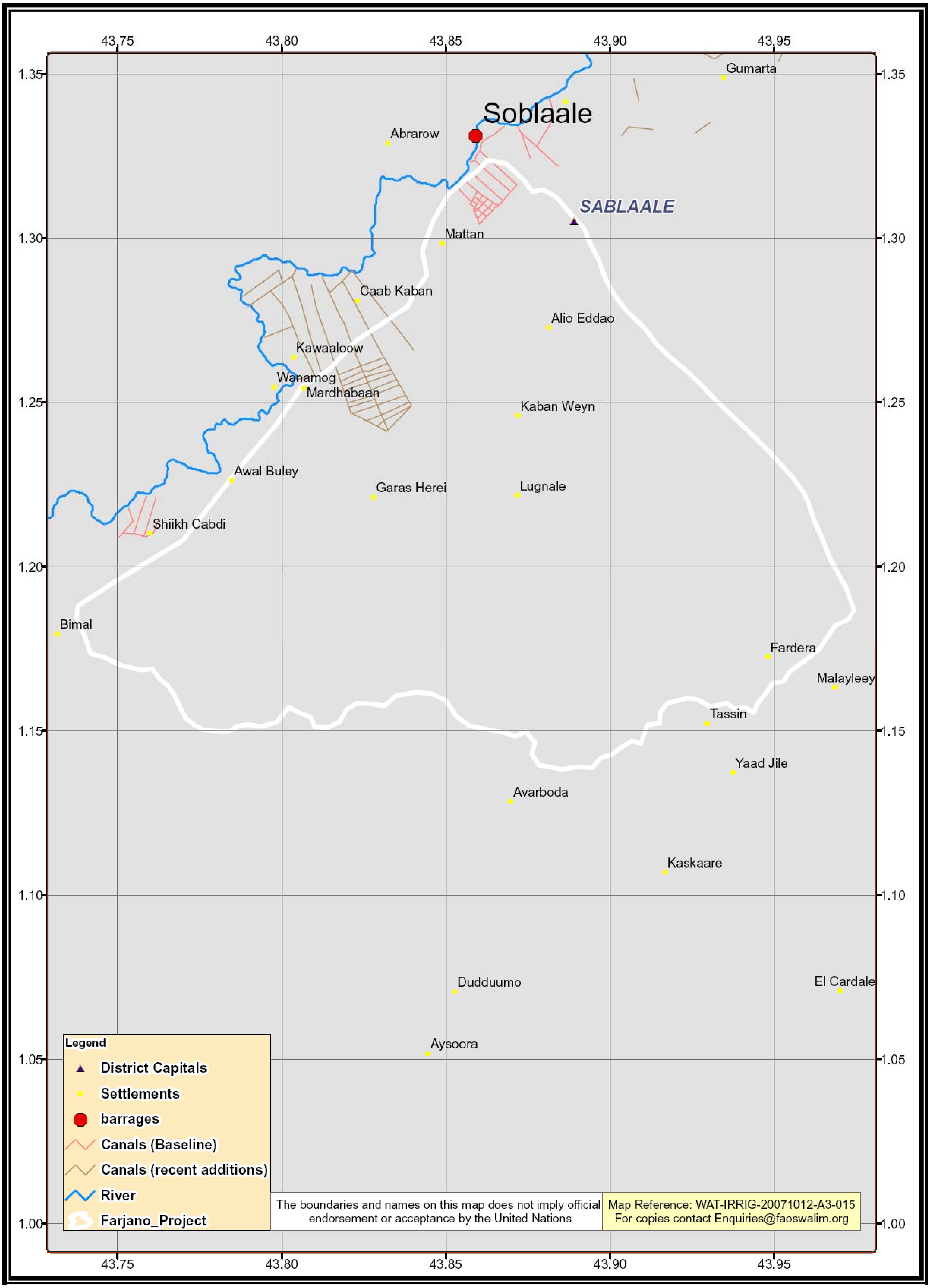
3.7.18 Wagaade Project



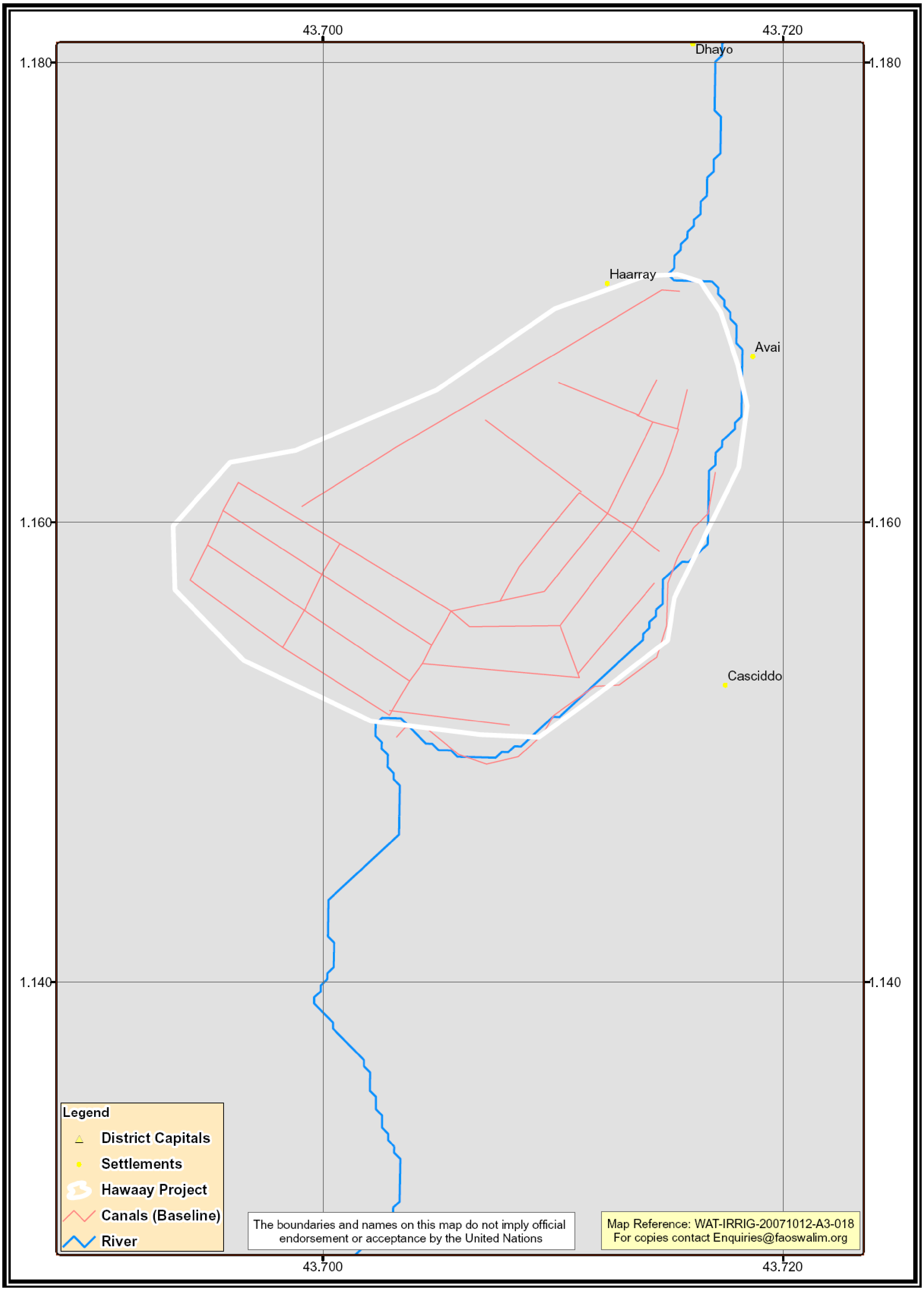
3.8 Refugee Farm



3.9 Kurtunwareey Settlement Scheme

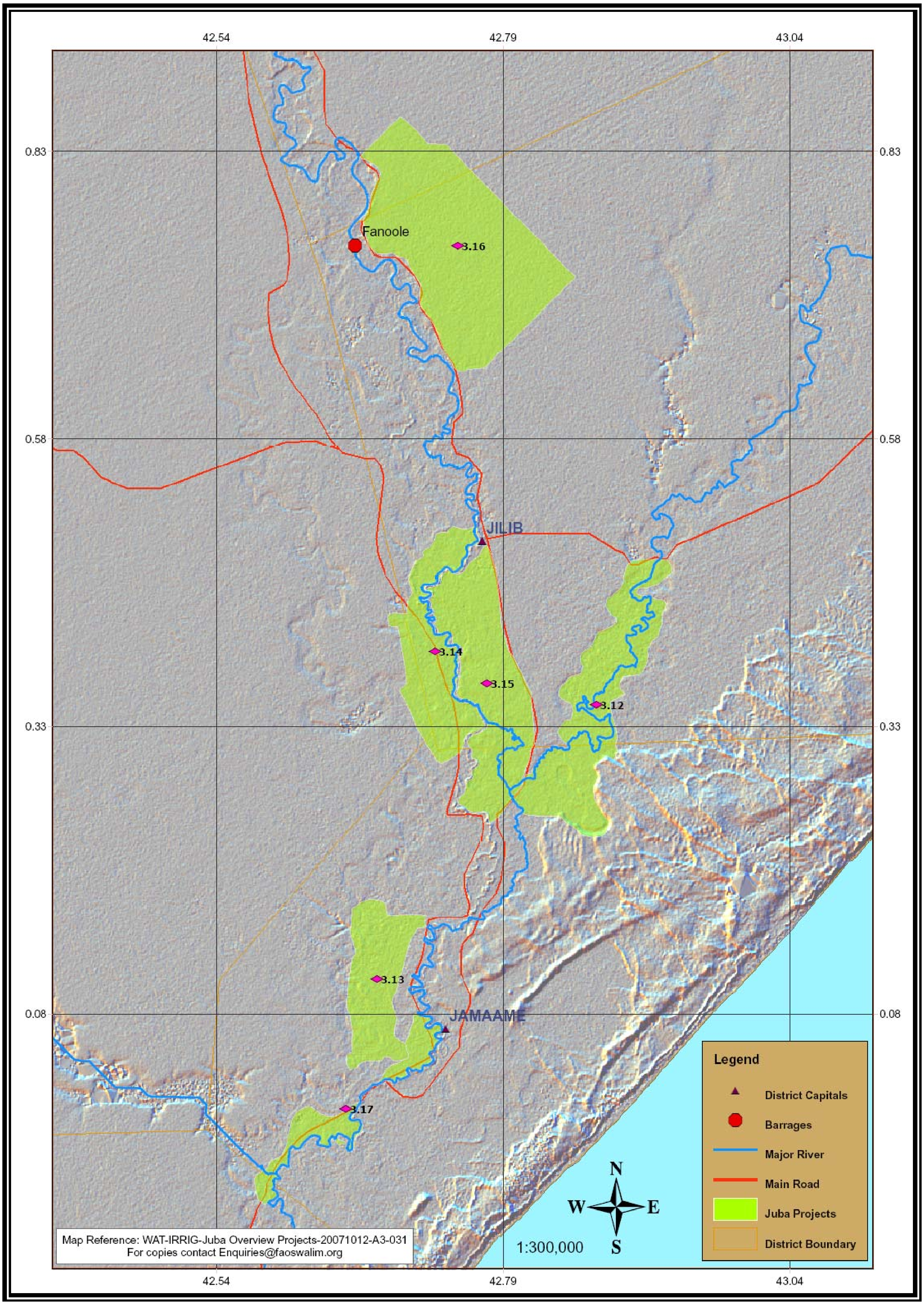


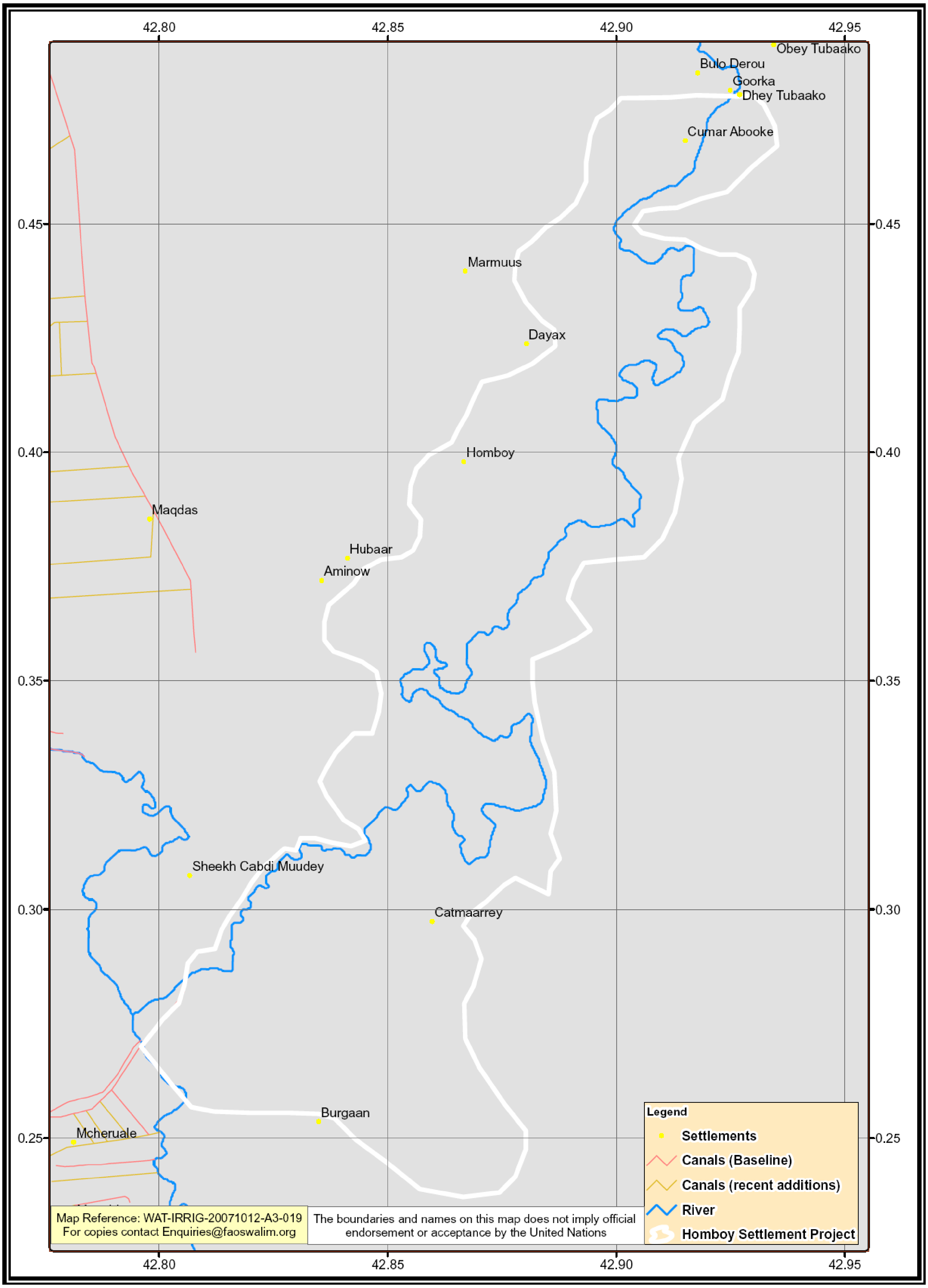
3.10 Farjano Project



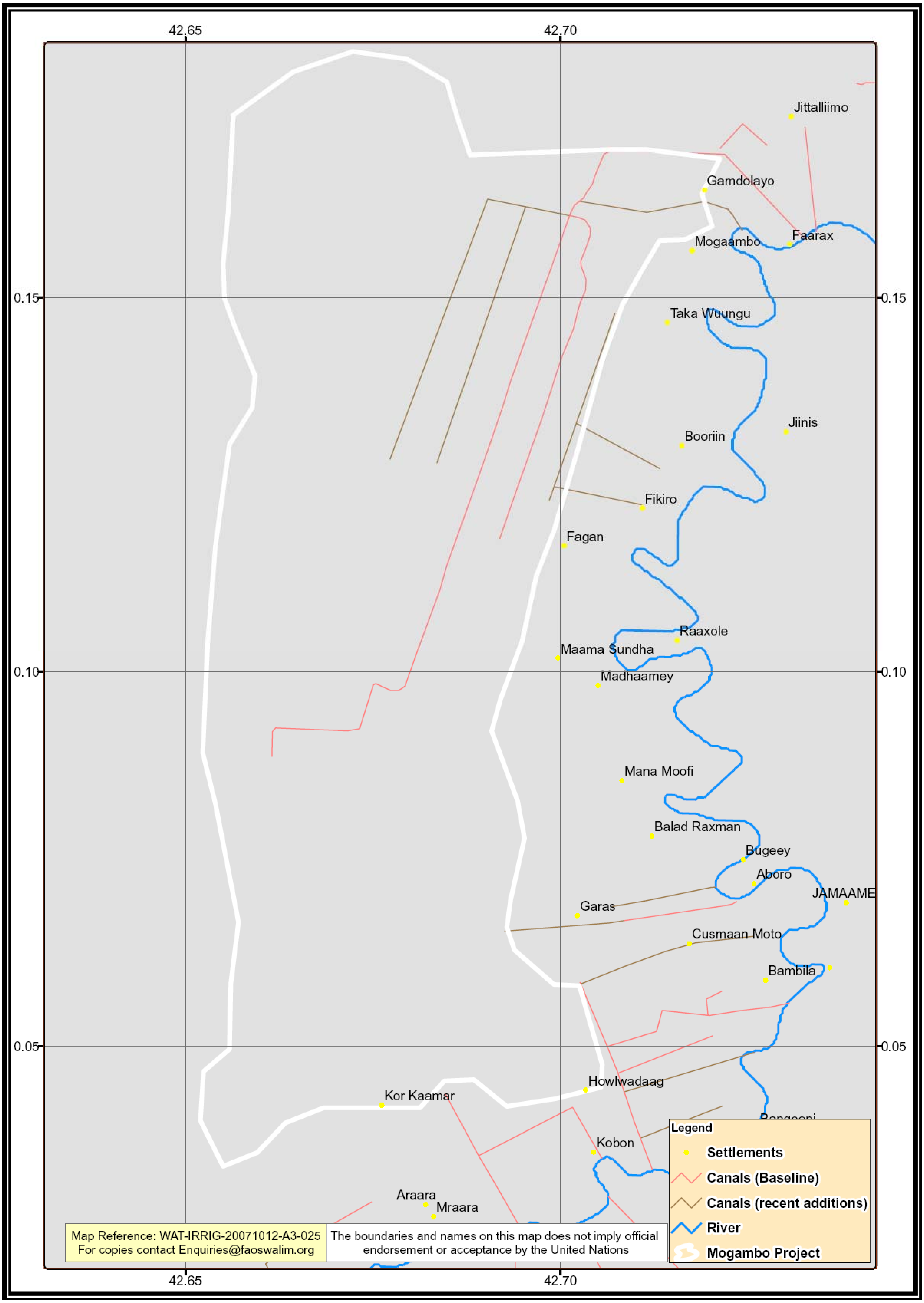
3.11 Haway Project

Barrages and Irrigation schemes in Juba River

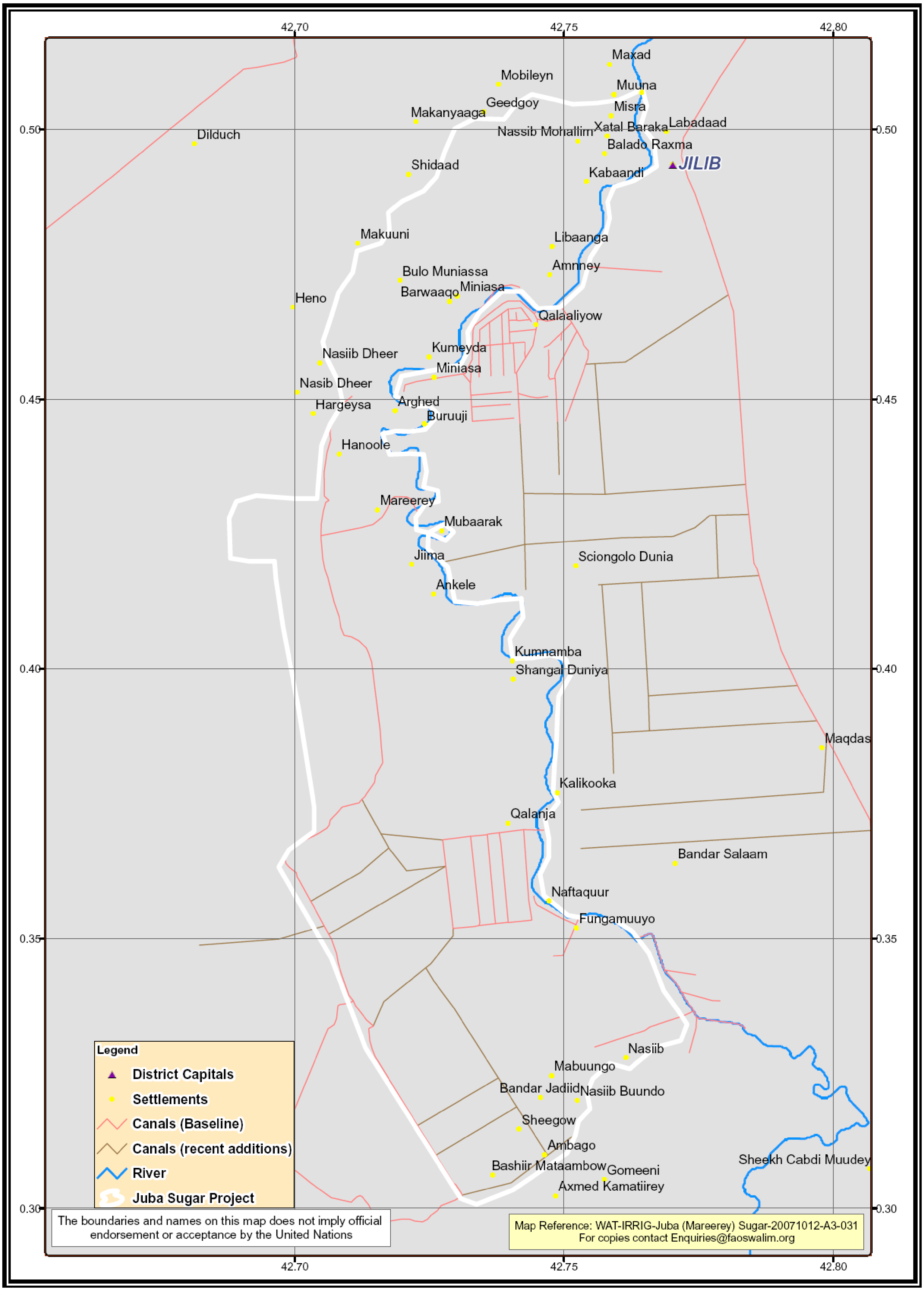




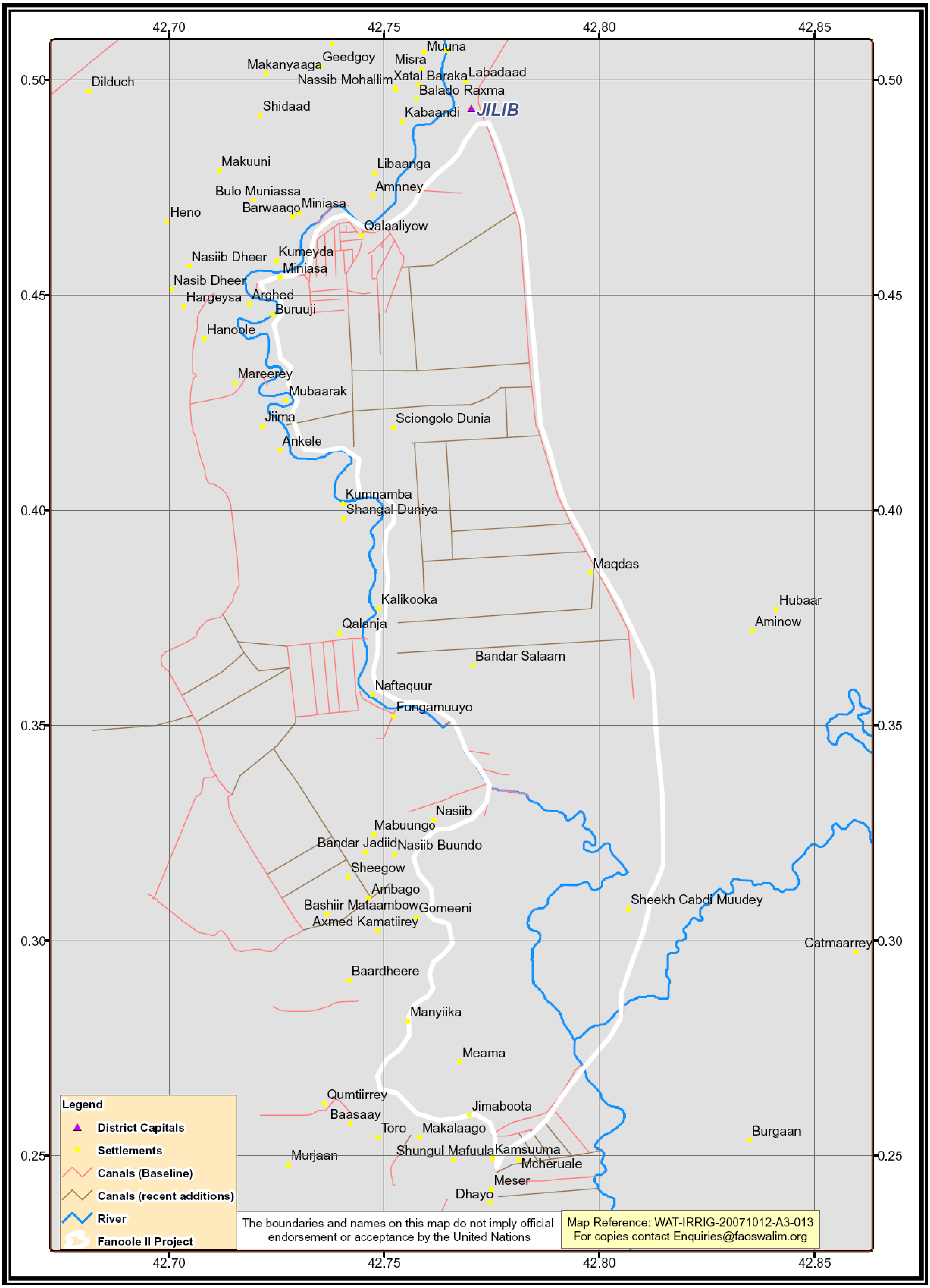
3.12 Homboy Settlement Project (Proposed)



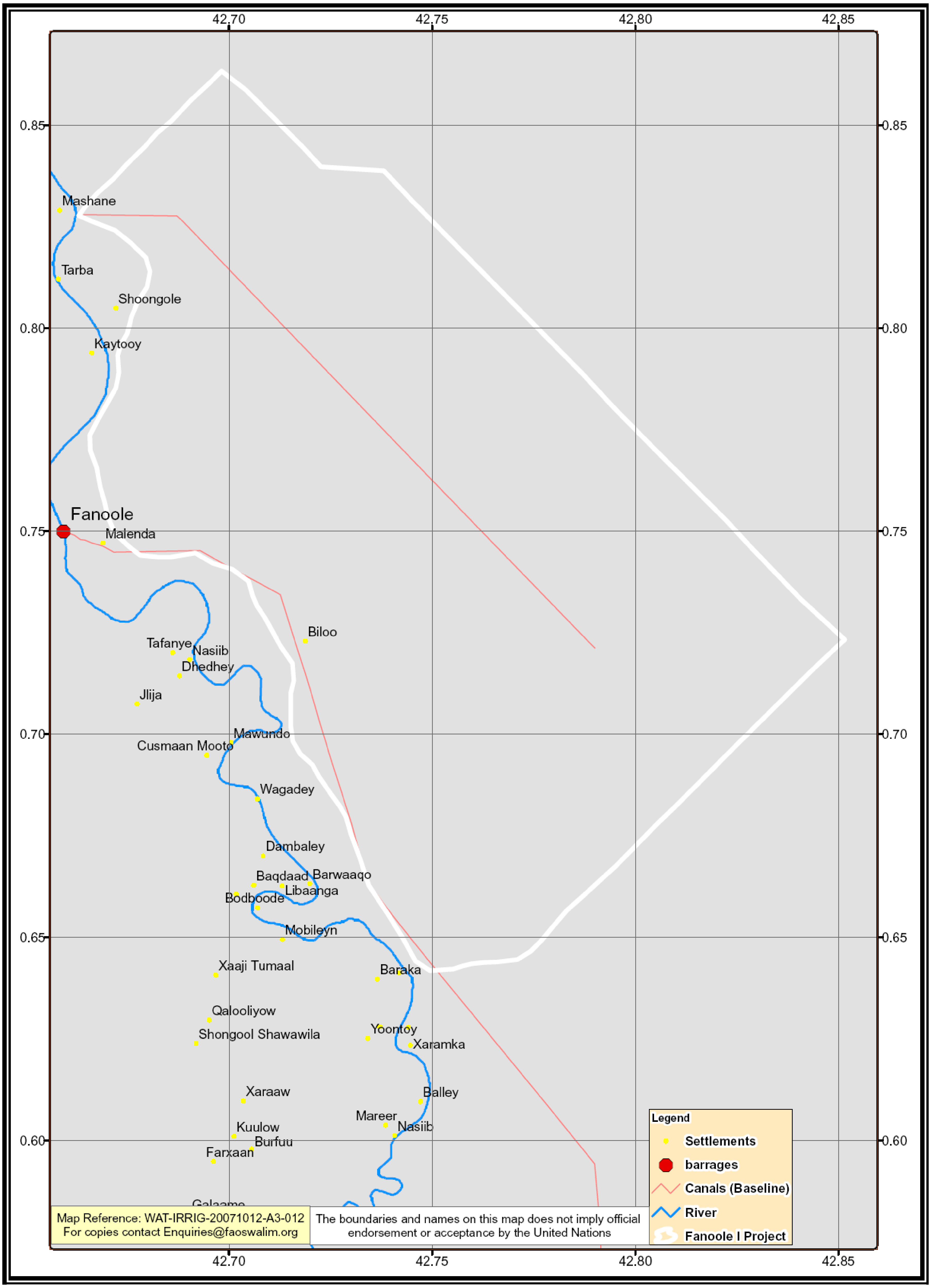
3.13 Mogambo Irrigation Project



3.14 Juba Sugar Project



3.15 Fanoole II Project



3.16 Fanoole I Project

Annex 4: Organization and Management of Irrigation Schemes: *Mogambo irrigation project case study*

A4.1 Project administration

The success of the Mogambo Irrigation scheme depended on the establishment of an effective management and organisational structure at the start of the project. The underlying concept was one of direct line control from the General Manager downwards. The Mogambo board was composed of representatives from three Ministries, viz. Agriculture and Livestock, Forestry and Range, and Industry, plus representatives from the State Planning Commission and the Juba Valley Development Authority. The departmental organisation structure of the scheme was as shown in Figure A4.1.

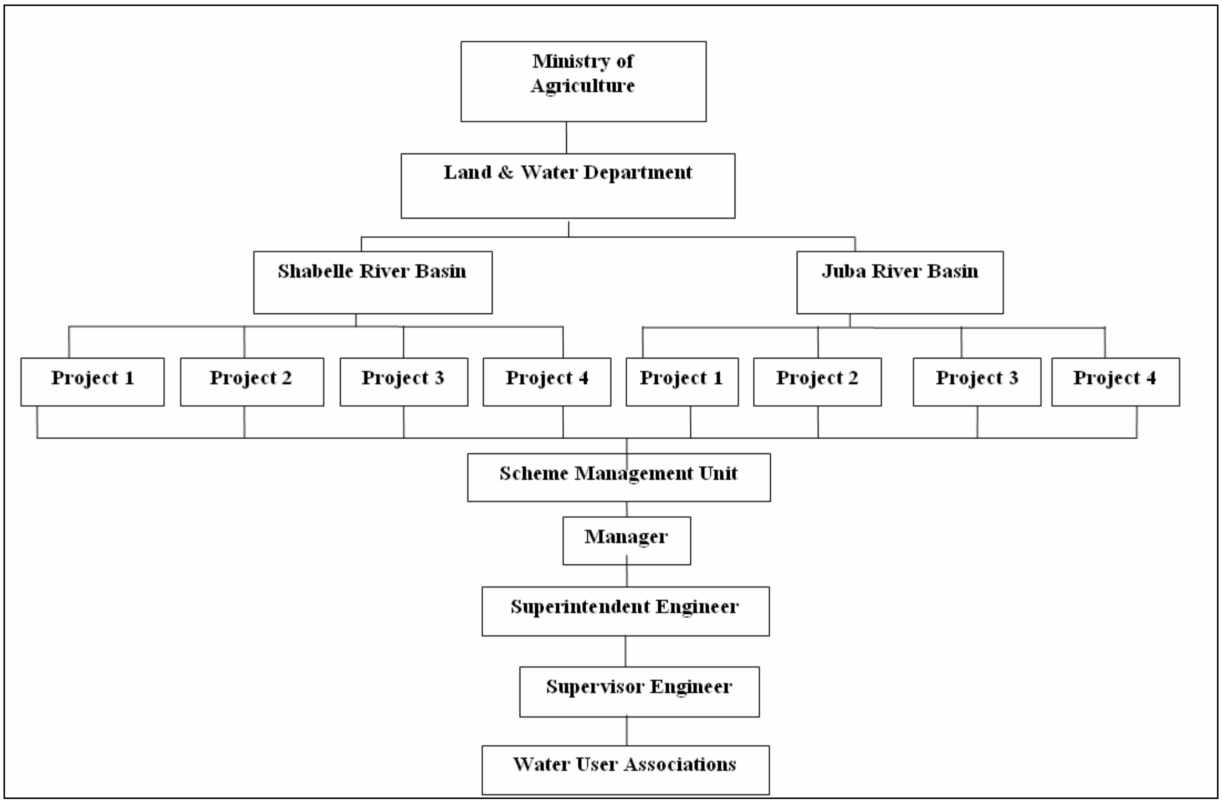


Figure A4.1: Departmental organization structure

The General Manager of the project also acted as the chairman of the board. The Deputy Manager (Operations) was in charge of all farm operations, operating through four farm managers and specialists in agronomy and irrigation. Farm managers assisted by supervisors for Irrigation, mechanization, and agricultural operations were in charge of day to day farm management. Operation of the irrigation system within each farm was under control of the farm manager in conjunction with an irrigation engineer. The operation and maintenance of the main canal and irrigation and drainage pump stations was the responsibility of an irrigation engineer (Figure A4.2a).

The farm managers directed the use and day to day maintenance of agricultural machinery, but servicing, repair and overhauls were carried out at the project headquarters workshops, supervised by the workshop manager. Training on the farm was supervised by the training manager under the general control of the Administrative Manager. There was a training officer located on each farm in order to incorporate training in daily farm routine. A training centre at headquarters catered for formal training and practical demonstrations. The administrative manger was responsible for personnel and community services. The chief accountant controlled the financial side of farm management, responsibilities including budget, wages and stores control.

A4.2 Operation and maintenance of irrigation and drainage systems

The irrigation engineer was in charge of overall operation and maintenance, but much of the routine work was done under supervision of each farm manager on his farm. The irrigation engineer supervised the operation and maintenance of the main pump station, the main canal and settling basin, the sprinkler pump station, the drainage pump stations and the storage reservoirs. A team of operators and maintenance staff with appropriate machinery and vehicles ensured that the right amounts of water were in the right places at the right times.

Distributary canals were operated by ditch riders under the direction of irrigation supervisors working in conjunction with the irrigation engineer. Field irrigation was organized by block supervisors on each farm, working through foremen and irrigation labourers (Figure A4.2b). Maintenance of canals and drains in the farm was organised on a daily basis by the operational staff and most of this work included bank repairs to field channels; weed clearance was done by hand (Sir Mott Macdonald and Partners, 1978).

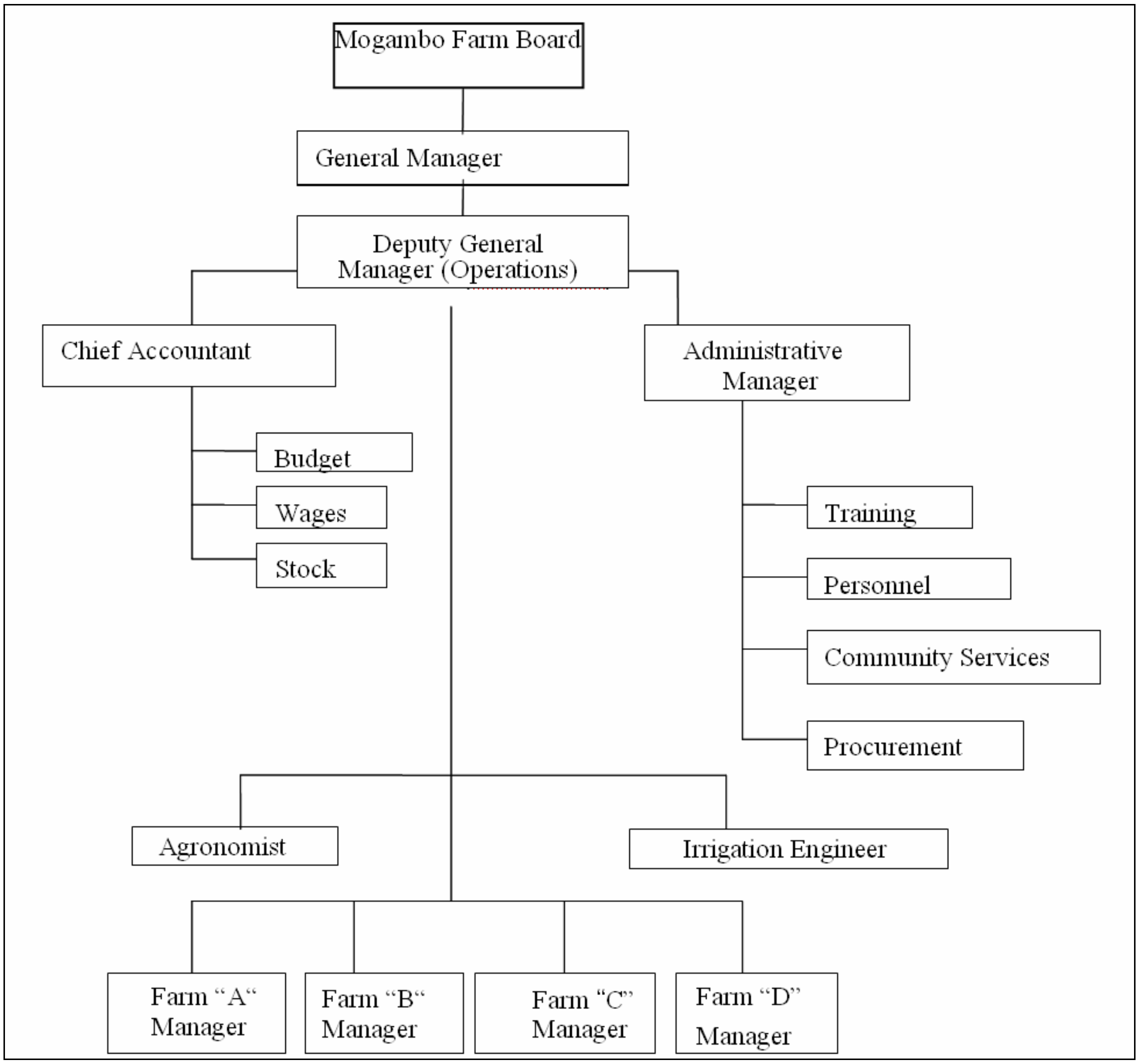


Figure A4.2a: Mogambo irrigation scheme management

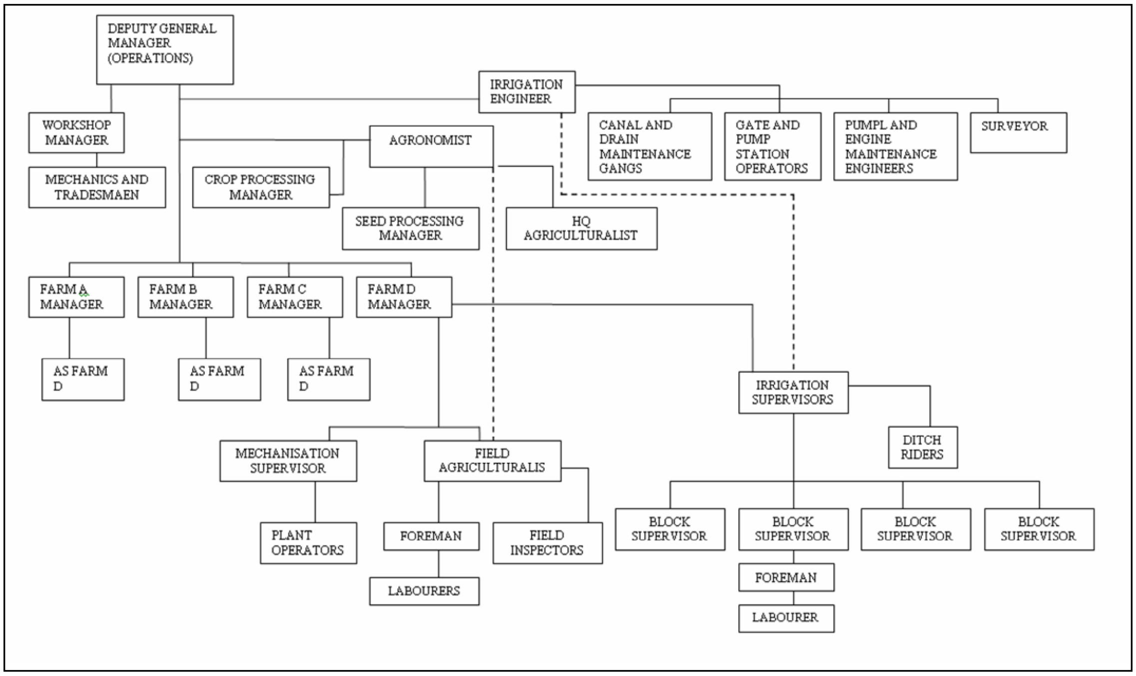


Figure A4.2b: Operation and maintenance of irrigation and drainage systems

A4.3 Farm irrigation practices

Farm irrigation practices were basically the delivery of water to fields, application of water to the field, the use of water by crops and the removal of water or drainage by surface and subsurface means.

A4.4 Delivery to the farm

The first concern in delivering water to the field was that flow rates should be appropriate for the field application system. The field application systems were modified while flooding systems that were inherently very inefficient were classified as graded irrigation systems. Graded irrigation systems required that flow rate to the field be adjusted to allow rates of advance and recession to balance the opportunity time required to infiltrate the required irrigation. This was a major constraint because the low intake soils required that opportunity times equal a minimum of three hours, and in many instances as much as 24 hours. This precise flow regulation was not considered possible either due to the capability of irrigation systems or farmers' capabilities.

The low infiltration of soils further suggested that field irrigation systems could be a level–basin irrigation system. This allowed irrigation with any flow rate that was the minimum for the size of the basin available and a maximum based on the erosion constraint for the soil. In addition, infiltration opportunity time included extra amounts needed for leaching of salinity. In 1990, conditions in irrigated areas did not permit a uniform application of water and this resulted in under-irrigation of upper areas of the basin and over-irrigation of the lower areas. Under-irrigation contributes to salinity accumulation and over-irrigation contributes to a high water table, which in turn also increased salinity.

Water delivery at the field level also needed to reflect crop water requirements. This meant less frequent irrigation when crops were small or when evapotranspiration rates were low, and more frequent irrigation when crops were sensitive to water stress and evapotranspiration rates were high. Where the irrigated areas were relatively small, demand or modified demand systems were provided to increase effectiveness of water use and maximize crop production. The most serious constraint to improved crop production and effective water management was the undependable delivery of irrigation water at the field level (Agrar-Und Hydrotechnic GMBH, 1990).

A4.5 Field application systems (tertiary canal system)

The pre-war irrigation system in Southern Somalia was characterised by non uniform distribution of water. Water was application depth varied between 15-25 cm or more. Bi-directional slopes and random high and low areas on field surfaces precluded effective application of irrigation water. Field application systems needed improvements in land levelling. Components of the programme included a levelling service, appropriate system design and improved water application practices.

A4.6 Water removal system (drainage)

Lack of surface drainage for both rainfall and irrigation was a constraint to crop production in many areas. This was caused by low-intake soils due to the bunds around most field areas, and lack of surface channels to drain off excess water. Low areas in fields and areas at the low end of bonded areas have the effect of excess surface water on crops and effects on plant vigour. Sub-surface drainage was needed in areas where a high water table and surface soil salinity caused areas to be taken out of production. Saline groundwater and naturally saline soils indicated that groundwater levels had to be controlled, if irrigated lands were not to be taken out of production as a result of high water tables and/or salinity. The best approach to controlling both surface and sub-surface drainage was to control irrigation applications. In addition, design and management criteria had to be developed.

A4.7 Organizational constraints

Personnel were few and lacking experience in a number of areas in each department. They needed strengthening.

A4.7.1 Monitoring and evaluation

A monitoring and evaluation cell for action research and to assist in other areas was needed to initiate an irrigation water improvement programme. Performance evaluation of each service unit, such as land and water, extension and delivery of inputs provided inputs to defining further organizational needs in the ministry.

A4.7.2 Farmer organizations

Farmer organizations existed in a number of instances, for private efforts to divert irrigation water from the river. These apparently operated successfully but needed assistance to improve performance.

A4.7.3 State farms/schemes and projects

Many state farms, resettlement schemes and projects whereby irrigated areas were provided with water also needed various kinds of assistance, but operated organizationally with a paternal/directive type of operation. This area also needed improvement.