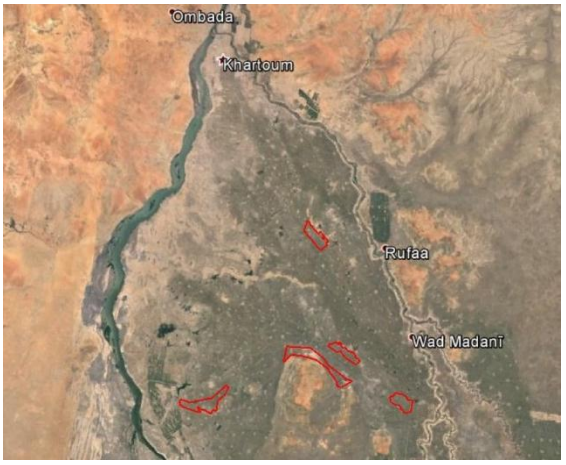
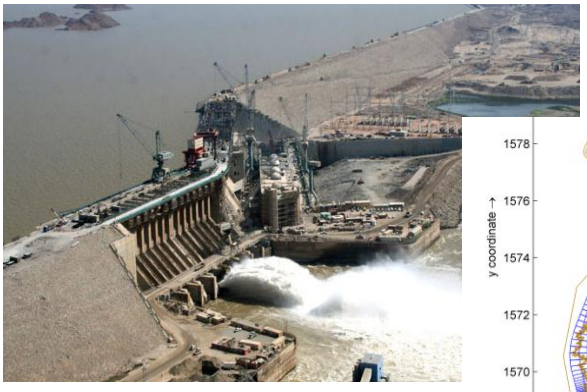
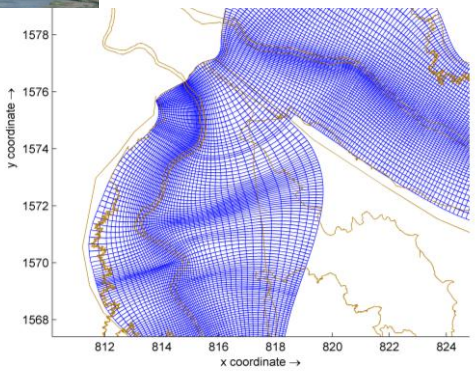
Hydraulics Research Center
مركز البحوث الهيدروليكية



Abstracts of Research projects implemented in 2016





December 2016

Preface

The Hydraulics Research Center (HRC) is the research arm of the Ministry of Water Resources, Irrigation and Electricity. HRC has the mandate of:

- *Implementing applied (solution-oriented) research in areas of: Hydraulics, hydrology, irrigation and water resources management.*
- *Carrying out consultancy studies for the water sector at large, with clients from inside and outside Sudan*
- *Conducting capacity building programs (training courses, workshops) related to the water sector*

This book contains summary of the research projects implemented in year 2016. It is a very wide set of research and consultancy projects, covering hydraulics and river morphology; water resources; water quality; hydrology, etc. The projects varies from small projects of 3 to 4 month, to large projects of 2 to 3 years.

For further information of these projects your are welcome to consult HRC library, or info@hrc-sudan.sd

Contents

1. River Navigation:

(Yasir S. Ali, Abu Obeida B. Ahmed, Yasir A. Mohamed, Almutaz A. Abdelfattah, Ruaa A. Nasereldein, Mohamed E. Elbushra, Elhadi, M. Hassen, Hana A. Mohammed, Hiba A. Musa, Abubaker M. Saeed Mogahid M. Siddig & Ahmed A. Osman)

Realizing the important role of river transportation along the Nile River and its tributaries the Navigation Department of the Ministry of Transport has committed HRC to conduct river navigability study. The study was conducted along the reach Berber-Khartoum-Kosti. The objective of the study is to delineate the accessible navigation path along the reach and identify locations of navigation obstacles. The methodology implemented in the study includes:

- Conducting topographic and river cross sections surveys.
- Hydrological analysis to assess historical water level variability in the rivers.
- Hydrodynamic modeling to determine navigation depth along the rivers
- Navigation charts and maps to guide river navigation.
- Quantity survey to determine volume of sand and rocks to be excavated.

The river reaches under study are Kosti – Khartoum and Khartoum – Berber, have lengths of 325km and 400 km, respectively. The hydrology of the two river reaches under study has been studied very thoroughly by analyzing the water level and discharge data of 18 gauging stations. The analysis showed large variation between maximum and minimum water level, which varies between 7 to 8 meters in the Main Nile, and around 5 meter in the White Nile River.

Two hydrodynamic models were built for the reaches Kosti - Khartoum and Khartoum- Berber to investigate the effect of different flow regimes on navigation depth. The models were calibrated and validated using datasets for the periods 2008-2010 & 2011-2013, for the main Nile and 2003-2005 & 2006-2008 for the White Nile, respectively. The hydrodynamic models showed minimum water depths for navigation, less than 3m, at some short distances near Khartoum, Shendi and Berber. This occurs during the dry seasons for about 2 to 4 month per year. The models results also showed that the flow conditions in the Main Nile will change completely after the operation

of the GERD. Also, the high velocity during August will be reduced from 2.8 m/s to 1.5 m/s after the GERD. Therefore, the operation of the GERD will have huge positive implications on river navigability along the Main Nile River reach.

Navigation maps for the reach were prepared according to the international navigation rules, and adopting the standard signs of SIGNI system for navigation buoys and beacons. Navigation maps with scale of 1:50,000 have been prepared for the two reaches. In total 27 maps have been prepared for the reach Kosti-Khartoum and 30 maps for the reach Khartoum-Berber.

Finally, the study have calculated the volume of sand to be excavated at shallow location (less than 3.0 m), to ensure continuous passage along the river reach. However, excavation of bed material in those alluvial rivers is not a recommended solution, as sediment will deposit back in few years' time.

2. The suitability of the Intake of North Bahri- El Tamaniat Pumping site:

(Yasir S. Ali, Abu Obeida B. Ahmed, Yasir A. Mohamed, Rami Kawas, & Hana A. Mohammed)

The Hydraulics Research Center (HRC) has implemented this study, as a national pioneer institute in studies and researches on the field of river morphology, based on the contract agreement signed on the 4th Of April, 2016, between "Khartoum State Water Corporation, KSWC" as a Client and the HRC.

The North Bahri – el Tamaniat Pumping Station (NBTPS), has been established on the Eastern Branch of the Main Nile at about 37 Km downstream the confluence (south Tamaniat village) in order to supply domestic water needs for the population scattered in the area from Al Kadaro in the South to Garri in the North of the station.

However, during recent years, the flow through the eastern branch has significantly reduced. Accordingly; the branch is passing remarkably low flows during the low season. This has created real complications in the reach concerned and thus shortage in water production. Nevertheless; the KSWC is planning to expand the pumping capacity at the same site.

The main objective of the study is to give a technical advice on the best way or interventions that has significant effect in changing the morphology of the river in order to divert more flows towards the vicinity of the North Bahri – el Tamaniat Pumping Station (NBTPS).

Hydrological analysis has been carried out to investigate the variation of water level, and hence expected river discharge and water depth in front of the pumping station is analyzed using Tamaniat gauge station. For the impact of the Ethiopian Grand Renaissance Dam (GERD) on flow regime along the Blue Nile, technical reports have shown that the GERD will modify the flow regime significantly by lowering flood level, and enhancing minimum level.

The hydrographic survey comprises the land and bathymetric surveys to define river cross section within the study area, and additional information and ground observations on the history of morphological changes in this river

reach were collected. This covers the flood plain on both sides of the cross section. The land and bathymetric surveys data were used to generate the contour maps of the river topography at the vicinity of the pumping site.

Multi-temporal Landsat data (satellite images) of the years 1984, 1995, 2014, 2015 and 2016 have been studied to trace any change of river morphology. ERDAS Imagine 9.2 image processing software has been used for processing the satellite image, while ArcMap 10.2 GIS has been used for analysis of the change. Mapping change of river morphology was achieved by computing the Normalized Difference Water Index (NDWI).

The long term morphological changes as derived from the satellite imageries are significant in particular the right branch as detailed in the following points

- The existing island in front of the pumping site was small in 1984 (10.4 m width) and started growing up in 1995 to 433.3 m width and further the width grows up to 741.4 m in, 2015 .
- In contrast to the island development, the right branch width has been reduced with time in 1984, 1995 and 2016, successively.

The key findings derived from the field visit, hydrographic survey, hydrological study and the satellite imageries analysis, reveal the following main conclusions.

- The analysis of the daily water level data for 42 years long for the neighboring station of Tamaniat (3 km downstream) from the pumping site, has shown that the minimum water level at the pumping site for a return period of 50 years is 368.4 m a.m.s.l which is below the bed level of the river branch at the pumping station.
- It is expected that the minimum water level will increase, and the maximum water level will decrease after the operation of the Ethiopian Renaissance Dam which is expected in the coming few years.
- The analysis of the satellite imageries of the study sites for years 1994, 1995, 2014, 2015 and 2016 shows significant morphological changes.
- The possible mitigation measured are also reported such as dredging, change the pumping site and river widening…etc

3. Investigation on the location of Al-Selate Pumping Station (Khartoum State):

(Ahmed A. Kabo, Abu Obeida B. Ahmed, Mohamed E. Elbushra, Ahmed A. Osman)

This study was conducted in accordance to the contract signed on 30 August 2015, between "Ministry of Agriculture- animal- wealth and Irrigation (Khartoum State)" as the client, and the Hydraulics Research Center (HRC), Ministry of Water Resources, Irrigation & Electricity (MWRIE), as a national pioneer institute in studies and researches in river morphology.

The main objective of the study is to give a technical advice on the best location for a new pumping station within the vicinity of the old Al-Selate Pumping Station (SPS) which was commenced in 1978 to feed about 16700 feddan. The pumping station is currently experiencing operational and water shortage problems due to inlet channel siltation and water escape during low flow seasons. Thus the research provides the technical findings and recommendations from the hydrological and morphological study of the Blue Nile River within the vicinity of (SPS), using historical satellite imagery (1973-2015), bathymetric and land surveys of 6.25 km reach and river bed and river bank soil characteristics.

The key findings are that, the Blue Nile in the reach of the study is reasonably stable, the meandering river showing repeated curvatures with radius of about 1700 to 2000 m. The main channel (thalweg) passes adjacent to the right bank from about 2 km upstream to about 1.6 km downstream the center line (CL) of the (SPS), showing deeper and narrower sections on the downstream side. Nevertheless, the reach is sensitive to the changes that might occur to sand across the river on the left bank and the sandy island emerging at about 1,600 m upstream the center line of the existing pumping station. River bed and the right bank soils are classified as loamy sand (60% to 70% sand, 27% to 30% silt and 3% to 5% clay). The main conclusions of thestudy are as follows:

- The reach under focus is suitable for pumping stations. To avoid usual siltation problems related to inlet channels, submersible pumps mounted on piles erected inside the river are recommended. Preferably at the geographic location (463894 E and 1715831 N, UTM Zone 36N)

and design water level must not be higher than 373.46 m.a.m.s.l which represents 100 years return period.

- Careful attention for the sandy island emerging at about 1600 m upstream the center line is quite important. Therefore, further investigation of the influences up stream reach may be necessary in order to define the most likely morphological changes and possible prevention measures.

4. The Sediment Monitoring Program of the Nile System – Season 2016:

(Nazik A. M. Ahmed, Eltaeb R. Abbas, Younis A. Gismalla)

The Blue Nile River and Atbara River that originate from the Ethiopian Plateau are the major source of sediment load in the Nile River. These two rivers brings about 180 million ton of sediment annually. Sediment deposition in the reservoirs and in the irrigation and drainage networks are the major operational problems in Sudan. Knowing the sediment load and its characteristics in different river reaches and that entering irrigation schemes is very crucial for sediment management. Since 1988 the Ministry of Irrigation and Water Resources has started a sediment monitoring program in Gezira Scheme and the Blue Nile system to assist in managing reservoir and canal sedimentation. The main objectives of the sediment monitoring program are:

- Quantify the sediment entering some irrigation schemes, particularly Gezira scheme, and determine its distribution.
- Establish a correlation between the rate of inflow and sediment concentration within the river Nile system and the irrigation schemes.
- Define the optimum filling dates for the Blue Nile reservoirs.

The sediment monitoring program started with 52 stations distributed at the head, middle and lower parts of the irrigation system in Gezira. Based on the long experience in sediment monitoring, the monitoring stations are modified to 13 stations along the Nile and its tributaries and in Gezira Scheme. In addition to these stations an intensive monitoring program was implemented during the flushing of Khashm El Girba reservoir in the period 1-4 August 2016.

Water samples from the different station are collected on daily basis using samplers, kept in plastic bottles with labels and transported to HRC laboratory in Wad Medani. For the case of El Girba flushing the water samples are collected every two hours from upstream and downstream the dam. About 1,800 water samples were collected this season from the different stations and analyzed in HRC laboratory.

The methods used in the sediment samples analysis include the turbidity-meter measurements and the classic gravimetric method. The volumetric method with different sedimentation time viz. 6, 24, 48 & 72 hours was used for

analyzing Khashm El Girba samples. The results from this method are compared with the other two methods adopted with HRC.

The results showed strong correlation, $0.86 < R^2 < 0.96$, between the turbidity-meter readings and the gravimetric method. The volumetric analysis with 24, 48 & 72 hours sedimentation time gave close results, $0.76 < R^2 < 0.86$, but higher than the other two methods. The volumetric method with 6 hours sedimentation time that is used in Khashm El Girba dam, gave very high sediment concentrations when compared with 24, 48 & 72 hours, which is not logical as deposited sediment volume should increase with time.

The sediment concentrations as well as the sediment loads for this season are higher than those for last season. This can be attributed to the fact that the Blue Nile flows are higher than last year.

The sediment passing downstream Sennar dam this year is 159 million ton compared to 44 and 149 last year and the year before, respectively.

Water released to Gezira Scheme this year during the flood season is 3.4 billion m^3 compared to 4.0 billion m^3 last year.

The total sediment load entering Gezira scheme is 8.6 million ton compare to 6.4 and 8.3 million ton last year and the year before, respectively.

5. Harnessing Floods to Enhance Livelihoods and Ecosystem Services in Gash Area, Sudan

(*Amira A. Mekawi, Abu Obeida B. Ahmed, Hana A. Mohammed, Yasir A. Mohamed & Abubaker M. Saeed)*

The research project "Harnessing floods to enhance livelihoods and ecosystem services" is funded by the CGIAR research program on Water, Land and Ecosystems (WLE) and it is being implemented in the Gash River basin in Sudan by the Hydraulics Research Center (HRC-Sudan) 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), and UNESCO-IHE.

The Gash River rises from the Eritrean/Ethiopian Highlands and ends in an inland delta called Gash Die. It has an estimated catchment area of 21000 Km^2 shared among Eritrea, Ethiopia and Sudan. The Gash River only flows between July and October while it becomes dry over the rest of the year. The Gash annual yield is about 0.65 Billion m^3.

In spite of its flow seasonality, 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, groundwater recharge, etc... In fact, most of the social and economic activities of the area depend on the river.

On the other hand, the unpredictable nature of the Gash flooding, the changes in the river beds and the considerable amount of sediment carried each year represent real challenges for development activities.

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

This research project has addressed four major areas to come out with an integrated approach for overall system management of the Gash River basin. The research areas components are as follows:

- The potentiality and availability of groundwater in Gash aquifer for domestic water use and for irrigating horticultural sector by using MODFLOW software for groundwater modeling.

- Water resources allocation of the Gash River between the different water users using RIBASIM model to study different water allocation scenarios and their impacts based on certain priorities.
- Ecosystem services and investigation of means of biodiversity enhancement especially downstream at (Gash Die) and studying the impacts of the upstream developments on the downstream.
- Impact of current and future development scenarios on the socio-economic settings in the Gash area.

This is in addition to consideration of outreach techniques to a wide range of stakeholders and beneficiaries through different communication strategies.

Most important results up to date can be summarized as follows:

- Water resources allocation scenarios have revealed that the average annual yield of the Gash River is partially sufficient for the dependent water users in the scheme. However, in case of low flow conditions, water allocation priorities have to be set for groundwater recharge and ecosystem services.
- The ground water basin is replenished by about 30% of the Gash River yield annually. Giving priority to domestic water supply, the water consumption of horticultural sector has to be decreased in the range 25-50%.
- The estimated ecosystem value in Gash area is about 33 million USD. Values such as education, health, settlement and culture considered non-use value and not estimated.
- Along the Gash River, education level decreases from upstream to downstream and this directly affects farm productivity, household income and nutritional outcome of the communities within the basin.
- For future development, attention is required to the impacts of upstream investments that influence on downstream development, i.e., Gash die.
- Strong commitment to an integrated approach for Gash River water resources management by involving governmental and non-governmental institutions can lead to optimized benefits for all users.

6. Africa to Asia - Testing Adaptation in Flood-Based Resource Management Project:

(*Amira A. Mekawi, Abu Obeida B. Ahmed, Ahmed A. Elamin, Yasir A. Mohamed & Abubaker M. Saeed)*

The program: Africa to Asia and Back again: Testing Adaptation in Flood-Based Resource Management is designed to contribute to the build-up of the practical knowledge and national and local capacity to systematically and comprehensively support the productive use of Flood-based Farming Systems (FBFS) for poverty alleviation and inclusive growth in water-stressed regions of Africa and Asia with relatively short flood periods.

The program is financially supported by IFAD over the period April 2015 to March 2018 and it focuses on consolidating and building upon the achievements of the preceding project Spate Irrigation for Rural Economic Growth and Poverty Alleviation (SIREGPA). This project was successfully implemented in Ethiopia, Sudan, Yemen and Pakistan by the Spate Irrigation Network Foundation (SpNF) from 2011 to 2014.

In Sudan, the Hydraulics Research Center (HRC-Sudan) is the implementing organization and the spate system of Gash Agricultural Scheme (GAS) is selected as a pilot project to conduct research activities. The specific objectives of the project in Sudan includes:

- Strengthening of the Sudan network on flood-based farming systems which was established in 2011 by engaging beneficiary sectors of farmers as well as professionals and practitioners who are involved in development of flood-based farming systems in Sudan.
- Conducting solution-oriented research to find out practical solutions for the urgent problems that threaten the spate systems in Eastern and Western Sudan namely in Gash River Delta and Khor Abu Habil Scheme where considerable number of population depend on these irrigation systems for their livelihoods and food security.

Capacity Building by offering short training courses and tailor-made trainings to professionals and farmers in areas relevant to the development of the flood-based systems and by contributing to the development of a group of young male and female professionals by offering internship programs to enhance the performance of the future leaders of such an important resource.

7. Satellite based ICT for improved crop production in the Gezira Scheme:

(Younis A. Gismalla, Khalid Biro, Yasir A. Mohamed & Amged A. Khalifa.)

Water scarcity and food security are the important issues for the growing population in the arid and semi-arid zones. Water is becoming an increasingly scarce resource for agriculture and other competing uses. With the increased demand for food of a growing population, the challenge is to increase agricultural production while reducing water. Satellite based ICT (mobile-phones and the web) can play a fundamental role in the communication process.

The Satellite based ICT for improved crop production in the Gezira irrigation scheme is a one year project funded by the Technical Centre for Agricultural and Rural Cooperation (CTA) through its "Building Viable Delivery Models for ICT4Ag" initiative and being implemented by eLEAF of the Netherlands and the Hydraulics Research Centre (HRC), Sudan. The project delivers irrigation advisory service based on satellite data to farmers in the Gezira irrigation scheme in Sudan via mobile phone text-messages and a web-portal. The developed tools can monitor field specific information by measuring nine parameters covering crop growth, moisture and minerals in addition to irrigation advice. Forty four farmers scattered over Gezira Scheme were selected for the pilot testing. The pilot period covered the winter season of 2014/2015 viz. wheat, chickpea and onions crops.

The delivered data on crop growth and agricultural water management are derived from results of the Surface Energy Balance Algorithm for Land (SEBAL). The SEBAL is an algorithm based on the energy budget reaching the earth's surface. It can compute the actual evapotranspiration of the crops, as well as the biomass production. High-resolution satellite images from Disaster Monitoring Constellation (DMC) and Landsat8 supplemented by NPP VIIRS surface temperature were used in operating the SEBAL algorithm for the ICT project in Gezira Scheme.

This project illustrates the success of the ICT for agricultural water and crop management in Gezira Scheme of Sudan. Some of the outcomes are, shorter irrigation interval based on actual field conditions and weather information.

As a result, farmers have irrigated more frequently with an increase of two irrigations to previous season. The total amount of water used for irrigation was less than the previous seasons according to the field interviews, which indicates increase in water use efficiency. The pilot farmers have an increase in wheat production between 40% -200% compared to previous season. The farmers have better field management as they receive irrigation advice via SMS on a frequent basis regardless of their location. Farmers accepted the new technology because it is easy, accurate and saved them both time and effort. Interesting information on impacts of nitrogen, water use efficiency and other parameters on biomass production and crop yield were also obtained.

8. GERD Study (Phase II):

(Yasir A. Mohamed, Abdelnassir K. Osman, Hiba A. Musa & Hana A. Mohammed)

The Blue Nile basin is currently experiencing new developments of dams in Ethiopia and Sudan, e.g., Mandaya, Karadobi, Beko Abo and Grand Ethiopian Renaissance Dam in Ethiopia, Upper Atbara and Setit dam in Sudan among many others. These developments will strongly affect the water flow in Sudan therefore, it is needed to take into account the impacts of these new developments on water resources management and reservoirs system operation in Sudan to able to modify the operation policy of the old dams to adapt to the new situation and to mitigate the negative impacts.

The impact of the GERD on the downstream hydrology and water resources have been assessed using river basin simulation modelling, hydrodynamic modelling, and analysis of satelitte imageries in phase 1.

The final conclusion from phase 1 is that, The GERD will create large positive impacts for Sudan on: irrigated agriculture; hydropower generation; pumping cost; navigation; reduction of flood damages, but also has negative impacts on: Reduction of flood plain agriculture, security of reservoirs operation, changes of the ecosystem, brick industry, reduction of flow during initial filling. The positive impacts can be realized, and negative impacts alleviated only with coordinated operation of reservoir system with that of the GERD, or at least informed operation of the downstream reservoir**s**. The present water use in Sudan, the irrigation demands, and hydropower generation, were not utilizing the full potential benefits of the regulated flow by the GERD. The benefits would have been very noticeable with new irrigation developments, and increased turbine capacity within Sudan.

The initial filling of the GERD reduces hydropower generation at AHD by 12 to 20% depending on sequence of average or dry years, respectively. The reliability of water supply for downstream demands of 55.5 Km3/yr exhibits shortage between 0 to 10% during initial filling if it is average or dry sequence of years. For steady state operation, the HP generation increases by 20% and 6% at Roseires and Merowe respectively while it reduces by 6% at HAD, while reliability of downstream water supply is not affected.

The modified water levels after GERD will reduce the flood plain areas and positively impact the navigation depth which will be increased by 1.8 – 2.5m during the dry seasons and decreases pumping cost of the stations along Blue Nile and Main Nile by 10 - 40%.

The same study is continuing into Phase 2, focusing on two main objectives, (i) to run a daily and 6-hourly simulation model of the Eastern Nile System to evaluate the influence of the daily and sub daily operation of the "GERD" on the operation of the Sudanese dams along the Nile River system, in particular Roseires and Sennar; (ii) to run the model on 10 daily time step to understand the impacts of the upstream reservoirs cascade (Mandaya Dam, Beko-Abo Dam, Karadobi Dam) on the downstream hydrology and water resources; and then proposing the best (adaptive) operation scenario for the Sudanese dams. These objectives will be assessed using the river basin simulation modelling.

The baseline models were set-up with the existing infrastructure and then calibrated and validated with historical hydrological data based on (2006-2015), and it performed very well. The second phase of the study is under progress and it hasn't been completed yet.

9. Impacts of floods and drainage on Gezira and Managil Villages:

(Hassen O. Elhardlo, Almutaz A. Abdelfattah, Abdel Salam M. salih, Izzeldin Saeed, Abu Obeida B. Ahmed, Mogahid M. Siddig, Ahmed A. Elamin & Mohamed E. Elbushra)

Some villages located in the south eastern part of Managil extension are subject to flooding every year due to floods coming from Managil plateau, Sagadi and Moyah mountains and drainage from Gezira scheme. The Hydraulics Research Center was committed to prepare a proposal to study the drainage problems in Gezira scheme. A multi-disciplinary technical team from HRC, the projects directorate and DIU was committed to conduct the study.

Based on several field visits and investigations the study team identified the following as the main cause of flooding problems:

- Streams resulting from heavy rains on Managil plateau, Sagadi and Moyah Mountains.
- Drainage water from sugarcane farms of the North West Sennar sugar factory.
- Existing drain conditions are inadequate to accommodate floodwater due to reduction in cross-section and deterioration of hydraulic structures.
- Human interventions such as creating embankments inside the drain to raise water levels for irrigation purposes, constructing new structures that cannot pass the design flood or diverting drain water into canals.

Another HRC team was formed to assess the existing conditions of the drain section, embankments, structures….. etc. and recommend solutions. The methodology followed this time includes surveying 94 cross-sections covering a length of 200 km of drain length and carrying out hydrological investigations. Different methods were employed in estimating surface runoff from the 3,900 km^2 drainage area. The study has shown that the design section of the existing drain is smaller than the required design section to pass the design flood, and the sizes of pipe bridges along the drain are insufficient to pass the flood water. Also, the drain section was not remodeled after the adding the sugar drain.

The study recommended three alternatives for solving the problem:

- Remodeling the drain section and all bridges along the drain according to the new design flood.
- Construct water harvesting structures to intercept part of the floodwater to be utilized drinking purposes. 31 suitable sites for Hafirs have been identified.
- Construct well-designed protective embankments around some identified villages.

10. Mapping of Cropped Areas in Gezira Irrigation Scheme Using Remote Sensing and GIS techniques:

(*Rami Kawas, Khalid Biro, Julia A. Mustafa, Amged A. Khalifa, Tameni Abdelrhman & Romisa fath-Erlhman*)

Mapping of cropped areas is very important for crop monitoring, irrigation water management, as well as yield estimation and forecasting. However, for large irrigation schemes such as Gezira (880,000 ha), mapping of cropped area using classical approach based on ground information becomes complex and prohibitively expensive. In many cases the accuracy depends very much on reliability of the ground monitoring system. Assessment of cropped area using remote sensing and GIS techniques is emerging as a potential methodology in this field.

This project presents the experiment to map cropped area in the Gezira Scheme (GS) using satellite images for mapping crops and minimize cost for period February 2016 to March 2017. Five Blocks were selected to implement the experiment and perform the field investigations. Landsat-8 satellite data (30 m resolution and free) were used for mapping the cropped area in GS. For that, a supervised classification was employed to identify the Land Use Land Cover LULC classes within the GS. This was applied through two methods, namely: the maximum likelihood classifier (MLC) and the object based image analysis (OBIA). The classification procedures were supported by ground truth data that have been collected during the field surveys.

The maximum likelihood classifier (MLC) is one of the most popular methods of classification in remote sensing, in which a pixel with the maximum likelihood is classified into the corresponding class.

Object-Based Image Analysis (OBIA) employs two main processes, segmentation and classification. Traditional image segmentation is on a per-pixel basis. However, OBIA groups pixels into homogeneous objects. These objects can have different shapes and scale. Objects also have statistics associated with them which can be used to classify objects. Statistics can include geometry, context and texture of image objects.

The produced LULC maps for the winter season during February 2016 indicate that the dominant crop in the five Blocks was Wheat. The error in the Wheat areas were found to be ranging between 0.3 to 5% for the MLC and 1 to 3% for the OBIA methods compared to the actual (ground) Block areas.

This experiment will continue to map all the crop types that might be cultivated during the summer season of 2016 and winter season of 2016/2017.The optimal date for assessing each crop will be determined depending on the accuracy. Hence the cultivated areas will also be determined, which will have great impact in Gezira agricultural water management decisions.

11. Calibration of Some Hydraulic Structures in Rahad Agricultural Scheme (RAS):

(Abu Obeida B. Ahmed, Mojahid M. Siddig, Ahmed A. Osman and Yasir A. Mohammed)

Accurate discharge measurement is essential for good and efficient water resources management, distribution and allocation. Hydraulic structures such as weirs, sluice gates … etc. are commonly used as discharge measuring tools as well as water control structures. Weirs are such type of structures that water spills over, while sluice gates the water passes through. For each category, there is a specific equation that estimates the quantity of water flow and the different parameters (variables) in each equation depends mainly on the type of structure and flow conditions. Due to long-term operation and any other factor such as replacement or rehabilitation of the structure, the governing equation may not give reasonable water flow estimates. In this case, the structure will be in a bad need for calibration.

This study has been carried out according to the articles of the contract agreement no. RIRP/$A_{5.1}$ between the Hydraulics Research Center (HRC) and the Implementation Unit of Rahad Irrigation Rehabilitation Project (RIRP/PIU), within the local components of the project. The main objectives of the study are as follows:

- Calibration of 20 hydraulics structures both sluice gates and weirs;
- Erection of 40 water level gauges upstream and downstream some selected regulators; and
- Training course on irrigation water management for engineers & technicians.

Calibration was done based on a set of measurements for a complete season. The discharge estimation was done by using Velocity Area Method (VAM). This method comprises of measuring the mean velocity (V) and the flow area (A) and computing the discharge (Q) from the continuity equation (Q = A*V). The straightness, stability, uniformity of cross-sections … were considered during selecting the different measurement sites. This is to satisfy the requirements of measurements accuracy according to ISO standards. Linear regression technique was used to derive the discharge coefficients after transformation of both gate and weir equations in linear format. Rating tables were also derived for the sake of easy use for. The water level gauges were already done and preparation for implementing the training course is online.

12. Water Quality – Wells in Wad Medani:

(Nazik A. M. Ahmed, Eltaeb R. Abbas and Ahmed A. Kabo)

Considering the fact that the ground water is site specific and the characteristics may significantly vary from one location to another with in relative small areas, this study is meant to evaluate the water quality of the wells to determine the suitability and the spatial variations of the properties if any. The study is also considered to be a good opportunity to train HRC staff and to expose HRC capabilities to others.

A number of 48 wells were investigated and samples were taken for chemical and physical analysis of different parameters such as: PH, Chloride, Turbidity… etc. The testes were done in the HRC lab using three equipment the Multi parameter portable meter, Palintest spectrophotometer and Turbidity Meter. The measures were analyzed and maps were drawn using arc map software. The measures were compared with three standards which are WHO Standard, Sudanese Standard and Wed-Medani standards. The outcomes of the study showed that most of the parameters from all wells fall within the recommended ranges.

The only exceptions are the higher observation in turbidity in three wells which is might be due to operation and maintenance effects on the samples. It was also found that the hardness is high in one well. 82% of the wells have higher range in alkalinity according to the WHO standards but are in range for the other standards also there are wells that are nearly about to exceed the standards in PH. All in All the ground water aquifer under Wad Medani suitable as potable water.

13. Seasonal forecasting for the Blue Nile at the Ethiopia-Sudan border:

(Hana A. Mohammed, Ahmed A. Osman & Mudathir H. Zaroug)

Being located in the central part of the Nile basin, Sudan is occasionally hit by severe floods which cause massive damages on lives and properties. Flash floods caused by heavy downpours are not unusual in many parts of Sudan.

The objective of the study is to identify the sequence of Pacific Ocean seasonal Sea Surface Temperature (SST) conditions that significantly affect the amount of the discharge from Ethiopia in order to provide a forecasting methodology to predict the seasonal flow of the Blue Nile at the Ethiopia-Sudan border, in addition to provide an advice about the flood season forecast of 2016.

The main output of this research was a methodology to try starting a seasonal forecast of the Blue Nile discharge at the border between Sudan and Ethiopia. The method was tested using historical data at site, to assess forecast margin. Data of ENSO (SST anomalies) and discharge data at Eddeim station from 1965 up to 2013were analyzed.

The method which has been used in this study was focused on studying the impacts of the SST anomalies over Nino 3.4 at the Pacific Ocean as the main factor. The SST anomaly is the sea surface temperature departure from the long-term mean, E1 Nino events are associated with high SST anomalies. Conversely, La Nina events are episodes of low SST anomalies.

The approach was correlating the SST anomalies in different quarters (12 overlapped quarters over the year) and the discharge of the season (June – July – August – September) using the historical data of Eddiem station. It has been found that the correlation between the SST index and the discharge of the Blue Nile at Eddiem are negatively correlated as stated by the previous studies. The best correlation was found between the discharge of JJAS and the quarter JJA with a correlation coefficient (0.57) and then it was used to predict the forecast of year 2016.

In order to have a good lead time for the predictions before the rainy season, the SST of JJA was taken from the forecast which is made by the IRI using different models; the average ENSO forecast was considered and then the

forecasted discharge of the Blue Nile River is likely estimated to be above the average discharge during the period JJAS.

The use of the equation that was developed from the correlation between the SST indices and the discharge indices provide an uncertainly prediction due to the scatter of the data, moreover using a forecasted ENSO index also might lead to some errors and so an investigation on the level of uncertainty when using the global SST to forecast the rainfall in the upper catchment of the Blue Nile and Sudan is required.

Further studies still need to be done on this field. There is a still need for a comprehensive study about the impact of ENSO on the rainfall of Sudan. Not all El Niño and La Niña events are the same; they have different timings and characters. In fact, different events start at different times of the year and their sequence exhibits different patterns. In particular, an attempt was made to identify the impact of seasonal SST conditions that significantly affect drought and flood conditions over the upper catchment of the Blue Nile in order to provide recommendations for possible use as input to seasonal water resources forecasting systems in Sudan.

It is also recommended to study the impacts of other factors such as Indian Ocean Dipole (IOD), the tropical Atlantic, and North Atlantic Oscillation (NAO) in Sudan and upper catchment of Blue Nile which haven’t been included in this study

14. الآثار السياسية والأمنية لسد النهضة الإثيوبي على السودان:

(Abdelaziz A. Balila &Yasir A. Mohamed)

تناولت هذه الدراسة تحليل الآثار السياسية والأمنية لسد النهضة الإثيوبي علي السودان آخذين في الإعتبار أن مياه النيل تحكمها إتفاقيات وقوانين دولية لايمكن التملص منها وعدم الإعتراف بها لأي دولة باعتبارها حق مكتسب علي مر التاريخ. كما ان تزايد الإحتياجات المائية لدول حوض النيل تضعها أمام الأمر الواقع في كيفية إستغلال الموارد المائية الخاصة بها مما يترتب عليه كثير من الآثار علي دول الحوض الأخرى خاصة دول المصب.

تأتي اهمية هذه الدراسة في أنها أجابت على كثير من الأسئلة المرتبطة بآثار سد النهضة السياسية و الأمنية علي السودان وفرص التعاون بين السودان وإثيوبيا بعد بناء سد النهضة. وقد خلصت الدراسة إلى أن هناك أثر واضح لسد النهضة علي السودان خاصة في المجال السياسي حيث تعتبر إثيوبيا الثقل الافريقي كما لإثيوبيا أثر واضح في الإستقرار السياسي والإنفتاح الخارجي للسودان.

كذلك بعد قيام سد النهضة يمكن ان يتطور التعاون الأمني المشترك بين الدولتين خاصة في مجال الحدود مما يسهل عملية التنمية الحدودية وقفل الباب أمام أي مهدد أمني. كما أن بناء السد أحدث نوع من الحراك الشعبي والحكومي المتمثل في الدبلوماسية الرسمية والشعبية والتي بدورها تسهم في تحقيق نوع من التكامل والتعاون الإقليمي المشترك. رغم كل الإيجابيات وفرص التعاون آنفة الذكر إلا أن سد النهضة يمكن أن يمثل تهديد أمني مباشر علي السودان في حالة عدم الإتفاق بصورة او بأخري علي طريقة تشغيل السد.

خرجت الدراسة بعدد من التوصيات أهمها:

- أن تقوم العلاقات الخارجية مع دول الحوض خاصة إثيوبيا علي تبادل المعلومات والمنافع والإبتعاد عن المواقف التكتيكية والعمل المشترك علي تنمية المناطق الحدودية.
- وضع خطة شامله لإستقلال الميزات التي يوفرها سد النهضه خاصة في مجال االزراعة وتوليد الطاقة الكهرومائية وتحقيق التعاون والتنسيق التام مع الحكومه الإثيوبيه فيما يتعلق بتشغيل السد.
- دعم المؤسسات العلميه ومراكز البحوث لتقديم دراسات عن المياه وتدفقات النيل بعد قيام سد النهضه وكيفية التأقلم معه.

15. إتفاقيات مياه النيل وأثرها القانوني على السودان:

(Mohamed M. Mohamed & Yasir A. Mohamed)

تحتوي هذه الورقة تلخيصاً لأهم الإتفاقيات والبروتكولات التي عُقدت حول حوض نهرالنيل.

بروتوكول روما عام 1891: وُقع هذا البروتوكول بين بريطانيا وإيطاليا في 15 أبريل1891م، وهو خاص بتحديد مناطق نفوذ كلٌ منهما في دول حوض النيل الواقعة في شرق أفريقيا وحتى البحر الأحمر ويتضمن هذا البروتوكول الآتي :(بأن لا تُنشئ إيطاليا أي أعمال على نهر عطبرة من شأنها أن تعوق إنسياب المياه التي تصل إلي نهر النيل).

إتفاقية أديس أبابا1902م: تم توقيع هذا الإتفاقية في 15مايو1902م بين بريطانيا والأمبراطورية الأثيوبية متمثلة في الأمبراطور(منليك الثاني). المادة الأولى و الثانية عبارة عن إتفاقية لترسيم الحدود بين السودان وإثيوبيا، أما المادة الثالثة تشمل تعهد إمبراطور أثيوبيا بأن لا يأمر أو يسمح بإقامة أي منشآت على النيل الأزرق وبحيرة تانا ونهر السوباط من شأنها أن تقلل المياه المتدفقة للنيل دون الموافقة المسبقة من حكومة بريطانيا وحكومة السودان.

إتفاقية لندن 1906م: تم توقيع هذه الإتفاقية في9 مايو 1906م بين الملك إدوارد السابع ملك المملكة المتحدة والملك نيوبولد الثاني ملك بلجيكا. تحدد هذه الإتفاقية الحدود بين السودان و الكونغو وينص البند الثالث على تعهد حكومة الكونغو بأن لا تقيم أو تأذن بإقامة أية أعمال على نهر سمليكي أو أسانجو يكون من شأنها تقليل حجم المياه التي تدخل الى بحيرة البرت المغذية لنهر النيل إلّا بالإتفاق مع الحكومة السودانية أوالبريطانية.

الإتفاق الثلاثي الموقع 1906م: يختلف هذا الإتفاق عن الإتفاق الموقع بين بريطانيا و بلجيكا في العام نفسه. وُقع هذا الإتفاق بين الدول الإستعمارية (فرنسا وإيطاليا وبريطانيا) في 13ديسمبر1906م يتعلق بمصالح الدول الثلاث في أثيوبيا.

إتفاقية روما 1925م: هي عبارة عن مجموعة خطابات تبودلت بين المملكة المتحدة وإيطاليا بشأن الإمتيازات المتعلقة بإقامة خزانات على بحيرة تانا و خط حديدي عبر أثيوبيا من أريتريا الى الصومال.

إتفاقية تقاسم مياه النيل1929م: هي إتفاقية أبرمتها الحكومة البريطانية بصفتها الإستعمارية لعدد من دول حوض النيل (السودان،أوغندا، كينيا، تنزانيا)،في عام 1929م مع الحكومة المصرية. تنظم تلك الإتفاقية العلاقة المائية بين مصر ودول الهضبة الإستوائية، في الخطاب المرسل من رئيس الوزراء المصري و المندوب السامي البريطاني.

إتفاقية لندن 1934م: وُقعت هذه الإتفاقية بين بريطانيا نيابة عن تنجانيقا (تنزانيا)، وبلجيكا نيابة عن رواندا و بورندي في 23نوفمبر1934م بشأن نهر كاجيرا، وهو احد روافد بحيرة فيكتوريا.

إتفاقية 1938م: وُقعت هذه الإتفاقية في 16ابريل 1938 بين المملكة المتحدة و إيطاليا حول بحيرة تانا،حيث ذكرت في جزء منها إعلاناً خاصا ببحيرة تانا مضمونه أن الحكومة الإيطالية تعي تماماً إلتزاماتها نحو المملكة المتحدة بشأن بحيرة تانا.

المذكرة المتبادلة في عام 1949م: تم تبادل المذكرات بين مصر وبريطانيا، نيابة عن أوغندا عام 1949م بشأن إشتراك مصر في بناء سد و خزان على شلالات أوين، بغرض توليد الكهرباء لصالح أوغندا، وتعلية الخزان لرفع منسوب المياه وتخزنها لصالح مصر.

إتفاقية 1959م: وُقعت هذه الإتفاقية بالقاهرة في نوفمبر 1959م بين مصر و السودان، وجاءت مكملة لإتفاقية 1929م وليست لاغية لها، حيث تشمل الضبط الكامل لمياه النيل الواصلة لكل من مصر والسودان في ظل المتغيرات الجديدة التي ظهرت على الساحة آنذاك وهي الرغبة في إنشاء السد العالي ومشروعات أعالي النيل لزيادة إيراد النهر وإقامة عدد من الخزانات في أسوان.

إتفاقية 1991م: وُقعت هذه الإتفاقية بين كل من مصر وأوغندا التي وقعها الرئيس المصري آنذاك حسني مبارك والأوغندي موسيفيني ومن بين ما وود فيها :-

أكدت أوغندا في تلك الإتفاقية إحترامها لما ورد في إتفاقية 1953 التي وقعتها بريطانيا نيابة عنها وهو ما يعد إعترافاً ضمنياً بإتفاقية 1929.

إطار تعاون يوليو1993م: وُقع في القاهرة في أول يوليو1993م بين كل من الرئيس المصري آنذاك محمد حسني مبارك و رئيس الوزراء الأثيوبي آنذاك - ميليس زيناوي، وكان لهذا الإطار دور كبير في تحسين العلاقات المصرية الأثيوبية وتضمن هذا الإطار التعاون بين مصر وإثيوبيا فيما يتعلق بمياه النيل.

تُعد الاتفاقيات بين مصر و السودان سارية المفعول من وجهة نظر القانون الدولي ولا يستطيع طرف أن يتحلل منها طبقا لإتفاقية فيينا بشأن التوارث الدولي للمعاهدات 1978م مثلها مثل إتفاقيات الحدود المستقرة والمقبولة من جميع اطرافها على الرغم من توقيعها سابقا. و بالتالي فان جميع دول حوض النيل ملزمة بالإتفاقيات السابقة، لاسيما وأن هذه المعاهدات لم تأت بمبادئ قانونية جديدة على خلاف القواعد العامة الحاكمة للنظام القانوني للأنهار الدولية، وإنما أكدت المبادئ التي سبق للفقه والعرف الدوليين قبولها، كمبدأ الإعتراف بالحقوق التاريخية المكتسبة، ومبدأ وجوب التعاون والتشاور والإخطار. و هذا يدحض حجة دول المنبع التي تقول ان إتفاقيات مياه النيل غير ملزمة لها ولا أساس لها لأنها إستعمارية.