RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR

HRC SUDAN Hydraulics Research Center مركز البحوث الهيدروليكية

Harnessing Floods to Enhance Livelihoods and Ecosystem Services in Gash Area

Progress Report – January 2016

Hydraulics Research Center (HRC)

Ministry of Water Resources, Irrigation and Electricity

P.O. Box 318, Wad Medani - SUDAN

Table of Contents

List of Figures

List of Tables

0. Overview

The research project "**Harnessing floods to enhance livelihoods and ecosystem services**" is funded by CGIAR research program on Water, Land and Ecosystems (WLE) and it is being implemented in the Gash area in Sudan by the Hydraulics Research Center (HRC) of the Ministry of Water Resources, Irrigation and Electricity over the period Jan. 2015 to Dec. 2016 in collaboration with its partners, Spate Irrigation Network Foundation, MetaMeta (leading partner), UNESCO-IHE.

The research project aims to optimize the use of floods for agriculture and ecosystem services to support livelihoods settings in the Gash River basin.

This report presents the progress of the project's different activities including management activities and visits by the partners during the first year 2015. The report also highlights in details the achievements of the main components of the project namely:

- Ground water modelling,
- Water resources allocation of the Gash River,
- Ecosystem services,
- Gender and equity, and
- Communication techniques.

1. Introduction

The Gash River originates from Eritrean Highlands and ends in Gash Die in Sudan. It has an estimated catchment area of 21000 km^2 which is shared among Eritrea, Ethiopia and Sudan. The Gash River is characterized by its seasonality and it flows torrentially between July and October while it becomes dry over the rest of the year. In spite of this changeable regime, the river is the main source of irrigation water of the Gash Agricultural Scheme "GAS", domestic water use of Kassala city and its surrounding area, ground water recharge, etc... In fact, most of the social and economic activities of the area depend on the river. The Gash annual yield is about 0.65 Billion m^3. On the other hand, the unpredictable nature of the floods, the changes in the river beds and the considerable amount of sediment carried each year represent a real challenge for development activities.

With reference to the main objective of the research project "Harnessing floods to enhance livelihoods and ecosystem services in Gash area", benefits maximization of Gash river floods can be seen from different angles as follows:

a) How to distribute or allocate Gash flood waters optimally to satisfy the different needs of water uses depending on the river.
b) Some studies state that the groundwater depletion ranges from 4 to 7 m in the aquifers within Gash River. The component of groundwater modeling would in depth investigate the current status and availability of groundwater and also the possible linkage with the surface water resources.
c) Investigation of means of biodiversity enhancement especially downstream (Gash Die) and studying the impacts of the upstream developments on the downstream.
d) Impact of current and future development scenarios on the socio-economic settings in the Gash area.
e) Integrated system management considering all components to achieve the research objective.
f) Outreach techniques to a wide range of stakeholders and beneficiaries through different communication strategies.

2. Research components

2.1 Groundwater modelling

The Gash River basin is one of the most famous alluvial basins in Sudan. Groundwater basins are part of the ecosystem, therefore the studying and addressing any ecosystem problems in Gash basin requires the understanding of the present and future performance of aquifers within the basin.

2.1.1 Objective

- Develop a strengthened conceptual foundation for local catchment and groundwater basins problems using an ecosystem approach.

- Increase ability to develop and demonstrate alternate management approaches for groundwater in the Gash basin.
- Increase ability to identify, engage, and communicate with stakeholders, women and youth to participate in groundwater management and awareness.

2.1.2 Approach/Methodology

To develop a groundwater flow model for the Gash basin, the ModFlow2000 software will be adopted using the Argose one interface, which is compatible with the developed thematic base maps build as shape files. Several input data was constructed and presented to be entered as model parameters in discrete data values or imported Arc Map shapefiles.

2.1.3 Achievements

For this component, different activities were conducted; they are summarized as follows:

- Intensive literature review for previous studies with relevance to groundwater modelling in Gash River basin.
- Collecting and analyzing relevant geological and hydrogeological data and collecting satellites images, maps, cross-sections and any other information necessary for building a groundwater model of the Gash basin, Fig.1.
- Development of the conceptual model of the basin, with its various physical, inflow and outflow components.
- Actual field measurements for groundwater levels' fluctuations were conducted in June 2015, Fig. 2.
- Data entry process and preliminary results. Fig. 3 shows the produced maps for water table elevation in the Gash basin.

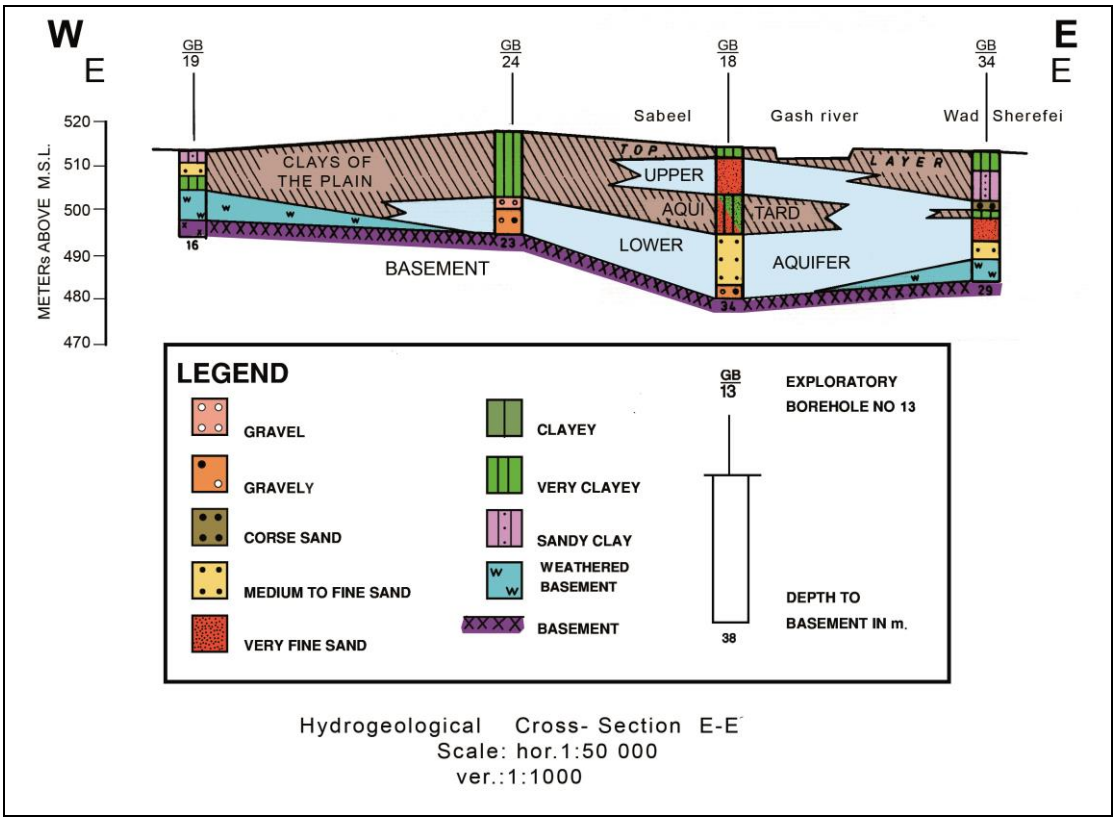


Fig 1: Example of cross-sections defining the aquifer geometry.

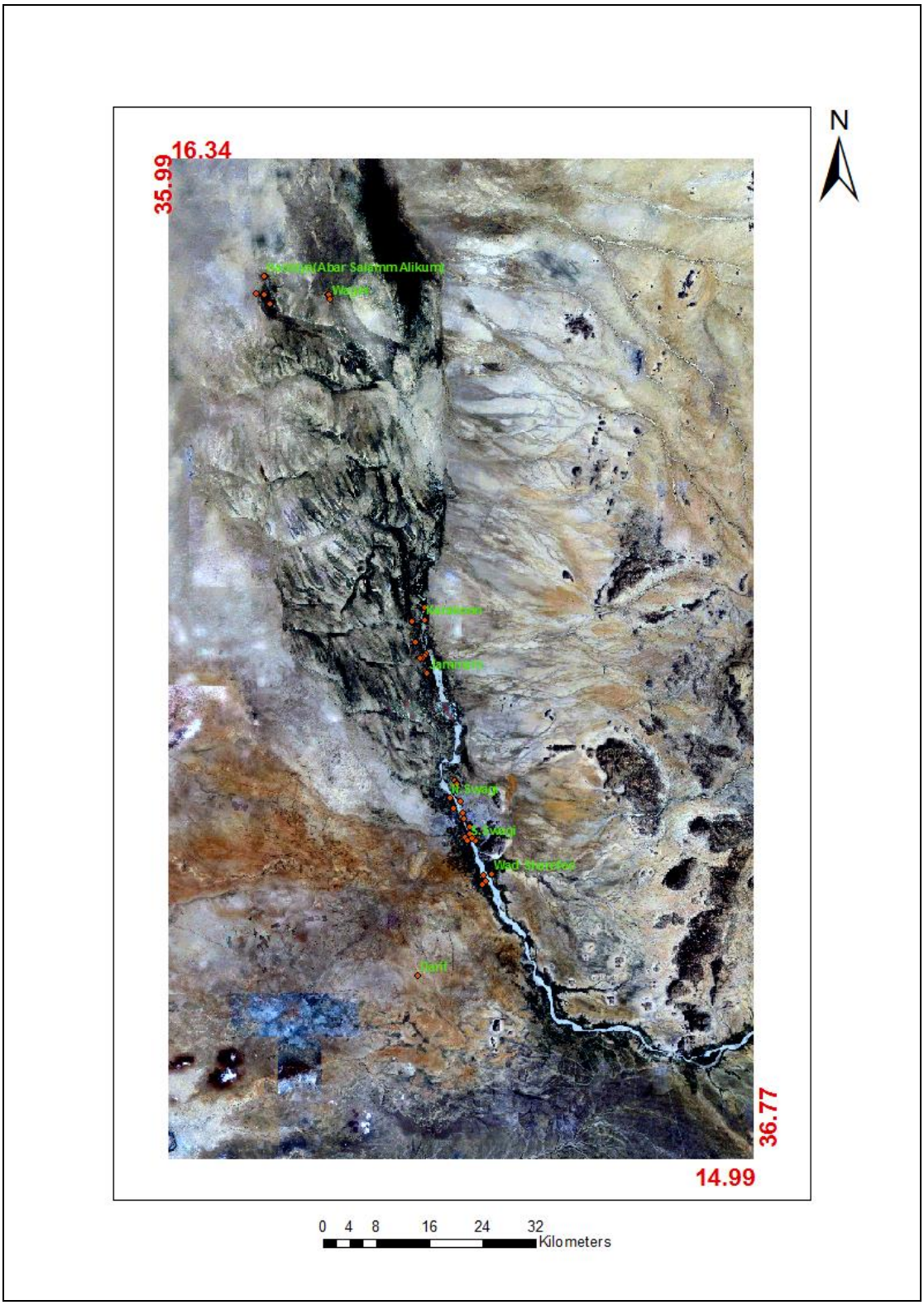


Fig 2: Location of wells monitored during field trip in June, 2015.

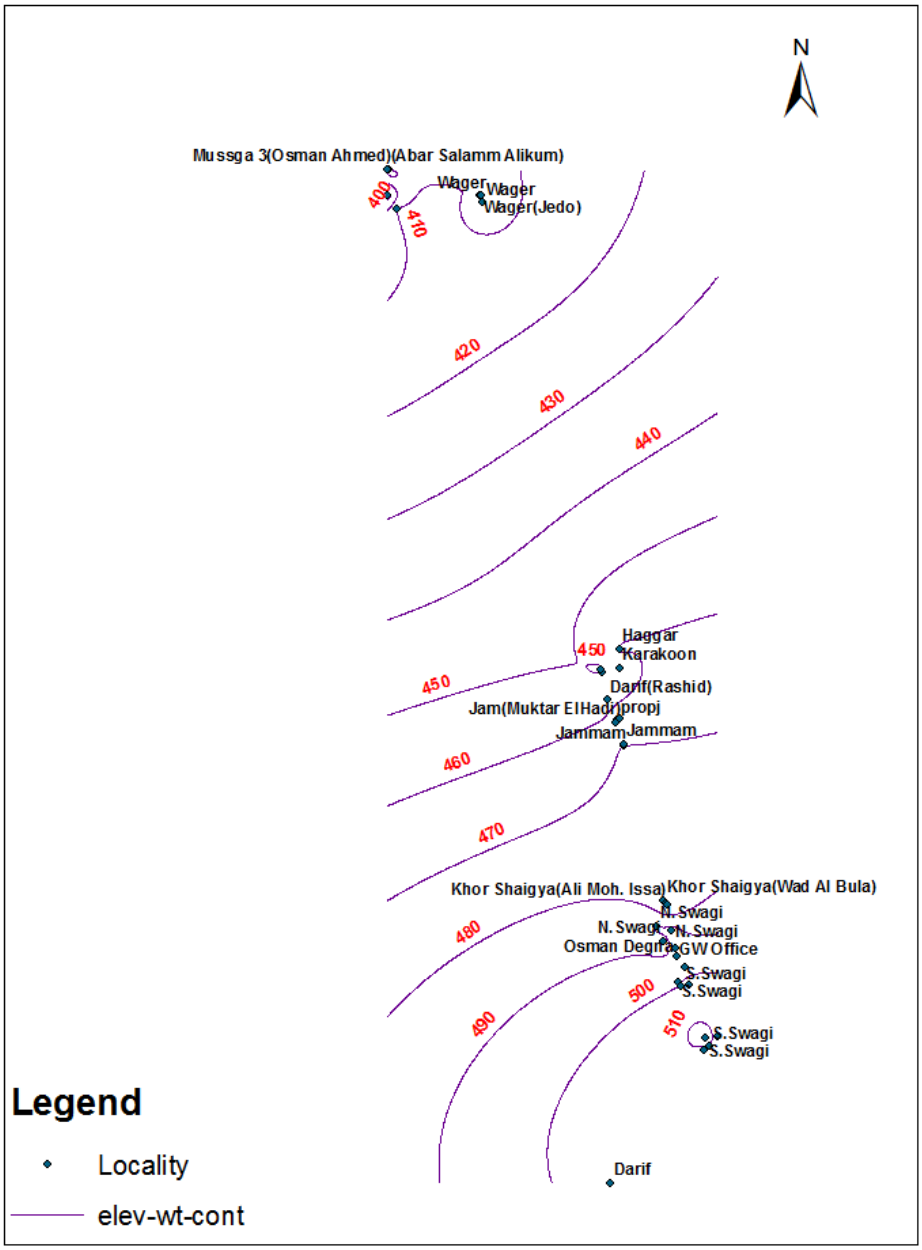


Fig 3: The elevation of the water table in the Gash basin.

2.1.4 Preliminary results

- **Determination of recharge to the aquifer**

The expected sources of recharge of the Gash alluvial aquifer are:

- Infiltration from surface water runoff in the Gash basin.
- Infiltration from direct rainfall.
- Inflow of groundwater from the alluvial aquifer and through the fractures from the catchment areas.

Two methods were used for calculating the recharge, one is the losses between two gauging stations (one in the upstream (EL Gera and the other in the downstream (Slam Allekim). The other method is by using difference in water level between dry and wet seasons. It is found that the total annual groundwater recharge is estimated at about 234.8 and 418 Mm^3/year respectively.

- **Preliminary results of developed model**

2.2 Water resources allocation of Gash River

This research component studies the impact of different scenarios on surface and ground water resources in Gash system in Sudan. The River Basin Simulation Model (RIBASIM) is being used to test different water allocation for: irrigation supply to Gash Agricultural Scheme, public water supply, minimum flow to Gash die, etc...

Fig. 4 below shows the schematization of surface and groundwater model of Gash system.

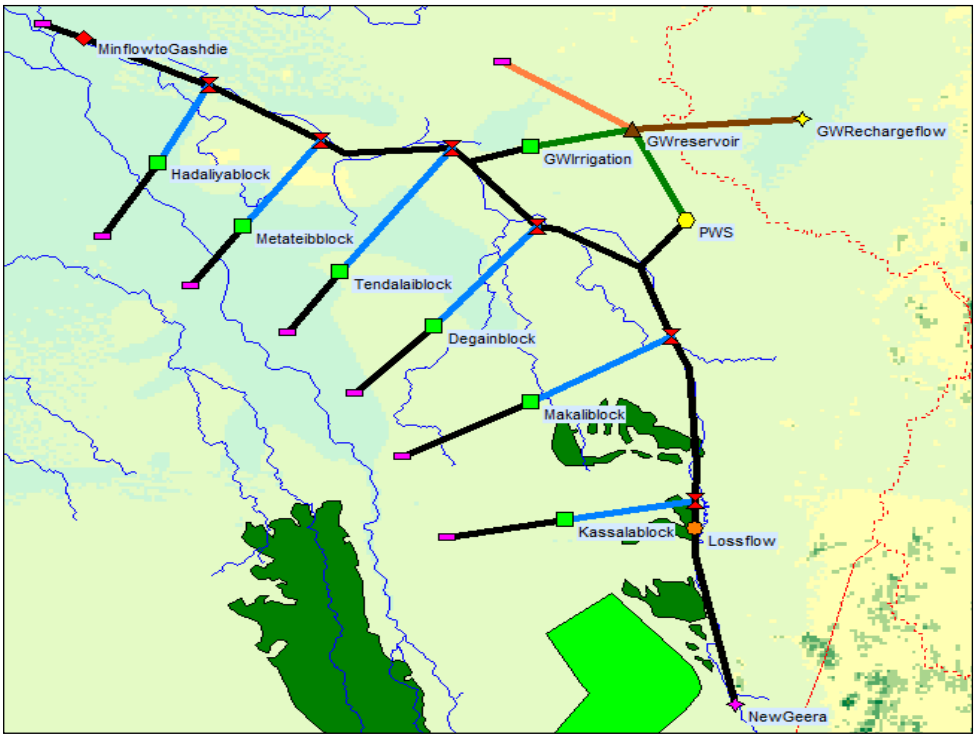


Fig 4: Schematization of surface and groundwater of Gash.

2.2.1 Preliminary results of the model first runs

- **Surface irrigation**

Fig. 5 shows the results of average annual demand-supply for the six blocks in GAS as calculated by the software. The shortage is estimated at only 4% on average of the total demand.

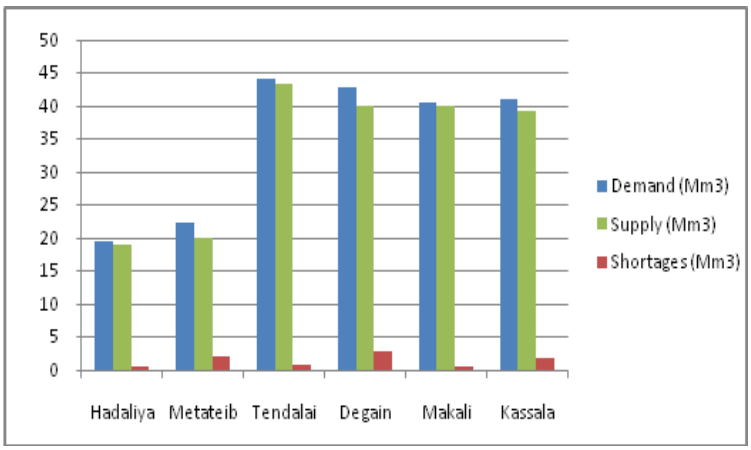


Fig 5: Demand, supply for GAS.

- **Flow to Gash die**

Fig. 6 shows the average 10-daily discharge to Gash die for the period 2000-2013.

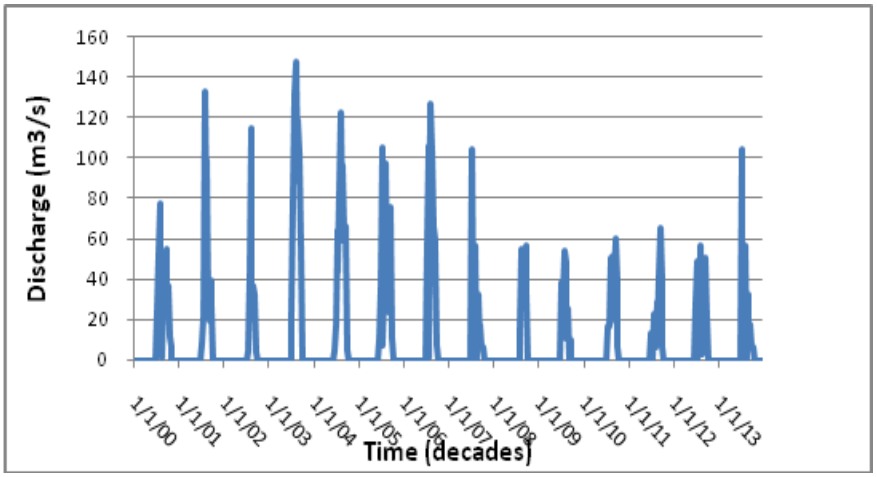


Fig 6: Discharges to Gash die.

- **Groundwater depth**

Fig. 7 shows the depth profile of groundwater reservoir as predicted by the model for year 2013.

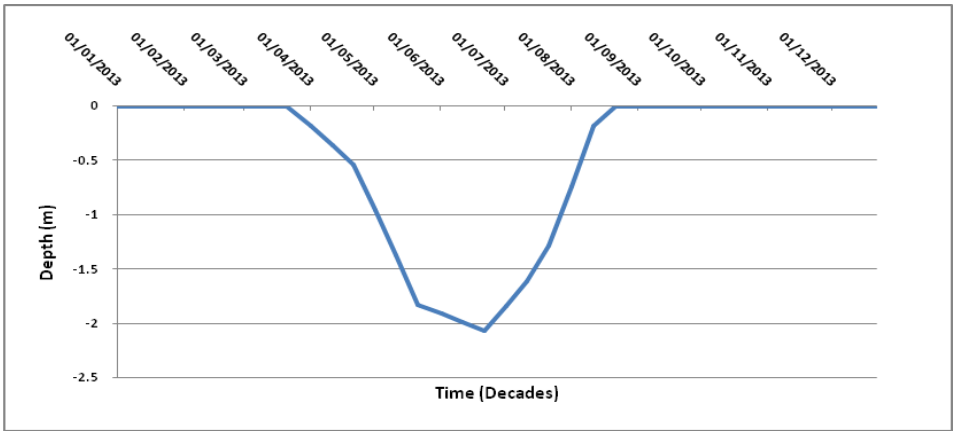


Fig 7: Groundwater depth profile.

The increase in groundwater depth during the wet season is attributed to the average recharge which is about 386.11 Mm^3; while the decrease in the dry season represents the abstraction for public water supply and private irrigation schemes which is about 132 Mm^3.

2.3 Ecosystem services

The Gash flood is distributed as 39% for irrigation, 28% for recharging ground water and 33% for grazing land and natural forests in the Gash Die.

Gash flooded areas have ecosystems with a great biodiversity of plants, animals and birds. Biodiversity in Gash can be seen during flood time (temperature is nice and humidity is high). Then wetlands are considered home for biodiversity. The spate fields, lakes and ponds are an excellent abode for highly important species of trees, birds and vegetation.

2.3.1 Livestock in the Gash River basin

The total animal population (Fig. 8) served by Gash flood plain equivalent to 3.5 million Animal Units (AU). One animal unit requires 1.08 ton of herd feed. This means the flood plain provide the livestock by 3.78 tons of herd feed annually. Also, Gash River provide the livestock with drinking water and the annual requirements for livestock is about 3000 m^3 and services require another 500 m^3.

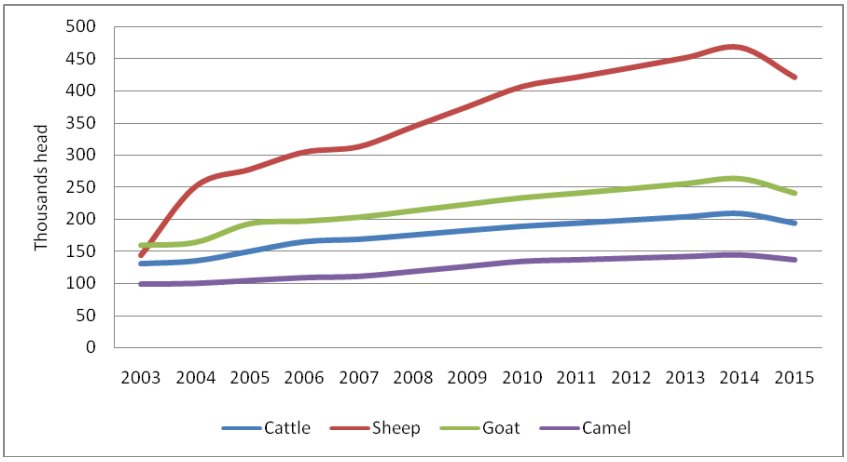


Fig 8: Animals in the Gash flood plains

The animals, in the Gash flood plain, are owned completely by pastoralists and agro-pastoralists. The pastoralists are categorized in three pastoral groups: nomads (30%), transhumant (20%), residents (40%) and refugees (10%). The pastoralists of the area are estimated to be 37,000 members; about 7500 of them is heedless, dealing with animals as workers. More information about the animals in Gash and their characteristics is found in Annex 1.

In the Gash, livestock is used for ploughing and bund building and it has been observed that, the farming systems in Gash is completely livestock based farming.

2.3.2 Flood management versus biodiversity and natural vegetation

Gash flood is closely linked to biodiversity and natural vegetation. It renews the soil annually by about 5 to 13 million tons of sediment and this encourages good vegetative growth of

plants. Flood is depositor of local biodiversity because it collects seeds from a large catchment area of about 21000 square kilometres and deposits them in moist soils and may feed Gash wetlands that are rich in species. Gash River is often unexpectedly rich depositories of vegetation. Natural species of vegetation are of considerable value and may provide an additional source of income to local communities e.g. Mesquite. Grasses and shrubs sustain livestock populations, while trees are used for various purposes such as woods and charcoal. In Gash, the mesquite trees, grass land and clay soil cover 19.15%, 10.05% and 19.25% respectively (Abuelgasim et al, 2011).

In the north and west where the rainfall is lower, the vegetative cover is poor and includes scattered acacia trees and short grasses and shrubs. On the clay soils in the northern reach of the Gash flood plain and the terminal fan, where the water table is shallow, the vegetation is denser and a significant area is covered with semi-evergreen woodland.

Multi human activities in Gash modify the landscape, such as poor farming systems, deforestation, and random animal breeding practices. These human practices degrade Gash watershed and reduce the amount of water available downstream.

2.3.3 Mesquite invasion in the Gash

Historically Mesquite was introduced in Sudan in 1917 to protect vulnerable lands and soils and accordingly to help curb desertification. However, it has occupied fertile land, agricultural area, watercourses, floodplains and highways.

Invasion of Mesquite in the Gash is presented by Fig. 9. More detailed information about Mesquite and its advantages and disadvantages can be found in Annex 1.

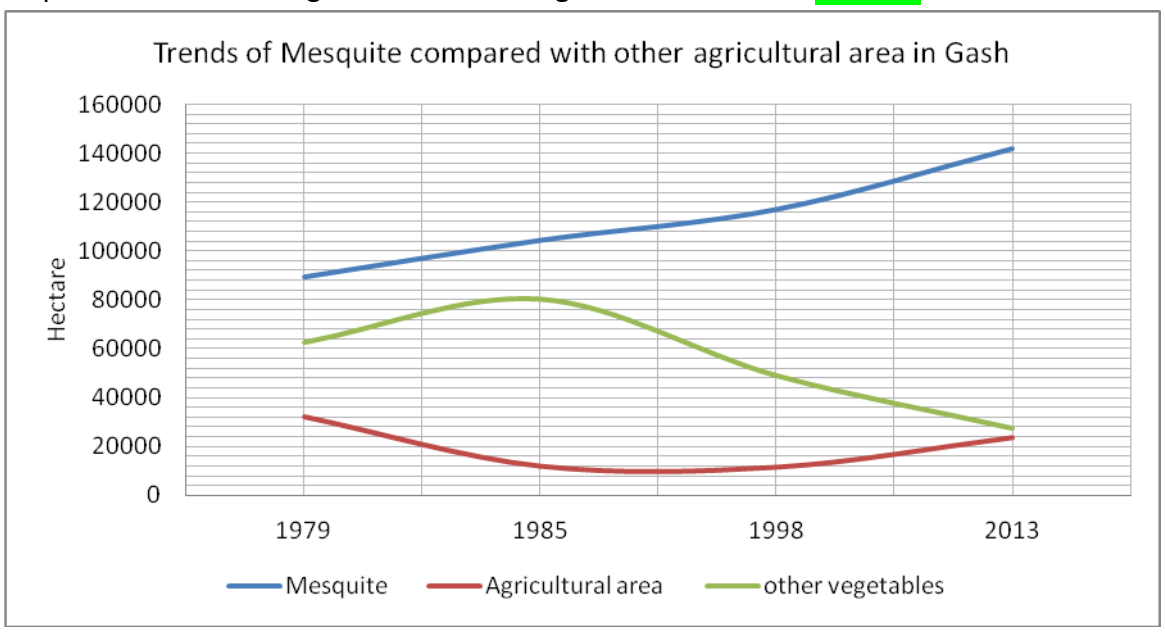


Fig 9: Trends of Mesquite compared with other agricultural area in Gash

2.3.4 Impact of upstream activities on downstream Flood Based Activities (FBA) (Gash die)

In floods like Gash, where the climatic and geological conditions at the source of the river in Eritrean highlands are completely different to those downstream, the activities in one place may directly impact the situation in another. Upstream impacts on downstream flood based

activities can be broadly divided into two types: human-influenced activities related to land use and natural impacts related to climate.

Also, flood management practices in upstream can have both beneficial and adverse effects on downstream communities. Upstream activities such as flood control, irrigation, and domestic water supply can influence the downstream flow in many ways (including timing and frequency).

Historical observation shows erratic behaviour of the Gash River. The flood patterns and floodwater discharges are changing due to climate change and increasing water use upstream. The sediments (5.5 million m^3 per year) are increasing due to deforestation in catchment area upstream. All these factors directly affect the downstream users as will be discussed in the following points.

- Impact of extensive land use upstream

The vegetation cover reduces soil erosion in upstream and thereby is expected to reduce sediment load in flood plain areas downstream.

In Gash, upstream farmers have shifted the cropping pattern from cereal crops into horticultural crops. That has improved the living standard of farmers, but has led to reduce spate flows to the downstream area and thus has deprived the tail-end (Gash Die) farmers of their livelihood.

- Expansion of horticultural production upstream and its impact downstream

In the upstream areas of Gash, horticultural crops (bananas, onions and other fruits) have witnessed increase in terms of cultivated areas. They are supported by groundwater wells. Expanding of cultivable land has a significant impact on the amount of water supplied downstream to Gash Die which suffered drinking water shortage most of the year. However, fruits have become the foundation of the economy and generated a significant demand for wage labor (Frank et al 2010).

- Upstream downstream and water quality linkages

It was found that water quality changes depending on the distance from the Gash River course, beside the change that occurs according to seasonality. Salt content ranges from 250 to 500 ppm for distances 500 to 1500 meter from the river course respectively (Khalil 2010).

For some areas, the Groundwater Administration has reported that the NO_3 concentration is as follows: Wad Sharifia 100 mg/L, Kassala 125 mg/L and Tokroaf east 165 mg/L.

- Impact of new structures (Spurs & Dikes) on downstream FBA

The protection system, to protect Kassala city from the high floods of Gash River, consists of 34 spurs and two external banks along the eastern and western sides of the river. These protection works will narrow the river course and reduce the flood time to recharge groundwater and it will also create high velocities that flush more sediment downstream and accordingly will reduce the irrigated areas.

2.4 Gender and equity

2.4.1 Gender population in the project area

The research project area falls within four localities out of the eleven localities that comprise Kassala State. These localities are Rural Kassala, Kassala, Rural Aroma and North Delta. The population in this area is 642956. The female population represents 47%. Based on their living mode, they are urban 51%, rural 39% and nomads 10%, Fig. 10.

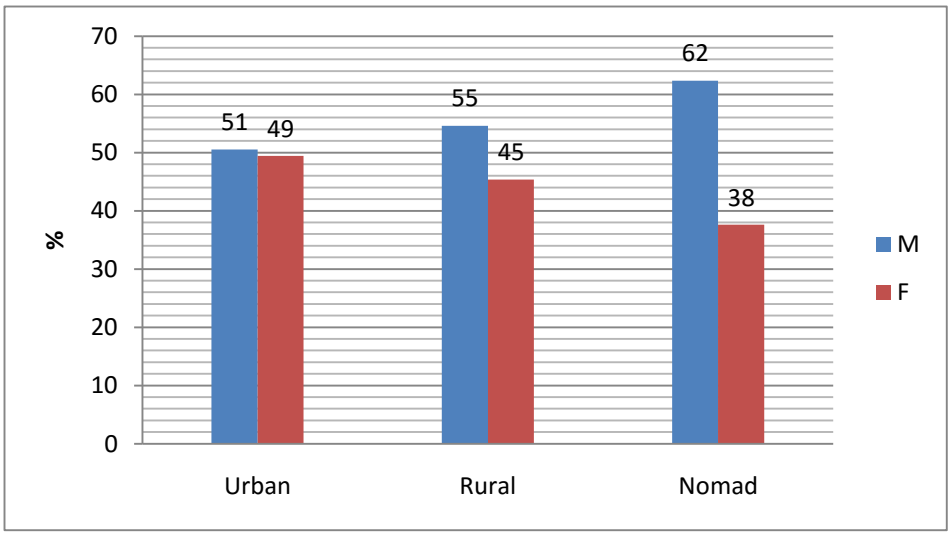


Fig 10: Gender representation based on living mode.

It must be recognized that the gender situation in the project area is problematic. Although it varies according to the socio-ethnic groups concerned, in all cases women are basically marginalized and excluded from most economic activities and the social and political decision making processes.

The major tribe in the project area is the Hadendowa and its affiliated groups. Other tribes include Beniamir, Northern Sudanese, Fellata, Rashaida and some tribes from Western Sudan. Highlights on the gender situation in different tribes, the contributed roles in society, constraints for youth, existing groups, institutions, organization, etc... can be found in Annex 2.

2.4.2 Livelihood mapping

Table 1 below describes the livelihoods along the project area from the perspective of the agricultural activity. Additional details on other activities can be traced from Annex 3.

Table 1: Description of livelihood along Gash area.

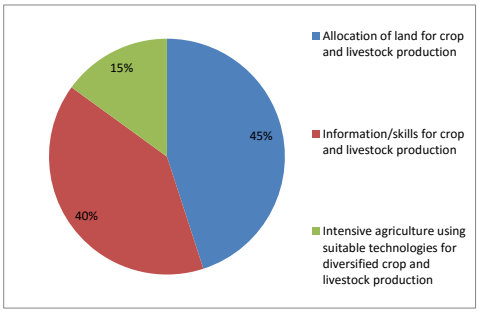
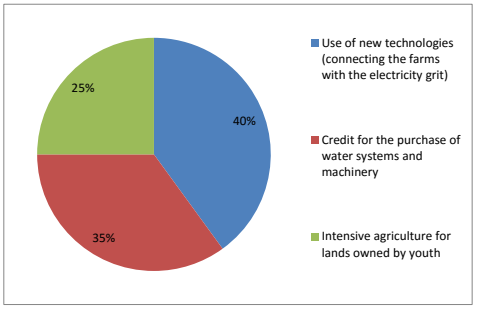
Zone	Agriculture
Upstream (from the entry point in Sudan up to Alsabeel area in the southern Sawagi)	- Irrigated farming (pump irrigated systems). - Vegetables and fruit trees. - Women own land. - Women and youth work as agricultural labors. - Markets are available in the villages and Kassala town.

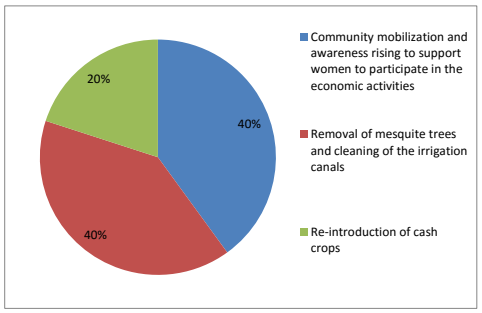
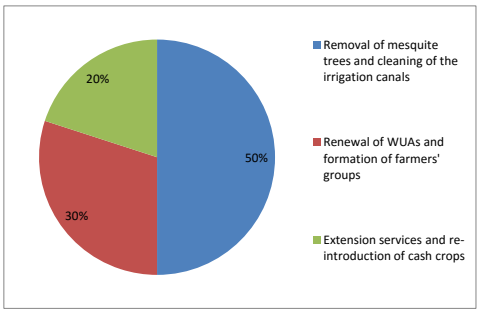
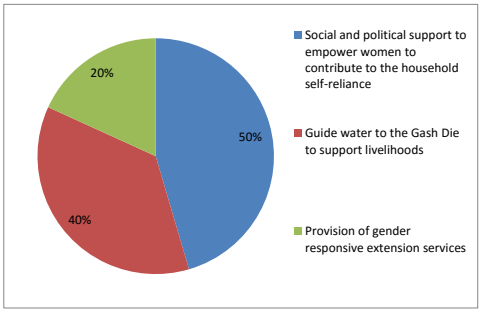
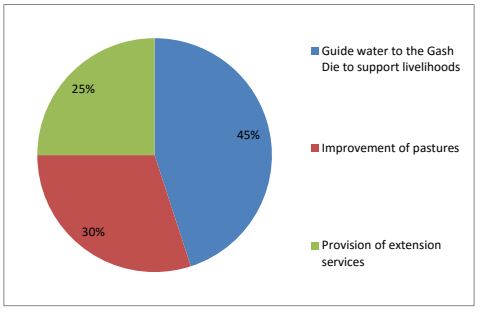
	- Medium literacy rate.
Mid-stream (from ALsabeel to Hadalia including SalmAlikom farms and Gash Scheme; North to Kassala town)	- Mainly food irrigated farms with limited area (Alsalam Alikom) of pump irrigated farms that cultivate vegetables and fruits. - Mainly one crop; Local variety sorghum. - Women own land but their names are not appearing; neither in the farmers' list nor in WUAs. - Women cultivate through the male relatives as share croppers. Women receive the same treatment as men when they apply share cropping. - Farms on the eastern part of the scheme receive more and regular water during the flood season where as those in the western part receive smaller amounts of waters and their crops might not reach the maturity. - Some of the youth own land. - Medium to low literacy rate.
Downstream (Gash Die)	- Availability of water depends on the water brought by the flood, it varies from year to another. - Main crops are sorghum and rarely vegetables in good floods. - Disappearance of nutritive grasses for livestock and their replacement with mesquite and other poor grasses. - High illiteracy rate.

2.4.3 Sex disaggregated data

Specific needs, priorities and constraints, of women and men in the upstream, mid stream, and downstream within the Gash River basin, were addressed to highlight the most important issues relevant to their livelihoods activities viz agriculture, livestock, etc... Table 2 below shows comparisons between priorities of women and men in the context of agricultural activity. More details can be found in Annex 3.

Table 2: Sex disaggregated data.

Sex	Female	Male
Upstream		

Mid stream		
Gash Die		

2.4.4 Key messages from the gender analysis

The conducted situation analysis reflects that some points need to be considered to rebalance the existing gender inequality as follows:

- **Farming context**

1. Water; Awareness raising and advocacy at policy makers, community leaders and technocrats levels, on the importance of rational use of the available resources and the equal distribution of benefits throughout the ecosystem.
2. Education is a human capital closely related to farm productivity, household income and nutritional outcome. It is noticeable education level decreased from upstream to downstream.
3. Land is a key productive asset for farmers, gender disparities in land holding in the Gash area is obvious , men own land and women ownership is usually smaller or invisible; all lists of farmers consist of male names even when women own some e.g. Gash Scheme.
4. Agriculture labor is important source of income for women in some areas where they are usually involved in planting and harvesting of onions. This source of income is only available for some time of the season.
5. Livestock is important for the livelihoods of families. Women mainly own small ruminants.
6. Agriculture extension is essential for improving the agricultural productivity; in the project area the extension service needs to be restructured, improved and supported to perform the expected roles and advancing gender.

- **Drinking Water**
    - Formation and capacity building of gender sensitive community based drinking water committees.
    - Awareness raising on the rational use of water.
    - Ensuring reasonable level of hygiene.

- **General recommendations**
    - The best scenario is to encourage land allocation for women, help them to have their land entitlements under their names and provide strong gender sensitive extension service that builds the capacities of women as farmers.
    - Support women to better manage their assets both agriculture and livestock.
    - Raise the general awareness on the importance of participation of men, women, boys and girls in all development activities to achieve enhanced sustainable livelihoods.

3. Communication products, official visits, …

Some products concerning communication and engagement are prepared like project brochures in both Arabic and English besides videos to document the launch of the research project in the Gash and the relevant introductory information. All these products are available in HRC website (www.hrc-sudan.sd) and will be uploaded to the Water Channel.

In August 2015, Dr. Ogutu Zadoc and Ms. Abby Waldorf representatives of WLE office in Ethiopia have visited Sudan on an official mission to follow up the activities progress of the project and they have also visited the project site in Kassala state. “Back to Office Report” is available in Annex. Also, Mr. Matthijs Kool from the leading partner was on mission to Sudan for similar purposes in September 2015 and he has provided a “Back to Office Report” describing in details the conducted meetings, interviews and field visits, see Annex.