United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

European Commission

Framework for Human Capacity Development in the Water Sector in Sudan

FINAL REPORT

Water Research Center
University of Khartoum

MARCH 2019

Table of Contents

Table of Contents i
List of Tables v
List of Figures vi
List of Abbreviations vii
Executive Summary ix

1 INTRODUCTION **1**
1.1 BACKGROUND 1
1.2 METHODOLOGY 2
1.2.1 Literature Review 2
1.2.2 Consultation Workshop 2
1.2.3 Visits and Interviews 2
1.2.4 Questionnaire 3
1.3 DATABASE FORMATION AND DATA ANALYSIS 3
1.4 HCD FRAMEWORK 3
1.4.1 Design of the Courses 3
1.4.2 Monitoring and Evaluation Framework 4
1.4.3 Validation Workshop 4
1.5 OVERVIEW OF THE HCD SITUATION IN SUDAN 5
1.6 SUDAN HUMAN CAPACITY PROFILE 7

2 THE WATER SECTOR OF THE SUDAN **9**
2.1 INTRODUCTION 9
2.2 WATER RESOURCES IN SUDAN 10
2.2.1 Rainfall 10
2.2.2 The Nile System 10
2.2.3 Wadis Waters 11
2.2.4 Groundwater 12
2.2.5 Summary of available water resources and potential threats 12
2.3 WATER RESOURCES INSTITUTIONS IN SUDAN 13
2.3.1 Evolution of the Institutional Framework 14
2.3.2 Other Institutions 17
2.4 LEGAL FRAMEWORK 18

2.5 POLICY FRAMEWORK 18
2.6 SUMMARY OF WATER RESOURCES MANAGEMENT PRIORITY AREAS 19

3 HUMAN CAPACITY DEVELOPMENT GAPS: LITERATURE REVIEW 20

3.1 CAPACITY DEVELOPMENT IN THE WATER SECTOR: HISTORY AND CURRENT SITUATION 20
3.2 PREVIOUS EFFORTS IN IDENTIFYING TRAINING NEEDS FOR CAPACITY DEVELOPMENT IN THE WATER SECTOR 21

4 CONSULTATION WORKSHOP 28

4.1 WORKSHOP SETUP, FORMAT AND PARTICIPATION 28
4.2 OUTCOMES OF THE CONSULTATION WORKSHOP 29
4.2.1 Training Needs Assessment for Starting Professionals 29
4.2.2 Training Needs Assessment for Technicians 31
4.3 ADDITIONAL RECOMMENDATIONS 33

5 VALIDATION WORKSHOP 34

5.1 INTRODUCTION 34
5.2 WORKSHOP SETUP, FORMAT AND PARTICIPATION 34
5.3 MAIN OUTCOME OF THE WORKING GROUPS 35
5.3.1 Working Group (1): Training Courses for Starting Professionals: 35
5.3.2 Working Group (2): Training Courses for Technicians: 36
5.4 GENERAL DISCUSSION, REFLECTIONS AND RECOMMENDATIONS FROM THE WORKSHOP 37
5.5 RESPONSE TO COMMENTS 38

6 TRAINING COURSES FOR STARTING PROFESSIONALS IN THE WATER SECTOR 40

6.1 TRAINING COURSE IN INTEGRATED WATER RESOURCES MANAGEMENT 40
6.1.1 Introduction 40
6.1.2 Objectives of The Course 40
6.1.3 Learning Outcomes 41
6.1.4 Training Period 41
6.1.5 Suggested Topics 41
6.1.6 Brief Outlines of the Topics 42
6.1.7 TRAINING METHODS 44
6.1.8 References 48
6.2 TRAINING COURSE IN WATER SUPPLY, SANITATION & HYGIENE (WASH) 50

6.2.1 Introduction 50
6.2.2 Objectives of The Course 50
6.2.3 Learning Outcomes 51
6.2.4 Training Period 52
6.2.5 Suggested Topics 52
6.2.6 Brief Outlines of the Topics 52
6.2.7 Training Methods 54
6.2.8 References 56
6.3 TRAINING COURSE IN DATA ACQUISITION AND ANALYSIS IN WATER MANAGEMENT 57
6.3.1 Introduction 57
6.3.2 Objectives of The Course 57
6.3.3 Learning Outcomes 58
6.3.4 Training Period 58
6.3.5 Suggested Topics 58
6.3.6 Brief Outlines of the Topics 59
6.3.7 Training Methods 61
6.3.8 References 65

7 TRAINING COURSES FOR TECHNICIANS IN THE WATER SECTOR 66
7.1 TRAINING IN DATA ACQUISITION IN SURFACE AND GROUND WATER 66
7.1.1 Introduction 66
7.1.2 Objectives of The Course 67
7.1.3 Learning Outcomes 67
7.1.4 Training Period 67
7.1.5 Suggested Topics 67
7.1.6 Brief Outlines of the Topics 68
7.1.7 Training Methods 69
7.1.8 References: 73
7.2 TRAINING COURSE IN CONSTRUCTION, INSTALLATION, OPERATION AND MAINTENANCE OF URBAN SURFACE DRAINAGE STRUCTURES AND NETWORKS 74
7.2.1 Introduction 74
7.2.2 Objectives of The Course 75
7.2.3 Learning Outcomes 75
7.2.4 Training Period 76
7.2.5 Suggested Topics 76

7.2.6 Brief Outlines of the Topics 76
7.2.7 Training Methods 78
7.2.8 References 82
7.3 TRAINING COURSE IN WATER & WASTEWATER QUALITY MONITORING AND ANALYSIS 83
7.3.1 Introduction 83
7.3.2 Objectives of The Course 83
7.3.3 Learning Outcomes 84
7.3.4 Training Period 84
7.3.5 SUGGESTED TOPICS 84
7.3.6 Training Methods 84
7.3.7 References 88

8 MONITORING AND EVALUATION FRAMEWORK 89
8.1 INTRODUCTION 89
8.2 PRE-COURSE ASSESSMENT 89
8.3 COURSE WORK 90
8.4 POST-COURSE ASSESSMENT 90
8.5 CONTINUOUS MONITORING 92
8.6 COURSE ASSESSMENT BY PARTICIPANTS' ORGANIZATIONS 93
8.7 SUCCESS INDICATORS 95

GENERAL REFERENCES 96

ANNEXES 98
Annex 1. List of participants (Consultation Workshop) 98
Annex 2. List of participants (Validation Workshop) 100
Annex 3. Validation Workshop Agenda 104
Annex 4. Photos from the Validation Workshop 105

List of Tables

Table 2.1: *The Flows of the Nile and its Tributaries in the Sudan* *11*
Table 3.1: *Top six thematic areas and their sub-categories for training in the water sector in Sudan as defined by the Ministry of Water Resources Irrigation and Electricity (MIWR, 2000)* *21*
Table 3.2: *Total number of personnel of the MWRIE to be trained up to year 2020* *22*
Table 3.3: *Top Ten Priority Areas For Training In The Water Sector In Sudan As Defined By Abdo (2013)* *23*
Table 3.4: *Final Results of the TNA in The Form Of Suggested Training Modules* *26*
Table 4.1: *Top Three Training Needs for Starting Professionals As Identified By Stakeholders in the Consultation Workshop* *30*
Table 4.2: *Top Three Training Needs For Technicians In The Water Sector Field.* *32*
Table 6.1: *Contact hours for IWRM Course* *45*
Table 6.2: *IWRM Time Table* *46*
Table 6.3: *Contact hours for WASH Course* *54*
Table 6.4: *WASH Time Table* *55*
Table 6.5: *Contact hours for Data Acquisition and Analysis in Water Management Course* *62*
Table 6.6: *Data Acquisition and Analysis in Water Management Time Table* *63*
Table 7.1: *Contact hours for Data Acquisition in Surface and Ground water course* *70*
Table 7.2: *Data Acquisition in Surface and Ground water Time Table* *71*
Table 7.3: *Contact hours for Drainage Structures and Networks Course* *78*
Table 7.4: *Drainage Structures and Networks Time Table* *79*
Table 7.5: *Contact hours for Water & Wastewater Quality Course* *85*
Table 7.6: *Water & Wastewater Quality Time Table* *86*

List of Figures

Figure 1.1: *Methodology for the Development of HCD & M&E Framework* 4
Figure 1.2: *Water Links with Important Sectors and Goals (WRC, 2018)* 6
Figure 1.3: *Factors Influencing Capacity Building in the Water Fields (Salih)* 7
Figure 2.1: *Organizational Structure of the Ministry of Water Resources, Irrigation and Electricity (MWRIE)* 16
Figure 3.1: *Linkage and Interdependencies between the Sustainable Development Goal (SDG) 6 and the Themes of IHP-VIII* 25
Figure 5.1: *Human Capacity Development Framework* 39

List of Abbreviations

ACEWATERII	African Centres of Excellence Water Project Phase II
AMCOW	African Minister's Council of Water
AU	African Union
CoE	Centre of Excellence
DIU	Dams Implementation Unit
EC	European Commission
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
HCD	Human Capacity Development
HYCOS	Hydrological Cycle Observing System
IGAD	The Intergovernmental Authority on Development
IHP	International Hydrological Programme
IOM	International Organization of Migration
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
KETS	Kenana Engineering and Technical Services
M&E	Monitoring and Evaluation
MWRIE	Ministry of Water Resources, Irrigation and Electricity
NATCOM	National Commission of UNESCO
NBI	Nile Basin Initiative
NCS	National Comprehensive Strategy
NCWR	National Council for Water Resources
NEPAD	Network of Partnership for Africa Development
NGOs	Non- Governmental Organizations
NSA	Nubian Sandstone Aquifer
NWC	National Water Corporation
OPEC	Organization of the Petroleum Exporting Countries
RCWH	UNESCO Category 2 Regional Center for Water Harvesting
SDGs	Sustainable Development Goals
SMA	Sudan Meteorological Authority
TOR	Terms of Reverence
UCO	UNESCO Cairo Office
UDWS	The Unit of Drinking Water and Sanitation

UNESCO	United Nation for Education, Science and Culture Organization
UNHCR	United Nations High Commissioner for Refugees
UofK	University of Khartoum
WASH	Water, Sanitation and Hygiene
WMII	Water Management and Irrigation Institute-Gezira University
WRC	Water Research Centre-Uof K
WRTO	Water Resources Technical Organ

Executive Summary

This is the final report on the study "Establishment of Human Capacity Development Framework addressing starting professionals and technicians in the water sector in Sudan". The study was carried out by the Water Research Centre, University of Khartoum, within the framework of the Human Capacity Development Component (HCD) of the project ACEWATER II of the AU-NEPAD Network of Centres of Excellence (CoE) on Water Sciences and Technology. The study started with a critical review of the water sector in Sudan and the challenges of water resources management that require training and capacity building at various levels. A comprehensive literature review was then carried out on the previous studies that have been conducted to identify HCD gaps and training needs. In these studies, the major water institutions, research centres and universities, training and capacity building centres, NGOs, and private sector in Sudan have been consulted to identify training gaps through structured questionnaires, visits, and interviews as well as through reviewing existing reports on training needs. It has been found that almost all institutions suffer from inadequate technical and manpower capacities, and they are in urgent need for training and capacity building. Top cross-cutting training areas identified from previous studies include planning, design, management, operation, and maintenance of: water resources systems, hydro-informatics and data acquisition, WASH, irrigation water use efficiency and productivity, Surface and groundwater resources assessment and management, watershed management, climate change, water governance and economics, and water diplomacy and cooperation. A consultation meeting with key Sudan water sector stakeholders was held at the WRC on 29th September, 2018 in which the gaps and training needs as identified from previous studies were discussed and refined. The participants of the consultation workshop were divided into two groups (starting professionals and technicians) and the top three priority training areas for each category were identified according to an agreed upon criteria. It was found from the consultation workshop that, in addition to the key training areas identified for each targeted group, there are similarities in the areas of training for both groups. Therefore, it was recommended to identify within each thematic training area, the components that are similar but it should include more practical emphasis for the technicians. A broad framework for HCD was then developed and endorsed by the core stakeholders during the consultation workshop. The HCD framework consists of the design of training and educational contents, identification of learning objectives and expected outcomes, development of learning material, modality of implementation and the recommended training institutions which should be coordinated by WRC. An important component of the overall framework is the design of a monitoring and evaluation framework. The framework is intended to be effective in assessing the progress in training programs relative to the objectives of the project.

As a final step to complete the study a validation workshop for the developed framework was conducted on the 9th of March 2019 in which a wide range of stakeholders covering various specializations and organizations participated. The specific goals of the workshop were to review, update and validate the developed three priority training modules for each of the two groups, and to agree on a strategy for the implementation, monitoring and evaluation, and

sustainability of the training programs. Many useful recommendations for improvements were made during the validation workshop, which were all incorporated in the final framework. Among the useful recommendations made during the valuation workshop are the establishment of partnerships between training institutions and water stakeholders, development of a training strategy in coordination with the stakeholder institutions within the remaining time horizon of the 2015-2030 SDGs, which should be geared towards achieving the sustainable development goals. Periodic monitoring and evaluation to assess how the training course is achieving its stated objectives and targets has been outlined in order to ensure sustainability of the training programs through adequate financial support from the government, stakeholder and donors.

CHAPTER 1

1 INTRODUCTION

1.1 BACKGROUND

This document represents the final product of the work carried out by the Water Research Centre, University of Khartoum (WRC) for the establishment of a validated Human Capacity Development (HCD) programme targeting junior professional and technicians in the water sector in the Sudan. The work was carried out within the framework of the (HCD) component of the project ACEWATER II of the AU-NEPAD Network of Centers of Excellence (CoE) on Water Sciences and Technology. ACEWATER II project is funded by the European Commission (EC) and it has two components; a research component and a HCD component. The HCD component is coordinated by UNESCO-IHP and is to be implemented in response to the call of the African Water Ministers' Council (AMCOW) Declaration urging the AU-NEPAD Water CoE to develop HCD Programmes targeting junior professionals and technician in the water sector at national level in the CoE countries.

According to the TOR for the assignment, the WRC has identified the HCD needs and priorities in the water sector in the Sudan through a multi-stakeholder participative approach. Accordingly, the HCD programme has been developed following the TOR requirements with stakeholder's involvement. To achieve this, the following activities have been conducted:

1. Launching a comprehensive study to identify the Water Sector's HCD needs in the Sudan including previous studies, surveys, interviews and consultations of national partners and stakeholders
2. Organization and implementation of a national dialogue for human capacity building in the water sector with all stakeholders and partners to define priorities from the needs, focusing at this stage on junior professionals and technicians.
3. Designing a national framework for HCD addressing junior professionals and technicians in the water sector, including an implementation framework, together with a Monitoring and Evaluation framework and success indicators.
4. Organization of a national validation workshop in which the developed national framework for HCD is reviewed and validated

1.2 METHODOLOGY

The study was carried out with close collaboration and coordination with the UNESCO National IHP Committee of the Sudan. This was made easier noting that the chain of the WRC and senior members of the WRC are active members of the Sudanese IHP committee. In fact, collaboration between the WRC and Sudan UNESCO is IHP committee already exists through joint studies on many water projects, training programs, conferences and seminars currently and over the past years.

The methodology adopted to accomplish the tasks was as follows:

1.2.1 Literature Review

The available literature/documents relevant to the consultancy assignment on the water sector in Sudan were reviewed including water policy and strategy, institutional set up and human capacity building gaps. This also included the training and capacity building institutions at different levels (Universities, research Centres, technical universities and centres, vocational training institutions, etc.). The types of training they are conducting, training objectives, training methods and material, and the targeted trainees were included in the survey.

1.2.2 Consultation Workshop

A consultation workshop with representatives of key Sudan water Sector stakeholders was organized. The objective of the workshop was confirming a common understanding of the problem, identifying the requirements for the assessment exercise, and agreeing on what support, studies, analyses and initiatives that individuals and/or organizations could contribute, or identify, as useful and important for the assessment. The data collection strategy and any new additional sources of relevant information were discussed.

1.2.3 Visits and Interviews

Visits and interviews were organized with senior officials of key water resources institutions, universities, water research centers, training institutions (professional and technicians training), UN organizations as well as NGOs and private sector. The questions raised focused on capacity building gaps at junior professionals and technicians levels, capacity building programs and initiatives that exist or are in the pipeline as well as the capacity building challenges facing these institutions.

1.2.4 Questionnaire

A questionnaire was designed and distributed to key stakeholders linked to the water sector including NGOs and the private sector in such a way that the basic information could be acquired on the skills, qualification, and training gaps of junior professionals and technicians. The questionnaire prepared for this investigation composed of three main parts:

1. Basic information about the respondent, his/her institution, suitable training modules that suit the institution and the capability of the institution to offer training modules.
2. Resource based information to test the respondent knowledge about the most important institution responsible for water resources management, the country water strategy and how it addresses specific issues and lastly the respondent's opinion on the main issues and challenges facing capacity building in water resources management in Sudan.
3. Training needs: In this part, the respondents were asked to rank the potential training areas in water resources management at both junior professionals and technicians' levels from the most important to the less important. According to the literatures and targets of SDG6 and IHP VIII, very important broad training areas were selected; each broad area included many thematic areas relevant to young professionals and technicians.

1.3 DATABASE FORMATION AND DATA ANALYSIS

The data on HCD gaps collected from the literature review, interviews and questionnaire were compiled in a database. The Statistical Package for Social Sciences (SPSS) was adopted for analyzing the data. The overall result of the analysis was a listing of the training modules for both young professionals and technician levels in priority order based on the frequency of responses.

1.4 HCD FRAMEWORK

From the results of analysis and the overall identified training gaps, the following training courses of the highest priority order were selected and the tentative course design was made

- Three training courses addressing starting water professionals.
- Three training courses addressing water technicians.

1.4.1 Design of the Courses

For each of the priority training course, the course design was carried out which includes the strategic goals, the learning outcomes, the course content, the target group, the suggested method of implementation together with a recommendation of the appropriate institution to conduct the training.

1.4.2 Monitoring and Evaluation Framework

In order to assess the quality of the courses in terms of structure, contents, training material, and the impact on the training on the professional and technical abilities of the trainees, a regular monitoring methodology is suggested using some success indicators.

1.4.3 Validation Workshop

A national validation workshop with key sector stakeholders was organized to assess the findings of the study and validate the developed HCD framework. Any comments or suggestions from the stakeholders for improvement of the developed HCD were taken into consideration and incorporated in the final framework.
Figure 1 shows the methodology that has been followed for the establishment of the validated HCD framework for Sudan

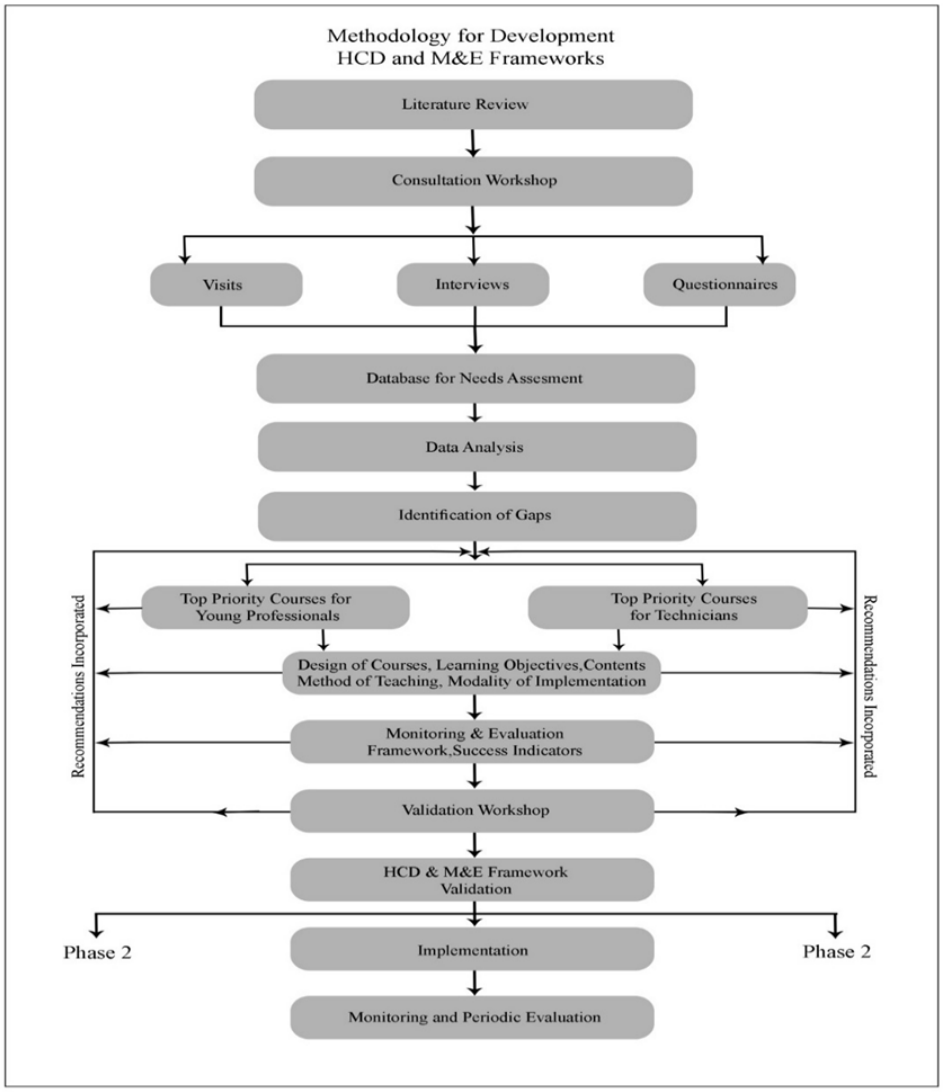


Figure 1.1: *Methodology for the Development of HCD & M&E Framework*

1.5 OVERVIEW OF THE HCD SITUATION IN SUDAN

Water is of the greatest strategic importance for Sudan's social and economic development, now and in the future. Its trans-boundary surface and groundwater basins, which are binding the Sudan to 13 of its African neighbor countries, bring an urgent call for cooperation that creates win/win situations. Given the present challenges and the growing projected pressures on water resources in the Sudan, there is an urgent need for increasing the number of competent and well trained water management practitioners especially at the young professionals and technicians levels. The need for training and capacity building at these levels has been highly emphasized in many meetings, conferences, seminars and workshops in order to achieve the sustainable development goal (SDGs) and the corresponding management objectives. There are many examples in the literature of unsustainable water resources projects which have failed as a result of lack of trained staff. Water resources management is a complex issue since water is connected to many other sectors. Figure 1 Indicates a simple picture of some of the complex connections of water that needs to be viewed and managed in an integrated holistic manner, and consequently its human resources development should consider these wide links. Having that in mind, Figure 2 indicates some of the factors directly influencing capacity building in the water sector.

Sudan was one of the leading countries in HCD in the water sector. This was reflected in establishing early in the 19th century, solid institutes for training the different cadres required for the sustainable development of its water resources. These institutes include the Faculty of Engineering (established in 1939) in the University of Khartoum (UofK), as the location for graduating young qualified engineers, the Khartoum Technical Institute to graduate qualified technicians; and a set of centers to graduate skillful laborers. Regrettably, this very logical pyramid with a number of skillful laborers for each technician and a number of technicians for a graduate engineer, following recognized international ratios between these groups. This logical setting has been disturbed considerably through the years with the pyramid being inverted with many engineers against one technician and even much fewer numbers of skillful laborers. Currently considerable number of faculties in the over 130 universities and university colleges graduate each year thousands of young water related graduates with much less number of technicians graduating from these universities or few remaining technician institutes. In spite of this disturbing situation there is an absence of ready statistics on the number of these graduates and technician as well as the qualities of the programs in these universities and institutes. In this respect this project came at the right time to compile the necessary data and information in this very urgent subject, make the necessary analysis and reach appropriate training modules that assist in correcting this worrying situation.

In terms of future water resources development to meet the growing demands, and adapt to climate change, Sudan has many options through better utilization of rain fed agriculture, enhanced water harvesting and artificial recharge technology, improved applications of water conservation , enhanced irrigation efficiency, safe utilization of non-renewable groundwater, and in the wise utilization of non-conventional water resources However, to be able to make use of these opportunities, there should be a well-built capacity to deal with water resources

management in a sustainable manner within the framework of an integrated water resources management approach. Therefore, training and capacity building to develop the human resources necessary for the Sudan to meet the above challenges is highly needed. This requires skillful laborers, qualified technicians, appropriate undergraduate and postgraduate training (at B.Sc. MSc and PhD levels), the provision of opportunities for post-doctoral research, continuing professional development, and the opportunity for stimulating careers to attract the most qualified persons to address these challenges.

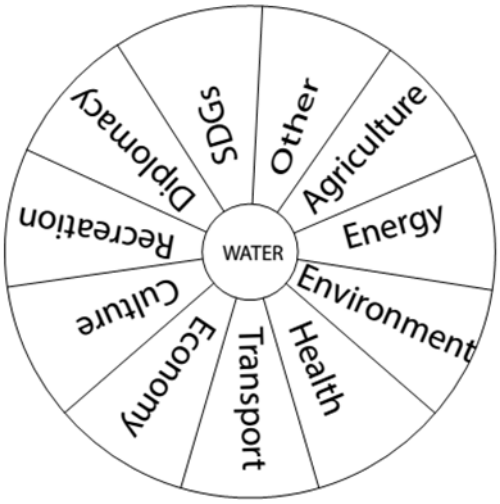


Figure 1.2: *Water Links with Important Sectors and Goals (WRC, 2018)*

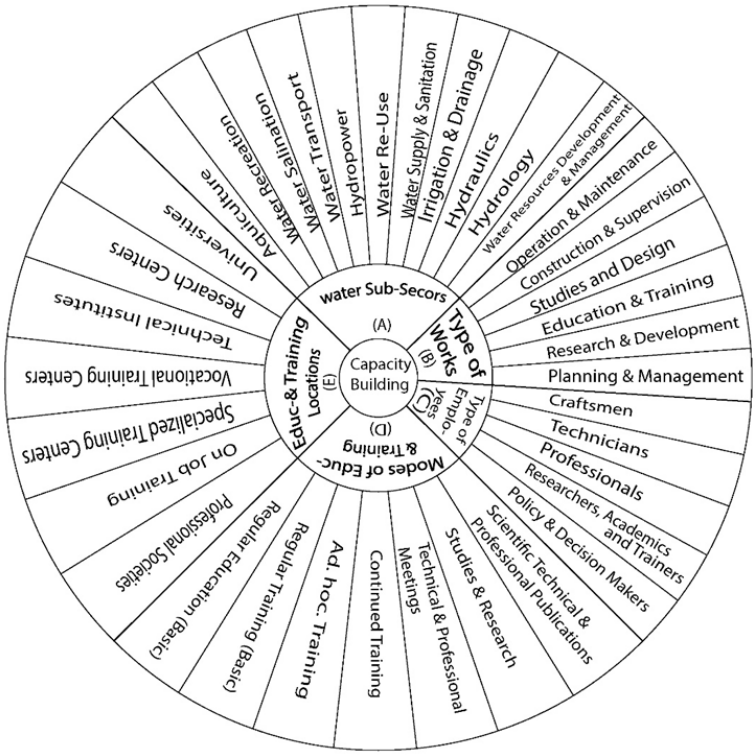


Figure 1.3: *Factors Influencing Capacity Building in the Water Fields (Salih)*

1.6 SUDAN HUMAN CAPACITY PROFILE

According to the functions performed, manpower in the major institutions involved in the water resources management in the Sudan can be categorized into six groups: Top Managers and Directors, Professionals, Researchers and academics, skilled laborers, Technicians, and Financial and Administrative Personal.

(i) Top Managers and Directors:

This category represents the civil service leaders, with adequate knowledge and skills to lead a group to achieve the goals of the institution. It is the category responsible for policy formulation, planning and general administration. This category includes: Undersecretaries of Ministries; Advisors; Directors General (DG) of companies, corporations, secretariats of specialized councils, and General Directorates and Directorates in Ministries.

The educational level of this group normally varies from B.Sc. to Ph.D. with working experience of more than 20 years. This group normally acquire high managerial and negotiation skills.

(ii) Professionals:

This category is mostly university graduates (engineers, geologists, scientists, etc.…) that carry out the main technical work in water resources institutions including technical studies and reports, planning, design, execution, operation and maintenance. The educational level of this group normally varies from B.Sc. to Ph.D.

(iii) Researchers and academics:

This is the category which conducts applied research in the field of water resources management. The educational level of this group varies from B.Sc. to Ph.D. This group normally has good knowledge of research and training of personal.

(iv) Technicians:

This is the category which assists the Researchers and Professionals in research work, programs of construction, field work, laboratory work, etc.… . The educational level of this group varies from above school leavers to Diploma (2 to 3 years).

(v) Skilled laborers:

This is the category which assists the professionals and technicians in manual skills during construction, operation and maintenance. Their education level is in secondary level vocational centers.

(vi) Financial and Administrative Staff:

This is the category which preforms clerical, personnel affaires, accounting and store keeping works. The educational level of this group varies from school leavers to B.Sc. And normally have administrative, accounting and typing skills.

The target groups considered in this study are starting professional and technicians. More precise definitions of these target groups were suggested during the consultation workshop as will be discussed in **Chapter 4** of this report.

CHAPTER 2

2 THE WATER SECTOR OF THE SUDAN

2.1 INTRODUCTION

Sudan covers an area of about 1.882 million km^2. According to the 2008 Census, it has a population of about 33 million with an annual increase of 2.8%. More than half of that population lives on just 15% of the land along the river Nile. The rest of the population lives in areas away from the Nile. Water has the greatest strategic importance for Sudan's social and economic development, and for the maintenance of peace within its borders. Water resources comprise three main categories, rainfall, surface water and groundwater, all of which are interrelated as part of the natural hydrologic cycle. The Nile River is the primary source of Sudan's surface water. Water resources of the seasonal streams or Wadis (called Non Nilotic Streams) also fall under this category. The sedimentary Nubian Sandstone and Um Ruwaba formations are the main sources of groundwater. The trans-boundary nature of water resources in Sudan makes it an important factor binding Sudan to its international neighbors. Sudan has a unique position in the Nile system, including more than 42 % of the Nile catchment area, and acting as receptor, source and transmitter. The Nile resource is shared between eleven riparian countries, major groundwater resources are shared with four other countries, and four seasonal rivers also cross international borders. Some 77% of currently identified water resources come from shared resources with other countries (Seifeldin, 2002).

The flow of the Nile is shared between Sudan and Egypt according to the 1959 agreement on the "full utilization of the Nile waters". This agreement stipulated yearly water allocation for Sudan of 18.5 billion cubic meters at Aswan (PJTC, 1962). According to this agreement the Sudan would also be allowed to undertake a series of Nile development projects. As Southern Sudan seceded from Sudan, it became the 11th riparian of the Nile Basin, and therefore it will have to decide on how to proceed on succession with respect to the Nile water agreement currently applicable. There are three Scenarios that the new Southern Sudan can decide on the issue of the 1959 Nile Agreement. These scenarios are discussed in some details in this chapter together with their future potential implications. The authors view is that if Southern Sudan decides to succeed into rights and obligations of the 1959 agreement, huge benefits could be achieved by the three countries, Southern Sudan, Sudan and Egypt. A brief discussion on potential lines of cooperation that would be beneficial to the three riparian countries is also given in the chapter.

2.2 WATER RESOURCES IN SUDAN

2.2.1 Rainfall

Rainfall occurs during 3 to 4 months of the year and varies according to three distinct zones; the desert zone north of latitude 17° with annual rainfall of less than 75 mm, the semi desert zone north of latitude 15° with annual rainfall of 75mm to 300 mm and the Savannah zone between latitudes 9° and 15° with annual rainfall of 300 mm to 900 mm. Typical to arid zone characteristics, rainfall data analysis in many areas of Sudan shows very high seasonality and variability in space and time with annual coefficient of variation ranging from 30% to more than 90 % in the northern desert. Analysis also shows annual rainfall decreasing trend and a marked shift in rainfall isohyets towards the southern part of the country (Yousra & Magdoline, 2009). Furthermore, rainfall records for many stations, show increased frequency of droughts over the past 40 years. In north Darfur for instance, 16 out of 20 driest years on record have occurred since 1972. It appears from the above features that the climate in Sudan is influenced by global climate change (Abdo & Salih, 2011). Such erratic nature of rainfall in Sudan and its concentration in a short season, places Sudan in a vulnerable situation especially with regards to rain fed agriculture which covers by far the largest area of the country.

2.2.2 The Nile System

The Nile Basin is shared by eleven riparian countries, namely: Burundi, D. R. of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Southern Sudan, Sudan, Tanzania and Uganda. The hydrology of the Nile and its tributaries is summarized in Table 2.1. According to the 1959 Nile Water Agreement between Sudan and Egypt, the net average annual flow at Aswan of 74 BCM (Billion Cubic Meters) is shared between the two countries as 55.5 BCM for Egypt and 18.5 BCM for Sudan (20.5 BCM at central Sudan). The Agreement also established the rights of the other riparian countries for the utilization of the Nile Waters.

Sudan contributes to the flows of the Nile from Bahr El Jebel, Bahr El Gazal and Pibor basins as well as the seasonal streams which join the Nile and its other tributaries. Therefore Sudan could be considered as a source and a path. Furthermore, Sudan's contribution to the Nile could be increased through conservation of the river flow in the wetland areas (swamps) in Southern Sudan if appropriate political, social and environmental measures are considered. It is worth mentioning that evaporation and evapotranspiration losses in the wetland areas in Southern Sudan are estimated to be within 45 BCM/ year (PJTC, 1961).

Table 2.1: *The Flows of the Nile and its Tributaries in the Sudan*

Tributary	Total Annual Average Supply (BCM)	Flow Characteristics
Blue Nile	50.7	Average daily peak discharge falls from 535 MCM/day in August to only 11 MCM/day in April
Rahad	1.09	Flow from July to November
Dinder	3.0	Flow from June to November
White Nile	27.8 (at Malakal)	Daily flow falls from 114 MCM/day in November to 54 MCM/day in April
Bahr El Gazal	14	Only 0.5 BCM reaches Malakal (considerable losses in swamps of South Sudan)
Bahr El Jebel	26 at Mongalla	Only 14.0 BCM reaches Malakal (considerable losses in swamps of South Sudan)
Sobat	13.3 reaches Malakal	Losses in Baro and Machar reach 8 bcm. Flows range from 8 MCM/day in April to 66 MCM MCM/day in November
Atbara	12 (7 from Setit and 5 from Atbara branch)	Low regulated flows from February to June
Main Nile	84 (at Aswan)	Average daily peak flow of 690 MCM/day (August-Sept.) and a low flow of 74 MCM/day (April-May)

Modified from Adam and Monshid (1996). (MCM: Million Cubic Meters)

2.2.3 Wadis Waters

There are a large number of seasonal streams (locally called Wadis) which are spread in many regions of Sudan and which are not considered as part of the Nile Basin. The major four of these streams are Gash and Baraka, which are shared with Eritrea, and Azum and Howar which are shared with Chad. Flow from these streams is sporadic and varies considerably from one year to another following the erratic nature of rainfall. They may flow for few days or few hours during the rainy season from July to October, and usually become dry during the rest of the year. The total annual Wadi flow in Sudan is estimated to vary from 5 to 7 BCM. However, absence of monitoring networks and lack of adequate understanding of Wadi hydrological processes are serious constraints impeding Wadi water resources development in Sudan. The situation is exacerbated by the Decentralization Act of 1994 which shouldered the

responsibility of Wadi water resources development and management to the States Governments which often suffer from lack of funds and inadequate capacity.

2.2.4 ***Groundwater***

Sudan has high potential of renewable and non-renewable groundwater resources which are important sources of water supply for domestic, industrial and agricultural uses. It is a key element for human settlement and sustained socioeconomic activities. The most important aquifer in Sudan is the Nubian Sandstone Aquifer (NSA) which is shared between Sudan, Egypt, Libya and Chad, and the Um Ruwaba formation which has recently become a shared resource between Sudan and Southern Sudan. Despite the large number of previous studies on groundwater resources in Sudan, there is no unified value of their estimated strategic storage potential. However, the various estimates given in the literature do indicate that it is huge. Regarding groundwater recharge, there are also differences in the estimated annual volume, yet the figure of 4 BCM/year has been circulating in various reliable sources (Abdo & Salih, 2012).

Groundwater management in Sudan is faced with many challenges. The most obvious of these challenges is the absence of quantitative and qualitative monitoring and scarcity of information on aquifers geometry and their hydro geological characteristics. Another major difficulty is related to the understanding of flow dynamics, recharge sources, volumes and mechanisms for the different aquifers. Fractured aquifers in Sudan cover very large areas and provide an important source of water particularly in rural areas. A major problem encountered in the management of fractured aquifers is the limited understanding of their hydrogeology. The fractures characteristics could be extremely complex making it very difficult to locate areas of productive boreholes with sustainable groundwater yield. Vulnerability and risk of contamination of these aquifers from urban, agricultural and industrial activities are also very high (Abdo & Salih, 2012). Other key challenges facing groundwater management in Sudan are the management of shared non-renewable aquifer resources, lack of comprehensive guiding plans and policies, poor governance and legislative framework, inadequate capacity, and lack of coordination among groundwater sub sectors.

2.2.5 ***Summary of available water resources and potential threats***

Based on the above mentioned estimates, the current annual amount of renewable water available to Sudan is about 30 BCM (Seifeldin, 2002). Historically, Sudan's renewable water resources have exceeded demand, but demand has now increased to match supply, and projections based on future development strategies show large water shortages over the coming years (Seifeldin, 2001). Demand is projected to reach 50 BCM/year by the year 2025, an excess of some 66% over the current demand. This caused severe implications for Sudan, for example in meeting the Millennium Development Goals (MDGs) and could be an obstacle in meeting the 2030 Sustainable Development Goals (SDGs) of providing safe drinking water to all its

citizens and the natural habitat as well as the dreamed food production and sound industrial development. The lack of adequate safe drinking water, in particular, has negative impacts on human health and social and economic development. Water deficits also have major implications for the agricultural sector of the economy. Agriculture is important in terms of food security, its contribution to the economy and exports which amounts to 34% of the GDP, and its position as the country's main source of employment. Furthermore, the vast fertile land resources of the country and the potential for the conservation of considerable volumes of water resources from the swamps of Southern Sudan have classified Sudan as the basket food of Arab World.

Current estimates of water resource availability take no account of some potential threats to those resources. The likelihood of climate change due to global warming has been confirmed by the 2007 report of the International Taskforce on Climate Change and more recent studies. Its impacts on the Nile water are highly uncertain, but in general, the frequency of extreme floods and droughts is likely to increase. Furthermore, increasing drought frequency would lead to yet more severe water deficits, with potentially devastating effects on domestic water supplies, crops, livestock and the environment. Water resources are also vulnerable to pollution within the country or outside its borders, and to miss-management practices in upstream catchments. Luckily, there are options to meet the water deficiency in the future through better utilization of rain fed agriculture, enhanced water harvesting and artificial recharge technology, improved applications of water conservation, enhanced irrigation efficiency, safe utilization of non-renewable groundwater, and in the wise utilization of non-conventional water resources. However, to be able to make use of these opportunities, there should be an up to date knowledge base and well-built capacity in the framework of an integrated water resources management approach.

2.3 WATER RESOURCES INSTITUTIONS IN SUDAN

There are many Ministries, Agencies, and Institutions that have a stake in water resources management and use in Sudan. Generally, there are three levels of government institutional authority; National or Federal level, State level and Local level. At the Federal level the water resources institution responsible for water resources management is the Ministry of Water Resources, Irrigation and Electricity (MWRIE). Prior to 1995, water affairs in Sudan were fragmented between different Ministries and Institutions mostly with conflicting interests and minimum coordination. Realizing this drawback, the Government started in the last decade some major steps for rectifying the situation. One of these major steps is bringing down the responsibility of all the water resources affairs under the umbrella of the Ministry of Water Resources Irrigation and Electricity. Another major step is the formulation of the National Council for Water Resources (NCWR) with the objective of formulating common water resources policies and coordinating the activities of all water sector agencies and stakeholders. The NCWR has the Water Resources Technical Organ (WRTO) as its executing arm. Another major change is the adoption of the Federal system of government through which some of the responsibilities of water resources management were handed to the States and also the irrigated

agriculture to the Ministry of agriculture. The Federal system of Government was a major step towards decentralization. The responsibility of water resources is shared between the Federal government and the State. While the regional and inter-state waters are governed by the Federal government, the local surface and groundwater is the responsibility of the State government. Within the State, the water utilization responsibility is divided between two ministries; the Ministry of Physical Planning and Public Utilities and the Ministry of Agriculture.

2.3.1 Evolution of the Institutional Framework

The responsibility of water resources monitoring, assessment, development and management in Sudan at the independence time (1956) was under the responsibility of the Ministry of Irrigation and Hydroelectric Power which later became the Ministry of Irrigation and Water Resources. Later in 2012, the irrigation part was transferred to the Ministry of Agriculture consolidating the Ministry of Water Resources to be then for overall management of water resources. Less than six months later, that ministry was combined with Electricity and Dams to form the Ministry of Water Resources and Electricity (MWRE). A more recently, irrigation has been brought again back to MWRE to become MWRIE which is entrusted for monitoring, assessment, planning and development of the water resources in the country. These resources include surface water, groundwater, water supply, wastewater treatment sewage and sanitation at the national level. Provision of drinking water at the state level is the responsibility of each state. The organizational structure of the then MWRIE is given in **Figure 2.1**. Three important entities of the 10 units that are directly linked to the Minister's office are:

i. Dam Implementation Unit (DIU).
ii. Water Resources Technical Organ (WRTO).
iii. The Unit of Drinking Water and Sanitation (UDWS).

Because of the importance of the international waters in the country economy, the ministry established the WRTO to be entrusted for that issue. The WRTO is now part of the MWRIE and it was established in 1992 prior to the National Council of Water Resources (NCWR). It was then considered to be the executive body for the NCWR when it was formulated in 1995. Other duties of the WRTO are to prepare and review the legislations, regulations, and management framework of the water sector of the country including the shared waters. Thus the WRTO has close contact with all riparian countries and is responsible for all matters related to bilateral and regional agreements as well as cooperation issues dealing with shared water resources. It also represents the country in negotiations with riparian countries for the realization of joint projects for the development and management of the Nile waters and shared aquifers to achieve mutual benefits. In general, the WRTO is responsible for integration and coordination of all aspects and duties pertinent to water resources assessment, demand, management, and development, especially in shared waters. Other related water Directorates directly under the undersecretary are:

- General Directorate of polices, planning and projects.
- General Directorate of the Nile affairs and dams.

- General Directorate of Groundwater and Wadis.

These directorates perform their activities at the federal level and put plans for better utilization of the available resources. The main objectives are to develop the national resources, supervise the implementation of the infrastructure, operate and maintain the existing structures like dams, and monitor the different usages among the various sectors. The mentioned directorates coordinate the usage of the water resources among the various states especially for the national cross-states surface and ground waters.

On the other side measurement of rainfall and evaporation is the responsibility of the Meteorological Department which is part of the Ministry of Defense till this year where it is transferred to MWRIE. There is coordination between the MWRIE and the Ministries of Agriculture, Environment, Forestry, and Urban Development, Industry, Meteorological authority and related academic and research institutions. A high committee for the utilization and optimization of the Blue Nile waters is formed within the MWRIE to regulate and coordinate between the concerned institutions

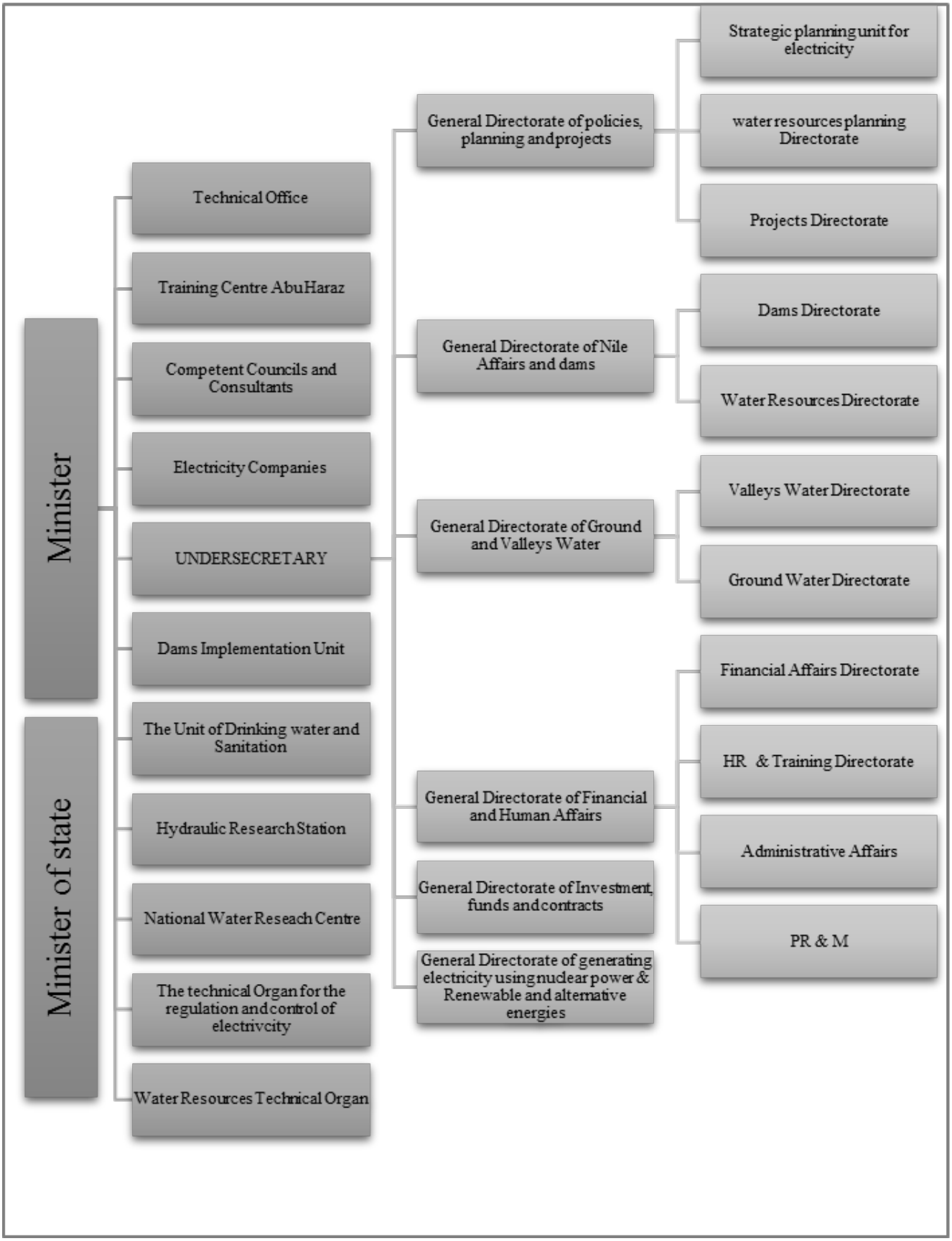


Figure 2.1: *Organizational Structure of the Ministry of Water Resources, Irrigation and Electricity (MWRIE)*

2.3.2 Other Institutions

In addition to the Ministry of Water Resources, irrigation and Electricity and its various entities outlined above, there are other governmental, nongovernmental institutions and private consultancy firms that deal in one way or another with water resources management. The most important of these are:

A) Governmental

- Federal Ministry of Agriculture and Forestry.
- State Ministries of Agriculture, Animal Resources and Irrigation.
- State Ministries of Physical Planning and Public Utilities.
- Federal Ministry of Environment.
- Federal Ministry of Education (Sudan IHP NATCOM).
- Federal Ministry of Higher Education and Scientific Research (Universities and Research centres).
- Sudan Meteorological Authority (SMA).
- Agricultural Research Cooperation.
- Ministry of Foreign Affairs.
- Ministry of Industry.
- Ministry of Health.

B) Non-Governmental Organizations and Private Sector

There is a large number of NGOs and UNOs working in water resources in various parts of Sudan, mainly in water supply and sanitation. Examples of these are Sogia, Islamic Dawa, Sudanese Environmental Protection Association, FAO, UNICEF, UNHCR, UNESCO, UN Environment, IOM, Practical Action, and Plan Sudan.

Examples of well-known private firms working in water resources management are University of Khartoum Consultancy Corporation, Shoura Consultants, Kenana Engineering and Technical Services, NEWTEC Consulting Group, And YAM Consulting Group.

C) Universities and Research Centres

There is big number of Universities and Research Centres that are involved in research in water issues, training for BSc, MSc and PhD in water management as well as professional training. Examples of these institutions are:

1. Water Research Centre, University of Khartoum.
2. Department of Civil Engineering, University of Khartoum.
3. Faculty of Geography, University of Khartoum.
4. UNESCO Chair in Water Resources, Omdorman Islamic University.
5. Water Management and Irrigation Institute (WMII), Gezira University.

6. College of Water and Environment, Sudan University of Science & Technology.
7. Faculty of Engineering, Sudan University of Science & Technology.
8. Water Harvesting Centre, University of Nyala.
9. Faculty of Engineering, University of Nyala.
10. Faculty of Engineering, University of Sennar.
11. Faculty of Engineering, University of Kasala.
12. Faculty of Engineering, University of Red Sea.
13. Faculty of Engineering, Blue Nile University.
14. Regional Centre for Water Harvesting, Ministry of Water Resources, Irrigation and Electricity.

2.4 LEGAL FRAMEWORK

There is no existing one single legal document that governs the development, management and utilization of water resources in Sudan. However, there are different existing water related legislations which can be regrouped into two groups based on the time of their approval (Seifeldin, 2005):

Prior to 1992: the policies and legislations used to appear in each sub-sector (irrigation, hydropower, domestic, etc…) as these sub-sectors were under different institutions. The major part of water resources policy, strategies, plans, development and management used to be the responsibility of the Ministry of Irrigation and Hydropower (now Ministry of Water Resources, Irrigation and Electricity).

Post 1992: A comprehensive review of policies and legislations has taken place, under which the MIWR then embraced most of the sub-sectors, namely policy making and legislations, planning, and coordination of all the water resources. Consequently, the drinking water became the responsibility of the MIWR. This section provides a brief overview of these developments:

The main water regulations in Sudan are based on the 1951 Regulations, which are licensing regulations for pumping water from the Nile according to the Nile Pumps Control Act 1939 (repealed) (ElMufti, 2002). Recent instruments have modified the 1951 regulations; e.g. the Water Resources Act of 1995 (MIWR, 1995). Another major development in the legislation policy is the Irrigation and Drainage Act of 1990, which regulates irrigation and drainage in Sudan. In addition, there are more than forty pieces of legislation which illustrate a variety of different policies that govern the use and protection of water resources of Sudan (Seifeldin, 2005).

2.5 POLICY FRAMEWORK

According to the National Comprehensive Strategy (NCS) of 1992, the irrigation and water resources institution is considered part of the agricultural sub-sector. The economic sector

comprises the agricultural sub-sector and other sub-sectors. The policy objectives and strategies of the water resources institution can mainly be outlined as full and efficient utilization and development of water resources, construction of dams on the Nile and Wadis, addressing the problem of silt in reservoirs , enlargement of existing reservoirs through heightening and construction of new dams, developing water equipment manufacturing industry and developing economic criteria for the utilization of water in such a manner as to maintain a balance between the cost on one hand and the economic and social return on the other.

Bearing in mind the experiences, limitations and lessons learnt from the implementation of the 1992 Water Policy (MIWR, 1992), and taking into consideration future aspirations of the people and the realities of the world around, the 1992 Water Policy was updated in 2000. The National Water Policy draft of 2000 (Eltom et al., 2000) was a single policy document which had to be improved based on the new country developments. The Integrated Water Policy of 2007 (MIWR, 2007) has been developed based on the Transitional Constitution of Sudan, water policies of 1992 and 2000, and macroeconomic policies and development strategies. The formulation of the Water Policy of 2007 was also based on sound water resources assessment, establishment of effective regulatory framework and capacity for enforcement of approved legislations, promotion of the role of women, and creation of incentives for the sustainable use of water resources.

2.6 SUMMARY OF WATER RESOURCES MANAGEMENT PRIORITY AREAS

From the previous discussion a summary of the priority areas that require HCD are:

1. Arid Zone or Dry land hydrology (surface and Groundwater).
2. Water Conservation (water harvesting, Management of aquifer Recharge, demand management, non-conventional water).
3. Watershed Modelling and Management.
4. Strategic water resources planning and management.
5. Hydro-informatics.
6. Hydraulics, River Morphology and Sediment Transport.
7. Climate change Studies (Impacts and Adaptation).
8. Flood and Drought Management.
9. Irrigation Management (irrigated and rain-fed agriculture).
10. Water Supply and Sanitation.
11. Trans-boundary Water Management.
12. Water-Energy-Food-Ecosystem Nexus.
13. Water Economics and Governance.
14. Water Diplomacy and Cooperation.

CHAPTER 3

3 HUMAN CAPACITY DEVELOPMENT GAPS: LITERATURE REVIEW

3.1 CAPACITY DEVELOPMENT IN THE WATER SECTOR: HISTORY AND CURRENT SITUATION

Broadly speaking, several national, regional and international institutions played a role in capacity building and development in the water resources sector in Sudan. The Ministry of Water Resources, Irrigation and Electricity (MWRIE), however, had and continues to be the leading institution and the governing body. Through its lifetime, MWRIE operated under different names combining the responsibilities of water resources management, hydropower and, during most periods, irrigation. Nonetheless, capacity development in the water sector has always been an important part of the Ministry's responsibilities.

Major efforts in capacity development conducted by MWRIE include "The Irrigation School", "Training Unit of MWRIE" and "Knowledge and Skill Transfer". The Irrigation School is a program designed to provide newly recruited technicians and engineers with the required knowledge and skill for their positions. It is intended as a preparatory program that facilitates easy integration of employees into the Ministry work. Training Unit of MWRIE is an administrative unit under the Ministry mandated to facilitate training and development for employees by providing support for engineers and technicians to obtain higher degrees and professional membership. Finally, "Knowledge and Skill Transfer" is an informal yet a powerful capacity development technique in MWRIE where junior engineers and technicians obtain experience and skill from senior individuals on a daily basis.

Furthermore, regional and international institutions have participated over the years in developing human resources for the water sector. Examples of recent regional programs are the Nile Basin Initiative (NBI) program and the IGAD-HYCOS program, meanwhile in the international level, UNESCO-IHE has provided significant training for capacity development. Organizations such as World Bank, OPEC and JICA played a significant role as well by funding rehabilitation projects (e.g. Gezira Rehabilitation Project funded by OPEC) and establishing training centers such as Training Center of the National Water Corporation (NWC) funded by JICA. UN organizations such as FAO, UNICEF, UNESCO, WHO, UNDP, WB, UN Environment and IOM have also provided many opportunities in capacity development. The Water Research Center, University of Khartoum WRC (2017) provides a detailed historical overview of the several training initiatives and programs conducted by different national, regional and international institutions.

In recent years, the number of training, academic and research institutions related to the water sector in Sudan has increased significantly. Examples of such centers are the UNESCO Category 2 center "Regional Center for Water Harvesting" (RCWH), Water Research Center at University of Khartoum, Engineering Training Unit at University of Khartoum and Training Center of UNESCO Chair in Water Resources at Omdurman Islamic University. While the availability of several centers indicates the high potential that can be attained in enhancing the water sector in Sudan including improved capacity development, it also draws attention to the need for collaboration between these different entities. Therefore, identifying key and priority training needs in the field of water resources in Sudan is more than ever needed.

3.2 PREVIOUS EFFORTS IN IDENTIFYING TRAINING NEEDS FOR CAPACITY DEVELOPMENT IN THE WATER SECTOR

Early efforts for identifying training and education needs for personnel in the water sector have been outlined by Salih (1993) where he classified personnel into four categories: Research and Development (R&D) personnel, professionals, technicians and craftsmen. The study identified the required education and training needs for each category in a broad manner.

In 2000, the Ministry of Water Resources Irrigation and Electricity as part of the FAO Regional Project "GCP/RAF/286/ITA" conducted a study in order to formulate a national policy on water resources management. The study defined training needs in the water sector into six key categories and specific areas within each category. Training needs identified in this study are summarized in Table 3.1, while detailed information about training needs is provided in (MIWR, 2000).

Table 3.1: *Top six thematic areas and their sub-categories for training in the water sector in Sudan as defined by the Ministry of Water Resources Irrigation and Electricity (MIWR, 2000)*

Key area	Specific Areas
Strategic water resources planning and development	Integrated water sector master planning, Dry-zone hydrology, Risks and uncertainty in water resources, surface and groundwater storage, conjunctive surface, rain and groundwater use, Efficient water allocation, Disaster management, projects formulation and appraisal.
Management	Upgraded basic management skills, corporate planning and management, economic analysis techniques, financial management, construction management, O&M management.
Information Technology	Management Information system, Geographical information system, Engineering Analysis system, Socio-economic information, environmental information, Environmental Impact Assessment.
Water Resources Assessment	Water resources procedures and guidelines, Hydrometeorological monitoring.

Key area	Specific Areas
Natural Resources and Environmental Management	Environmental monitoring, Environmental Impact Assessment, Integrated ecosystem management, Environmental protection and conversation.
Research & Development (R&D)	Develop cost effective and appropriate technologies for efficient water use, treatment and sound research into environmental techniques procedure including potential climate change and its impact on water resources.

According to this study, the total numbers of personal of the MWRIE that need to be trained on each appropriate area for different training periods projected up to year 2020 are given in Table 3.2

Table 3.2: *Total number of personnel of the MWRIE to be trained up to year 2020*

DESCRIPTION	NUMBER
- Long term (more than 6 months) - Medium term (3 – 6 months) - Short term (1 - 3 month) - Workshops, seminars, and conferences (1-2 weeks)	444 1076 1800 2500

In 2013 UNESCO Cairo Office UCO in collaboration with WRC organized a workshop on Water Sciences for Peace and Sustainable Development in the Eastern Nile: Perspective of Future Cooperation within the framework of the UNESCO's International Hydrological Program (IHP) project on "Water Sciences for Peace and Sustainable Development in Africa" (UCO, 2013). A plenary session was organized in which representatives from the four Eastern Nile countries (Sudan, Egypt, Ethiopia and South Sudan) identified key areas where HCD is needed which are summarized as follows:

- Climate change, conjunctive use of groundwater and surface water.
- Benefit sharing in transboundary water management.
- Water sanitation and hygiene.
- Water harvesting and management of groundwater recharge.
- Water quality management.
- Data acquisition, management and dissemination with emphasis on GIS/RS applications.

One of the workshop recommendations was to conduct a training needs assessment for each country to define training priorities and gaps.
(UCO, 2013)

As a follow up to the workshop recommendation, the Water Research Center at University of Khartoum, sponsored by UNESCO Cairo Office, conducted a comprehensive study to identify training needs in the water sector in Sudan. The study brought together

professionals from a wide variety of institutions including the Ministry of Water Resources, Irrigation and Electricity and its various units, other ministries such as the Ministry of Agriculture, Animal Resources and Irrigation of Khartoum State and the Ministry of Health as well as academic and research institutions, NGOs and private sector (Abdo, 2013). The study predefined seven main training categories with each consisting of several sub thematic areas. Data from questionnaires were analyzed to define the main three sub thematic areas within each of the seven categories; detailed results of the questionnaires are reported in Abdo (2013). Furthermore, the study defined top ten priority areas (Table 3.3) that should be the focus of future training in the water sector in Sudan.

Table 3.3: *Top Ten Priority Areas For Training In The Water Sector In Sudan As Defined By Abdo (2013)*

Thematic area	Strategic goals
Design and evaluation of hydrological networks (monitoring networks)	To enhance data collection for sustainable management and development of water resources
Hydrological characteristics of arid zones	To provide better understanding of wadi systems and wadi water resources management
Groundwater water resources assessment, development and management	To provide knowledge base for groundwater resources for sustainable use
Enhancement of irrigation water use efficiency	To provide tools for best irrigation practice for improved productivity and food security
Water quality analysis and standards	To set standards for water quality for the different uses and reduce health complications resulting from use of unsafe water
Environmental impact assessment of water projects	To provide tools for judgment of suitability of water projects to safe guard the environment and enhance sanitation development options
GIS and Remote sensing applications in water resources management	To introduce state of the art technology in water management and enhance the use of available spatially distributed RS and GIS database in water management
Sediment management in reservoirs and irrigation schemes	To prevent silting up of reservoirs and irrigation networks thus saving huge financial resources
Design and management of water harvesting systems	To better manage water supply to improve water availability and enhance food security specially for rural areas

In 2017, a study was conducted by the WRC to identify water sector training needs with specific reference to attaining Goal 6 of the Sustainable Development Goals (SDGs): and the themes of UNESCO IHP-VIII (Abdo, 2017). The study found that there are interdependencies between the objectives of both SDG6 and IHP-VIII; these interdependencies can be summarized in six overarching themes that define training needs in the water sector in Sudan. Figure 3.1 shows the linkages and interdependencies between the targets of SDG6 and the themes of IHP-VIII which can be summarized in 6 main themes for training. **Table 3.4** summarizes the final results of this study.

.

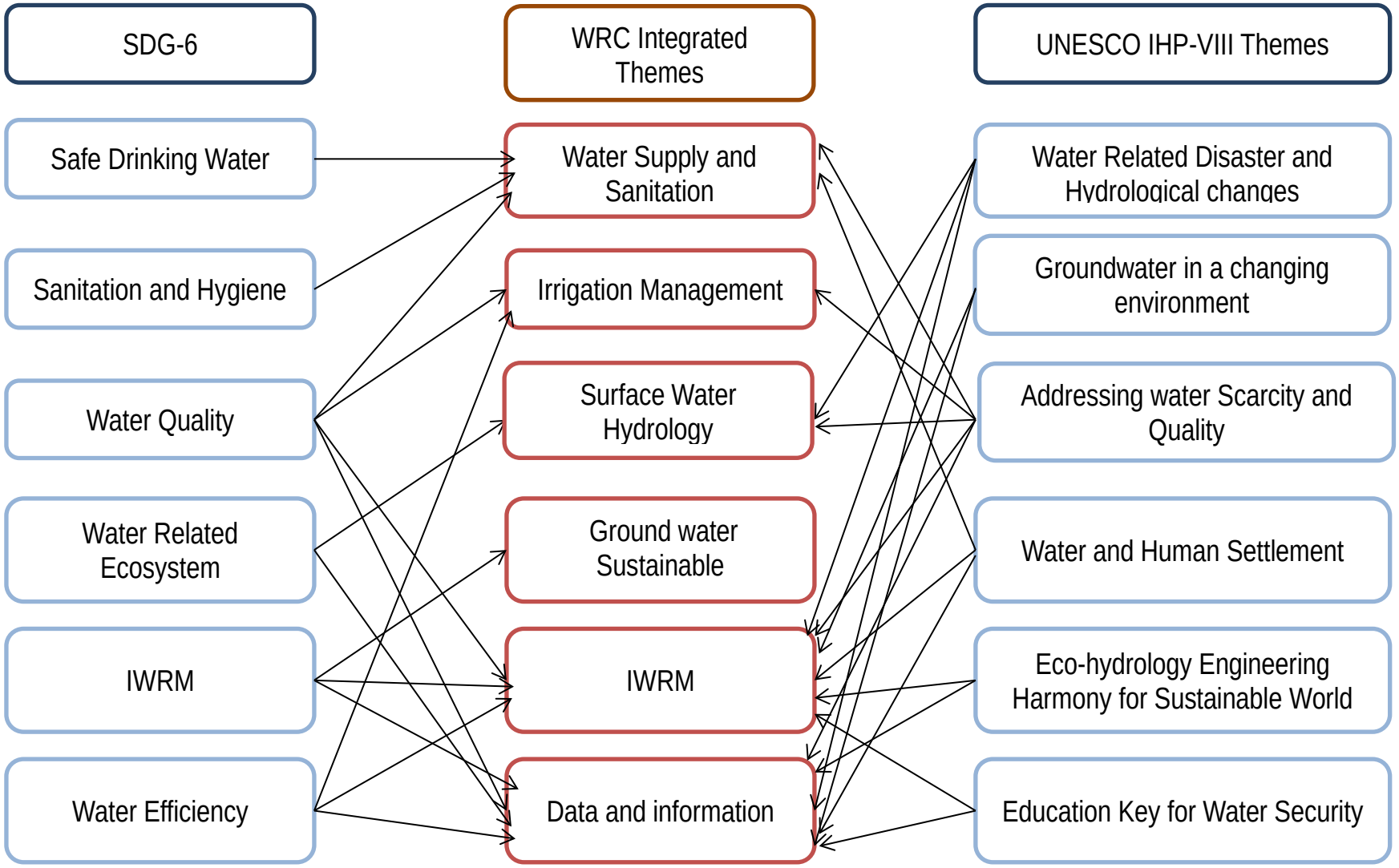


Figure 3.1: *Linkage and Interdependencies between the Sustainable Development Goal (SDG) 6 and the Themes of IHP-VIII*

Table 3.4: *Final Results of the TNA in The Form Of Suggested Training Modules*

Suggested training modules	Covered contents	Target audience
Theme 1: *Water Supply and Sanitation*		
Water, sanitation and hygiene (WASH)	Planning, design, operation and maintenance of water supply systems (source, treatment and distribution)	Water professionals, and researchers
	Drinking water quality standards and analysis methods	
	Water, sanitation and hygiene (WASH)	Water professionals, researchers, NGOs
	Waste water treatment and reuse	
Theme 2: *Irrigation Management*		
Design and management of Irrigation Systems	Modern Irrigation Techniques	Irrigation practitioners and private sector professionals
	Design of irrigation systems	
	On-farm irrigation water management	
	Estimation of Crop Water Requirements	
	Enhancing irrigation water use efficiency	Irrigation practitioners, researchers, and private sector professionals
	Improving productivity of Rain-fed agriculture	
	Calibration of irrigation control structures	
Theme 3: *Surface Water Hydrology*		
Surface water resources assessment and management	Rainfall-runoff modelling and hydrological forecasting	Water professionals, and researchers
	Arid Zone or Wadi Hydrology	
	Design of Small Dams in Wadi systems	Water professionals, researchers, NGOs
	Design, operation and Management of water harvesting systems	
Theme 4: *Groundwater Sustainable Management*		
Groundwater modelling, design, and operation	Ground water protection and remediation	Groundwater professionals, researchers, private sector practitioners
	Sustainable Management of non-renewable aquifers	
	Groundwater modeling	
	Well design, construction, operation and management	

Theme 5: *Integrated Water Resource Management*		
Public awareness and community participation for sustainable watershed management	Public Awareness & Community Participation in Water & Environmental management	Water resources professionals, researchers, Socio-economists, Community leaders
	Water-Energy-Food security Nexus	
Climate change impact: adaptation and resilience	Climate change impacts on water resources & adaptation measures	Water resources professionals and researchers
	Echo Hydrology and Echo-system Management	
Water diplomacy and transboundary cooperation	Trans-boundary water resources management	Water resources professionals, researchers, and institutional representatives (such as media, law, hydro-politics, socio-economics)
	Legal aspects of water resources management	
Theme 6: *Data Acquisition and Management Tools*		
Hydroinformatics and data management	Remote Sensing and GIS in Water Resources Management	Water & IT professionals, researchers, meteorologists
	Data management (processing, storage, retrieval, & dissemination)	
	Design of surface and groundwater monitoring networks	Water professionals, researchers, meteorologists, technicians
	River flow measurements	

Chapter 4

4 CONSULTATION WORKSHOP

On 29th September 2018, the Water Research Center organized a consultation workshop with the general objective of establishing a national Human Capacity Development (HCD) Programme addressing training needs of junior professionals and technicians in the water sector of the Sudan. The specific goals of the workshop were to identify three priority research modules for each of the two groups of starting professionals (engineers) and technicians.

4.1 WORKSHOP SETUP, FORMAT AND PARTICIPATION

Selection of participants in the consultation workshop was performed to ensure that key Sudan water Sector stakeholders are represented. Participants came from academic and research institutions (e.g. Water Research Center at University of Khartoum, UNESCO Category II center "Regional Center for Water Harvesting", UNESCO Chair in Water Resources in Omdurman Islamic University), governmental agencies and ministries such as various units of the Ministry of Water Resources, Irrigation and Electricity (e.g. Dams Implementation Unit (DIU), Drinking Water and Sanitation Unit), NGOs, UNOs (UN Environment) as well as private sector (KETS). A list of participants and their affiliations is provided in **Annex 1.**

The workshop commenced with a short lecture by Professor Gamal Abdo, the Director of the Water Research Center at University of Khartoum, to provide a background on the AU-NEPAD Centres of Excellence, ACEWATERII project and a summary of the workshop objective as well as previous efforts conducted to identify training needs in the water sector in Sudan. The goal of providing a brief description of previous efforts is to take full advantage of the available literature in training needs assessment. The lecture was followed by a fruitful discussion regarding issues that should be taken into consideration before starting the exercise of identifying training needs. Issues that have been raised include:

- Discussion about the existing national policies that organizes the training of individuals in the water sector in Sudan. Such policies might have been formulated by agencies related to education and training of individuals such as the Ministry of Higher Education and Scientific Research and the Ministry of Water Resources, Irrigation and Electricity. The main goal of this discussion was to make sure that if such policies exist, then training needs shall be defined such as to conform to the guidelines of these general governmental policies. The primary outcome of the discussion was that there is a lack of comprehensive national policies regarding the training of personnel involved in the water sector (engineers and technicians).

- Discussion about the criteria used to identify the top three training priorities for each targeted group (starting professionals and technicians). Some participants were concerned that in the absence of clear criteria regarding the selection of training needs, experts will be biased towards the selection of thematic areas that are related to their field of expertise. Suggestions for selection criteria brought by participants include giving higher priority to cross-cutting thematic areas that permeates to most if not all other thematic areas. An example of such thematic areas is "Data Acquisition and Information Management" as it is a key area for all categories of water resources management including urban surface water drainage, groundwater management, irrigation, water supply and sanitation and integrated water resources management. Another suggestion was to assign higher priority to thematic areas that suffer from a lack of skilled human resources and are of importance to the daily life of residents in Sudan. These areas include water supply and sanitation with specific focus on pumps and water intakes as well as a focus on urban storm water drainage, an issue of great importance to major cities in Sudan, specifically Khartoum.

In order to conduct the training needs assessment exercise, participants were divided into two groups: the first group goal is to identify three training priority needs for starting professionals and engineers meanwhile the second group is to identify three training priority needs for technicians. The two groups have also been asked to discuss related issues such as the challenges facing training of individuals as well as institutions that can host the suggested training modules.

4.2 OUTCOMES OF THE CONSULTATION WORKSHOP

4.2.1 Training Needs Assessment for Starting Professionals

- **Definition of targeted group:** The participants of the consultation meeting defined starting professionals as those who have a bachelor's degree with less than 5 years of related experience, from any discipline related to water resources and have interest to continue working in the water sector whether they have a M.Sc. degree or not.
  Disciplines related to water resources include Civil, Chemical, Agricultural, Water, Environmental and Irrigation Engineering, Hydro-geology, Chemistry, Biology, Water Sanitation and Hygiene (WASH), Agriculture, Water Economics, Water Diplomacy, Water Governance, Geography and Remote Sensing.

- Challenges facing the training of starting professionals in the water sector in Sudan include:

- Lack of clear government training policies related to water. However MWRIE offers an orientation period for their new staff.
- High rate of brain drains.
- Great expansion in graduates from different universities, with little focus on practical knowledge and related courses and a disregard to addressing the actual market needs. Lack of specializations in universities in specific tracks of water.
- Suggested Training period: (1-2 weeks); agencies should release their employees for training during this period, and from previous experiences any period longer than this the participants will lose focus.
- Priority training areas for starting professionals as recommended during the consultation meeting are given in Table 4.1 together with the rationale behind selection and the subcomponents of the themes.

Table 4.1: *Top Three Training Needs for Starting Professionals As Identified By Stakeholders in the Consultation Workshop*

Rank	Training Theme	Rationale	Sub components
1	Data Acquisition in Water Resources Management	Hydrological information is essential for planning design and management of water resources systems. Deterioration of monitoring networks, lack of data and poor quality of existing data are major constraints. Open sources data provide a good opportunity for data acquisition. There is lack of capacity in this area and training of professionals is needed.	a. Surface and groundwater monitoring networks b. RS/GIS and open source data c. Data management, storage, Preservation, Dissemination and Utilization. d. Data analysis and interpretation.
2	Water Sanitation and Hygiene.	Diseases arising from poor quality water and sanitation are major causes of mortality worldwide. Diseases burden could be effectively reduced by improving water, sanitation and hygiene. Historical background show that improving water, sanitation and hygiene is most effective than medical intervention.	a. Water, sanitation and hygiene (WASH) concept. b. Planning, design, operation and maintenance of water supply systems. c. Drinking water quality standards and analysis methods. d. Low cost wastewater treatment technologies. e. On-site waste water treatment systems and pollution control. f. Waste water treatment and reuse.

3	Integrated Water Resources Management	Traditionally, water management in Sudan is taking place in a rather uncoordinated and fragmented institutional approach. Integrated Water Resources Management (IWRM), as a more flexible and comprehensive approach, is now widely recognized as the most strategic approach and preferred way to deal with the various challenges of water resources management. WRC as a multi-disciplinary capacity building institute, training and capacity building in IWRM is one of the priority areas of the WRC. The basic knowledge on IWRM will be disseminated to young professionals	a. IWRM Concept b. IWRM and Social Dimension c. IWRM and Economics d. IWRM and Ecosystems e. River Basin Planning and Management f. Water Law and Policy g. Water Policy and Regulation h. Stakeholder Participation i. Water diplomacy and cooperation. j. Water governance

4.2.2 Training Needs Assessment for Technicians

- **Definition of targeted group:** Technicians are those who have an academic degree of 2-3 years after high school regardless of their age and rank in their agencies (either early or mid-career), however, those who satisfy the education requirements in this definition but are in high management levels are excluded from this definition.

- Challenges facing the training of technicians in the water sector in Sudan include:
  - Lack of training institutions that provides high quality training for technicians.
  - Lack of national policy regarding employment of technicians; examples of this includes strict job requirements where applicants are required to have a high university degree in order to be employed as well as low salaries for technicians.
  - Lack of legislations.
  - Lack of capacity building policies and programs.

- Suggested institutions to host training modules for technicians in the water sector:
  - Engineering Training Unit, Faculty of Engineering, University of Khartoum.
  - Training Center of UNESCO Chair in Water Resources in Omdurman Islamic University.
  - Training Center of the Water National Corporation (NWC).
  - Water Research Center at University of Khartoum.
  - Training Center at Hydraulic Research Station at the Ministry of Water Resources and Electricity.
  - Department of Civil Engineering, Sudan University of Science and Technology.

- Priority training areas for technicians as recommended during the consultation meeting are given in Table 4.2 together with the rationale behind selection and the subcomponents of the themes.

Table 4.2: *Top Three Training Needs For Technicians In The Water Sector Field.*

Rank	Training Theme	Rationale	Sub components
1	Data Acquisition in surface and ground water.	Availability of information is of great importance to water resources management and decision-making, therefore, accurate measurement and sampling techniques are highly needed.	a. Flow and velocity measurement. b. Suspended and bed load sediment measurement. c. Bathymetric survey. d. Water quality measurement. e. Groundwater water table. f. Well pumping test.
2	Construction and Installation, Operation and Maintenance in Urban surface drainage.	Current situation of storm water drainage structures in major cities in Sudan has deteriorated significantly. Thus, the importance of training of technicians and capacity building in construction and operation of urban surface drainage structures and networks.	a. Drainage channels. b. Road drainage. c. Pumping stations. d. Intake structures in water supply systems. e. Screens and pumps. f. Water harvesting structures maintenance.
3	Water quality monitoring and analysis.	Ensuring that water quality is in accordance to international standards is of great importance to attain high standards of health. Thus, technicians have to be highly qualified in water quality sampling and testing both in the field and laboratory.	a. Field measurement and sampling techniques. b. Preservation and transportation of samples. c. Laboratory tests.

4.3 ADDITIONAL RECOMMENDATIONS

The main recommendation of the consultation workshop, in addition to the key training areas identified for each targeted group, is that there are similarities in the areas of training for both targeted groups. Therefore, it is important to identify within each thematic training area, the components that belong to professionals and engineers on one hand, and technicians on the other hand.

Most participants also proposed that training programs might consist of two parts, one for technicians and the second part for professionals. Overall, coordinating the organization of training programs for both targeted groups is very essential to develop effective training programs that address the needs of Sudan in the water sector.

CHAPTER 5

5 VALIDATION WORKSHOP

5.1 INTRODUCTION

The third document submitted to UNESCO IHP covered the TOR activity (3) "Designing a national framework for HCD in Sudan". **Figure 5.1** represents a broad framework of the six training courses for the "starting professionals" and "technicians" following the priority areas endorsed by the core stakeholders during the consultation workshop of 29th September 2018 and reported in the Sudan Desk Study of October 2019. As a final step to complete the study a validation workshop for the developed framework was conducted in the 9th of March 2019 in which a wide range of stakeholders covering various specializations and organizations participated in the validation process. The specific goals of the workshop were to review, update and validate the developed three priority training modules for each of the two groups, and to agree on a strategy for the implementation, monitoring and evaluation, and sustainability of the training programs.

5.2 WORKSHOP SETUP, FORMAT AND PARTICIPATION

Selection of participants in the validation workshop was performed to ensure that key stakeholders of the water sector in Sudan are represented. Participants came from academic and research institutions, governmental agencies and ministries, NGOs, UN representatives as well as the private sector. A list of participants and their affiliations is provided in **Annex 2**. while the workshop agenda is given in **Annex 3**. It is to be noted that most of the participants of the consultation workshop held in September 2018 were present in the validation workshop, in addition to other key specialists from the water sector.

The workshop commenced with a presentation by Professor Gamal Abdo, the project coordinator to provide a background on the AU-NEPAD Centres of Excellence, ACEWATERII project with focus on the HCD component, and a summary of the workshop objective as well as efforts conducted to establish a HCD framework targeting starting professionals and technicians in the water sector in Sudan. This was followed by six presentations on the details of the established training modules as well as a seventh presentation on the recommended monitoring and evaluation approach. In order to have an in depth discussion on the established HCD programs, participants were divided into two working groups. The first group goal is to review the details of the three training modules for starting

professionals, while the second group is to review the three training modules for technicians. The group leaders were of the two working groups were then allowed to present the outcome of the discussion in their sessions to the joint meeting as given below.

5.3 MAIN OUTCOME OF THE WORKING GROUPS

5.3.1 Working Group (1): Training Courses for Starting Professionals:

The main points raised during this working group session for each of the three courses are:

A. Integrated Water Resources Management IWRM

- The course material should be simple without too much technical details bearing in mind that the course will draw participants from different water related institutions.
- The topics on stakeholder participation and gender role in IWRM could be included to the section on principles of IWRM and should be briefly introduced.
- Participants from the disciplines of political science, social science and law should be included in the target group.
- An introduction on water policies, strategies and plans should be included in the module.
- Water governance issues should be introduced.
- Sections on groundwater management and groundwater monitoring should be included since groundwater is an important resource in Sudan.
- A section on water balance over a basin should be included in the hydrology section
- Include to the target group participants from NGOs, governmental, non-governmental agencies and private sector.
- There should either be a specific topic on Water Policy in legislation or at least address that to a significant degree in this module.
- National Water Policy is essential to IWRM. There is a need to look at other sector policies as well including environmental, agriculture, forestry, mining….
- Implementation of the module should be geared towards achieving the Sustainable Development Goals (SDGs).

B. Water Supply Sanitation and Hygiene (WASH)

- Include the algae aspects in the biology and microbiology section.
- Water leakage and leakage detection and measuring devices should be introduced.
- Advanced treatment methods should be introduced as well as desalination.
- More emphasis should be given to practical aspects and practical work could be distributed according to the topics.

- Response to disease outbreaks, such as cholera and setting up water and sanitation protocols for temporary response centres should be included.

C. Data Acquisition and Analysis in Water Management

- A section to raise the awareness of the participants on the importance of data and data challenges should be included.
- Some open source data websites should be shared with the participants.

5.3.2 Working Group (2): Training Courses for Technicians:

The main points raised during this working group session for each of the three courses are:

A. Data Acquisition in Surface and Groundwater

- Include a section on field report writing methodology.
- Include a section on trouble shooting during measurements.
- Include a section on data transmission systems.

B. Construction, Installation, Operation and Maintenance of Urban Surface Drainage Structures and Networks

- More focus on the practical aspects.
- Include a section on operation in emergency situations.
- Briefly discuss safety measures.
- Include operation and maintenance of water harvesting structures.
- Introduce concrete repairing in drainage structures.
- Introduce some manuals.

C. Water & Wastewater Quality Monitoring and Analysis

- More focus on practical aspects, exercises and discussion.
- Add a section on sampling protocol.
- Add a section on contingency planning.
- Focus on site visits to waste water treatment plants to understand the challenges.

5.4 GENERAL DISCUSSION, REFLECTIONS AND RECOMMENDATIONS FROM THE WORKSHOP

1. Participants highlighted the disturbing gap in experienced professionals and qualified technicians in the water sector and emphasized the urgent need for training and capacity building as a fundamental requirement for achieving proper water resources management.
2. The role of AU-NEPAD in addressing capacity gap was greatly appreciated.
3. Partnership between training institutions and water stakeholders is important and should be established together with coordination mechanism geared towards strengthening the HCD program. Such partnerships will help in bridging the capacity gap that exists for both junior professionals and technicians.
4. There is a lack of comprehensive national policies regarding the training of personnel involved in the water sector (engineers and technicians).
5. There is no clear and unified definition of the target groups of young professional and technician within the stakeholder institutions; however, the definition adopted within this study is acceptable.
6. A training strategy should be established in coordination with the stakeholder institutions which includes the numbers to be trained, how many time a course is repeated and the phasing of these course within the time horizon 2020-2030, and the courses should be geared towards achieving the sustainable development goals.
7. The enabling environment should be enhanced to avoid brain drain despite the fact that there is great expansion in graduates from different universities.
8. Stakeholders within State governments should be targeted as the capacity gaps within the states are bigger.
9. The training could start at national level; however, participants from the neighboring countries could be enrolled at a later stage.
10. Monitoring and evaluation is essential to assessing how the training course is achieving its stated objectives and targeted outcomes. The proposed framework suggested which included pre-course assessment, coursework, post-course assessment and continuous monitoring is adequate. However, assessment outcome of the monitoring and evaluation should regularly be summarized in formal assessment report (possibly every two years).
11. The issue of including the training modules within existing MSc programs was raised. Since the University process takes time for any changes to be made in existing programs, it was agreed to offer the courses initially as standalone courses. However, MSc students could take some of the courses as optional modules and a certificate issued by the University will be given.
12. Sustainability of the HCD program is crucial. To ensure sustainability, adequate financial support is required from the government and donors. State agencies such as the National Council for Training could be approached. Also regional agencies such as the Nile Basin Initiative (NBI) and IGAD could be approached.
13. It was recommended to prepare a budget for the implementation of the HCD program. An initial estimate of 500,000 USD is made which includes some supporting equipment.

5.5 RESPONSE TO COMMENTS

All the comments that have been raised during the validation workshop were taken into consideration in the draft final report as can be seen in chpters 5,6 and 7.

Annex C gives some of the documentation photographs of the validation workshop.

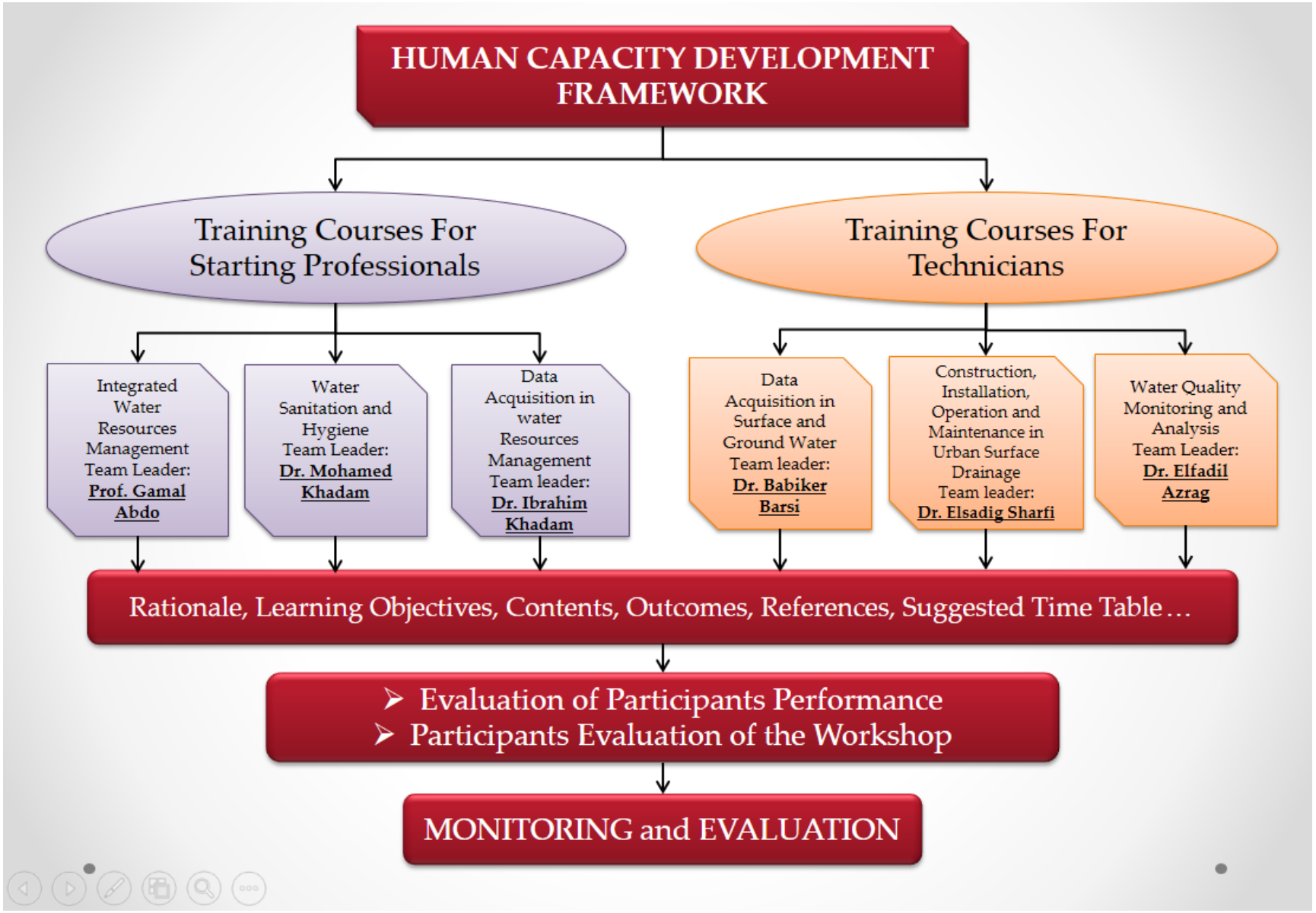


Figure 5.1: *Human Capacity Development Framework*

CHAPTER 6

6 TRAINING COURSES FOR STARTING PROFESSIONALS IN THE WATER SECTOR

6.1 TRAINING COURSE IN INTEGRATED WATER RESOURCES MANAGEMENT

6.1.1 Introduction

Sudan is currently facing considerable technical, social, economic and environmental challenges related to water management. Traditionally, water management in Sudan is taking place in a rather uncoordinated and fragmented institutional approach. Increasing demand for various uses, climate change as well as the need to sustain healthy environment call for a more detailed and holistic approach to managing water resources. Integrated Water Resources Management (IWRM), as a more flexible and comprehensive approach, is now widely recognized as the most strategic approach and preferred way to deal with the various challenges of water resources management. According to the conducted needs assessment study, there is a lack of capacity in Sudan to manage water resources in an integrated manner as well as a clear lack of knowledge among starting water professionals freshly graduating from civil engineering and related water departments on the concept and importance of IWRM. Accordingly, a training course on IWRM for starting professionals has been identified as one of the top priority capacity building area in Sudan.

One of the main mandates of the Water Research Centre, Faculty of Engineering, University of Khartoum is to encourage and support IWRM implementation in Sudan and enhance the national capacity in this crucial area through research and capacity building programs. In this context, the Centre is intending to offer a training course in IWRM to starting professionals in the water sector within the framework of the HCD component of the ACEWATER2 project of the AU NEPAD Centers of Excellence in Water Science.

6.1.2 Objectives of The Course

The objectives of the course are as follows:

1. To provide the participants with a sound foundation in the fundamental concepts of IWRM.

2. To develop the ability of the participants to formulate, solve and analyze water resources management problems in a holistic manner and to prepare them for their career as successful water professionals.
3. To provide the participants an opportunity to work together as part of an inter-disciplinary team.
4. To produce professionals with interdisciplinary knowledge and skills and capacity to respond to emerging challenges in water resources management and provide them with the ability to discover, apply, and solve increasingly complex water and environmental problems.
5. To prepare professionals capable of operating and managing water projects through well understanding of the available water resources, appropriate technology, and the socioeconomic and environmental aspects of the water projects.
6. To prepare the starting professionals for the necessity of life long continual seeking of new information and skills.

6.1.3 Learning Outcomes

1. An ability to understand the impact of water and water related issues in a global context and apply a holistic approach, methodologies and techniques to the field of Water Resources Management.
2. An ability to formulate and analyze water resource system components or processes to meet desired needs within realistic constraints such as environmental, socio-economical, water governance, political, legal, ethical, health and safety, and sustainability.
3. An understanding of professional, institutional arrangements, legal and ethical issues, and responsibilities as they pertain to water resource management.
4. An ability to use the techniques, skills, and modern modeling software tools necessary for water resource planning and management.

6.1.4 Training Period

10 working days (2 weeks) including exercises and group work on specific issues of IWRM.

6.1.5 Suggested Topics

- Principles of Integrated Water Resources Management.
- Introduction to Surface and Groundwater Hydrology.
- IWRM and Ecosystem
- Socio-economic aspects of IWRM.
- Legal Aspects of Water Resources Management.
- Water diplomacy and cooperation.

- Water Supply, Sanitation and Hygiene (WASH).
- Environmental Impact Assessment.
- Workshop: General issues in Integrated Water Resources Management.
- Exercises and Group work.

6.1.6 Brief Outlines of the Topics

1) Principles of Integrated Water Resources Management

- Definition of IWRM within the broader context of development.
- Complexity and key elements of the IWRM process.
- IWRM principles: social equity, economic efficiency and environmental sustainability.
- Socio-economic, legal and environmental aspects of IWRM.
- Stakeholder Participation in IWRM.
- Gender Role in IWRM.
- Important conditions for implementing IWRM.
- Challenges of IWRM implementation.
- River basin organizations and their role in IWRM implementation in trans-boundary rivers.

2) Introduction to Surface and Groundwater Hydrology

- The hydrologic cycle and associated physical processes (rainfall, evaporation, evapotranspiration, infiltration).
- Precipitation analysis and determination of aerial rainfall, rainfall frequency, intensity duration, frequency analysis and extreme values of precipitation.
- Land and water interaction including infiltration and soil moisture in the unsaturated zone.
- River flow analysis including flood frequency analysis and flow duration curves and draught frequency analysis.
- Rainfall-runoff relationships.
- Fundamentals of Groundwater hydrology, types of aquifers, equations governing GW flow, boundary conditions.
- Groundwater management, groundwater recharge, groundwater contamination, sea-water intrusion, surface groundwater interaction.
- Well technology.

3) IWRM and Ecosystem

- Principles of natural ecosystems and benefits to the society.
- Wetland and river flood plain ecology.
- Ecosystem services.
- Economic instruments for ecosystem valuation.

- Ecosystem sustainability and management.
- Environmental governance.

4) Socio Economics Aspects of IWRM

- An introduction about the key socio-economic aspects and issues and linkages with different environmental issues.
- Socio-cultural aspects of water use, e.g. attitudes, perceptions, values, and indigenous systems of knowledge.
- Economic aspects of water use, e.g. resource valuation and pricing, cost recovery and pricing, economic rights to water, optimal water use and efficiency, cost benefit analysis.
- Other socio-economic issues: gender and equity, access to water; demographic and spatial issues, stakeholder involvement, role of government and NGOs, water user groups, participatory methodology.

5) Legal Aspects of Water Resources Management

- Definition, Uses, and Challenges of International Watercourses.
- Evolution of Water Law on the Global, Regional and Basin-Level.
- Main Principles of International Water Law.
- Role of Law in Water Management.
- Water policy, strategy and plan.
- River Basin Organizations.
- Tools and approaches for trans-boundary water management.
- Trans-boundary water Issues of the Nile River Basin.

6) Water, Sanitation and Hygiene (WASH)

- Water, sanitation and hygiene (WASH) concept.
- Drinking water quality standards and analysis methods.
- Wastewater treatment technologies.
- Solid waste management.
- UNICEF Wash program in Sudan.

7) Water Diplomacy and Cooperation

- Introduction to the theory of water cooperation and diplomacy.
- International water laws and conventions.
- Mediation and negotiation concepts and skills in trans-boundary water resources management.
- Conflict analysis and dispute resolution mechanisms in trans-boundary water issues.
- Cases of successful trans-boundary cooperation.

8) Environmental Impact Assessment (EIA) of Water Resources Development

- Water resources development and environmental issues.
- Environmental regulations and requirements.

- Environmental Impact Assessment in Project.
- Methods of EIA.
- Environmental policies (agricultural, forestry and mining).
- Environmental Management Plan.

9) <u>Workshop: General issues in Integrated Water Resources Management</u>

- River Basin Planning and Management.
- Impact of climate Change on integrated water resources management.
- Water-Energy-Food-Ecosystem Nexus (WEFE).
- Water Induced Disasters and Risk Management.

6.1.7 <u>TRAINING METHODS</u>

Presentations, discussions, exercises, workshops, case study, group work.

Table 6.1: *Contact hours for IWRM Course*

Topic	Time (Hours)
Introduction to Surface and Groundwater Hydrology	10
Principles of Integrated Water Resources Management	10
Socio-economic aspects of IWRM	6
Legal Aspects of Water Resources Management	4
Water Supply, Sanitation and Hygiene (WASH)	4
Water diplomacy and cooperation	4
Stakeholder Participation in IWRM	4
Gender Role in IWRM	2
Environmental Impact Assessment for water resources development	4
Workshop : General issues in Integrated Water Resources Management	6
Exercises	6
Case Study: Group work	6
Total	**60**

Table 6.2: *IWRM Time Table*

WEEK 1					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Introduction to Surface and Groundwater Hydrology	Introduction to Surface and Groundwater Hydrology	Principles of Integrated Water Resources Management	Principles of Integrated Water Resources Management	Socio-economic aspects of IWRM
10:30 - 11	**break**	**break**	**break**	**break**	**break**
11 - 1	Introduction to Surface and Groundwater Hydrology	Introduction to Surface and Groundwater Hydrology	Principles of Integrated Water Resources Management	Principles of Integrated Water Resources Management	Socio-economic aspects of IWRM
1 - 1:30	**break**	**break**	**break**	**break**	**break**
1:30 - 3:30	Introduction to Surface and Groundwater Hydrology	Exercises	Principles of Integrated Water Resources Management	Exercises	Socio-economic aspects of IWRM

WEEK 2					
Day/ Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Legal Aspects of Water Resources Management	Water Supply, Sanitation and Hygiene (WASH)	Environmental Impact Assessment for water resources development	Workshop : General issues in Integrated Water Resources Management	Case Study: Group work
10:30 - 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Legal Aspects of Water Resources Management	Water diplomacy and cooperation	Environmental Impact Assessment for water resources development	Workshop : General issues in Integrated Water Resources Management	Case Study: Group work
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Water Supply, Sanitation and Hygiene (WASH)	Water diplomacy and cooperation	Exercises	Workshop : General issues in Integrated Water Resources Management	Case Study: Group work

6.1.8 References

[1] Rahaman, M.M. & Varis, O. 2005. Integrated water resources management: evolution, prospects and future challenges. Sustainability: Science, Practice, & Policy1(1):15-21. Published online April 12, 2005.

[2] Biswas,A.K.,Varis,O. & Tortajada, C. (Eds.) 2005. Integrated Water Resources Management in South and Southeast Asia. New Delhi : Oxford University Press.

[3] GWP/INBO (2009), Handbook for IWRM in Basins [1]

[4] Hornberger, G.M., Raffensberger, J.P., Wiberg, P.L., and Eshleman, K.N, 1998, Elements of physical hydrology. Johns Hopkins University Press, Baltimore, 302p

[5] Linsley, R.K. et al., 2000, Hydrology for Engineers –McGraw Hill So.

[6] Freeze, A. and Cherry, 1979, Groundwater hydraulics, Academic Press.

[7] Sharma, N.P., 1996, African Water Resources: Challenges and Opportunities, World Bank Technical Paper No. 331

[8] Abdel Mageed, Yahia, Environmentally Sound Water Management and Development, 9 Intl. J. Water Resources Dev. 155 (1993).

[9] Barreira, Anna, The Participatory Regime of Water Governance in the Iberian Peninsula 28 Water Intl. 350 (2003).

[10] Bauer, Carl J., Siren Song—Chilean Water Law as a Model for International Reform (Resources for the Future, 2004).

[11] Berkoff, Jeremy, A Strategy for Managing Water in the Middle East and North Africa (World Bank, 1994).

[12] Biswas, Asit K., Cesar Herrera Toledo, Héctor Garduño Velasco & Cecilia Trotajada Quiroz, eds., National Water Master Plans for Developing Countries (Oxford Univ. Press, 1997).

[13] Boisson de Chazournes, Laurence, & Salman M. A. Salman, eds., Water Resources and International Law (Martinus Nijhoff Publishers 2005).

[14] Bosnjaovic, Branko, UN/ECE Strategies for Protecting the Environment with Respect to International Watercourses: The Helsinki and Espoo Convention, in International Watercourses—Enhancing Cooperation and Managing Conflict, World Bank Technical Paper No. 414 (Salman M. A. Salman & Laurence Boisson de Chazournes, eds., World Bank 1998).

[15] Bradlow, Daniel, Alessandro Palmieri & Salman M. A. Salman, Regulatory Frameworks for Dam Safety—A Comparative Study (World Bank 2002).

[16] Braga, B. P. F., Integrated Urban Water Resources Management: A Challenge into the 21st Century, 17 Intl. J. Water Resources Mgmt. 4 (2001).

[17] Dinar, Ariel, ed., The Political Economy of Water Pricing Reforms (Oxford Univ. Press, 2000).

[18] Dinar, Ariel, & Ashok Subramanian, eds., Water Pricing Experiences—An International Perspective, World Bank Technical Paper No. 386 (World Bank, 1977).

[19] Doukhali, Mohammed Rachid, Water Institutional Reforms in Morocco, 7 Water Policy 71 (2005).

[20] Dyrnes, Gro Volkmar, & Arild Vatn, Who Owns the Water? A Study of a Water Conflict in the Valley of Ixtlahuaca, Mexico, 7 Water Policy 295 (2005).

[21] Dziegielewski, Ben, Message from the Executive Editor, 30 Water Intl. 269 (2005).

[22] Eckstein, Gabriel, & Yoram Eckstein, A Hydrogeological Approach to Transboundary Ground Water Resources and International Law, 19 Am. U. Intl. Law Rev. 201 (2003).
[23] Falkenmark, Malin, Water Management and Ecosystems: Living with Change, Global Water Partnership, Technical Committee, TEC Background Papers, No. 9 (GWP, 2003).
[24] UNEP, 2003. Empowering Women in Water Management and other Development Initiatives. A Training Manual: Focusing on Rainwater Harvesting. Earth Care Africa Monitoring Institute, Nairobi, Kenya.
[25] WEDC, 2001. Practical Guide to Mainstreaming Gender in Water Projects: Guidelines for Water Engineers and Managers, Loughborough University, UK. User-friendly guide for engineers and managers, together with a training pack and set of case studies to enable design of projects that meet the needs of women and men.
[26] Zaldaña, Claudia, 2000. In Unity There is Power: Processes of Participation and Empowerment. Towards Equity Series No.5.San José: World Conservation Union and Arias

6.2 TRAINING COURSE IN WATER SUPPLY, SANITATION & HYGIENE (WASH)

6.2.1 Introduction

Deficiencies in both water quality and quantity are significantly high in the Sudan, affecting the increasing demand for accessing safe drinking water for the population in the country (Access to improved water source was 58.7% according to Sudan Household Health Survey (SHHS 2006)). The adverse effects of shortage in water quantity and of poor water quality are evident in the occurrence and outbreak of several epidemics in the country.

Deficiency of proper sanitation systems in rural and urban communities of Sudan is even worse than the inadequacy in sufficient and clean water supply (39.9% according to SHHS 2006). Dry on-site sanitation systems (basically pit latrines) are utilized extensively in all rural areas of Sudan. In urban areas (cities) including Khartoum (capital of Sudan) more than 90% of population are utilizing pit latrines. The spread of infectious diseases due to poor hygiene, because of inadequate sanitation systems in the country, is high (Typhoid, diarrhea, eye diseases, skin diseases, cholera, etc.).

Therefore, serious environmental problems and challenges related to WASH require great and urgent actions in the whole country. According to the needs assessment conducted by WHO & UNICEF in Sudan, lack of technical capability & adequate institutional capacity are among the major problems of the WASH sector development. The shortage in trained professionals is highly and urgently needed in order to improve the efficient operation of the existing facilities as well as the implementation and operation of the future sector programs in line with the requirement of the Sustainable Development Goals (SDGs). According a training course in WASH for starting professionals has been identified as one of the top priority capacity building in Sudan.

The Water Research Centre (WRC), Faculty of Engineering, University of Khartoum, is encouraging & supporting the implementation of WASH program through research and capacity building programs. In this respect, the WRC is intending to offer the training course in WASH program to starting professionals in the water sector within the framework of the HCD component of the ACEWATER2 project of the AU NEPAD Centre's of Excellence in Water Science.

6.2.2 Objectives of The Course

The objectives of the course are as follows:

1. To strengthen the sanitary awareness of the professionals and facilitate the knowledge to allow them to make decisions in the public sanitation issues.

2. To provide the participants with the basic knowledge for planning, design, operation of water supply systems.
3. To furnish the candidates with the basic knowledge of physical, chemical and microbiological characteristics of water and wastewater.
4. To satisfy the requirement that the participants should have sound knowledge about the principles of on- site sanitation systems as related to design, improvement and sustainability.
5. To provide the participants with the basic aspects of water quality control parameters considering appropriate sampling & testing techniques with reference to recognized standards and guidelines.
6. To provide the participants with the basic concepts about conventional wastewater systems (treatment & collection), testing of wastewater parameters (BOD, COD, SS, etc.) and that reuse of treated wastewater as an important measure for conservation of water resources.
7. To produce professionals with knowledge to work together as part of an inter-disciplinary team and to develop the skills to enhance community participation in developing, implementing and operating any WASH project.
8. To emphasize to the participants, the importance of awareness programs and enforcement of legislation related to WASH as aspects that are essential tools to achieve development and sustainability.
9. To introduce to the participants, the importance of professional attitudes, team work and continued training.

6.2.3 Learning Outcomes

1. An ability of the professionals to plan, design and operate water supply projects that satisfy the requirement of the targeted communities with sustainable safe drinking water conforming with the recognized standards.
2. The professionals will be able to select the optimum conventional wastewater treatment systems that will be sustainable along the design period of the project and that proper reuse practices can be adopted.
3. An ability to understand principals of epidemiology, communicable and endemic diseases. The participants will understand the kingdom of microbes and to perform testing of microbiological samples.
4. An understanding of the professionals to improve and sustain the on-site sanitation systems and to encourage community involvement and participation.
5. Developing the skills of the professionals to prepare awareness programs, adopting acceptable legislations which are desirable to maintain the environment around us safe, clean and healthy.
6. Ensuring that professional attitudes and continued knowledge seeking are important tools for sustainability and development.

6.2.4 Training Period

10 working days (2 weeks) including laboratory experiments, seminars & two field visits.

6.2.5 Suggested Topics

- Environmental sanitation & control.
- Microbiology of water and wastewater.
- Water requirements for various purposes and Drinking Water quality parameters
- Water treatment and supply engineering.
- On-site sanitation systems, design, implementation & operation.
- Water pollutants, sewerage systems & reuse practices.
- Tools for management of wet utilities including enhancing professional attitudes and continuous training to achieve sustainability and development.
- Seminars, exercises, site visits & laboratory testing.

6.2.6 Brief Outlines of the Topics

1) Environmental sanitation control:

- Principle of epidemiology.
- Communicable and endemic diseases (Presentation from participants).
- Housing sanitation.
- Milk and food sanitation.
- Eradication and control of disease outbreaks such as cholera and other water borne diseases control of such diseases will be by facilitating appropriate water and sanitation systems.
- Institutional sanitation (Schools, hospitals, etc.). Swimming pools & camp sanitation.
- Refuse collection & disposal.
- Site Visits.

2) Water requirements & drinking water quality parameters

- Water use & availability.
- Factors influencing per capita water use & population forecast.
- Institutional & fire water requirement.
- Un-account-for water, demand variation & peaking factors.
- Physical, chemical & bacteriological water quality parameters.

3) ***Microbiology of water & wastewater***

- Basic principles of the morphology, fungi, protozoa, bacteria and viruses, Algae determination and its effect on water quality.
- Laboratory experiments will focus on microbiological examination of water & wastewater.
- Bacteriological standards for surface water sources and for treated wastewater.
- Field observations & sampling procedures.

4) ***Water treatment & supply engineering***

- Surface water treatment process (water intakes, plain sedimentation, chemical sedimentation, filtration (rapid & slow sand filtration), disinfection and desalination.
- Groundwater treatment process (aeration, softening, disinfection, etc.).
- Water distribution networks with accessories: pumps, reservoirs (ground & elevated tanks), piping material, leakage determination, measuring devices of application of software.
- Operation & maintenance of water plants & distribution networks.

5) ***On-site sanitation systems***

- Dry & wet on-site sanitation systems (Presentation from participants).
- Design, implementation & operation.
- Performance deficiency & impacts on hygiene.
- Low cost on-site improved sanitation systems.
- Community participation & awareness programs to achieve sustainability.
- Site visits.

6) ***Water pollutants, sewerage system & reuse practices***

- Definitions of main organic pollutants (Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), etc.)
- Aspects related to wastewater collection systems
- Conventional wastewater treatment processes (attached growth & suspended growth systems)
- Waste stabilization ponds
- Operation & maintenance of sewerage systems
- Reuse practices: restricted & unrestricted irrigation, fertilizers, energy conservation principle etc.

7) ***Tools for management of wet utilities to achieve sustainability***

- Monitoring & routine checking the performance of the systems.
- Rehabilitation & upgrading the systems.
- Adopting the principles of water equity & setting out adequate tariff systems for generation of fund.
- Enforcement of regulations & legislations.

- Awareness programs for the different sectors of the community (Presentation from participants).
- Stakeholder participation (WASH Committees) in the different WASH programs.

8) Exercises, site visits, seminars & Laboratory experiments

- Group work exercises for the different topics outlined above.
- Site visits to water & wastewater treatment plants.
- Seminars covering on-site sanitation systems, sanitation & hygiene, community participation & awareness programs.
- Laboratory experiments: microbiology, water & wastewater quality.

6.2.7 Training Methods

Presentations, discussions, exercises, site visits, field work, laboratory, experiments.

Table 6.3: *Contact hours for WASH Course*

Topic	Time (hours)
Environmental Sanitation control	8
Microbiology of water & wastewater	6
Water requirements & drinking water standards	6
Water treatment & supply engineering	8
On-site sanitation systems	6
Water pollutants, sewerage systems & reuse practices	8
Tools for management of wet utilities to achieve sustainability	6
Exercises, Site visits, Seminars & laboratory experiments	12
Total	**60**

Table 6.4: *WASH Time Table*

WEEK 1					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Environmental sanitation	Microbiology of water & wastewater	Water requirements & standards	Water treatment & supply. E	Water treatment & supply .E
10:30 - 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Microbiology of water & Wastewater	Microbiology of water & wastewater	Environmental sanitation	Water requirements & standards	Water treatment & supply .E
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Water requirements &standards	Experiments (Microbiology)	Environmental sanitation	Water treatment & supply .E	Exercise (Water treatment & supply .E)

WEEK 2					
Day/ Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Environmental sanitation	Water pollutants	Sewerage systems	Tools of management	On-site sanitation systems
10:30- 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	On-site sanitation systems	On-site sanitation systems	Sewerage systems & reuse	Tools of management	Exercise(Sewerage system &reuse)
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Seminar (Environmental sanitation)	Site visit	Experiments (water pollutants)	Site visit	Seminar (tools of management)

6.2.8 References

[1] Jerry A. Nathanson ,2004, Basic environmental technology –water supply, waste management, and pollution control ,4th ED., Prentice –Hall of India.

[2] Amal K. Datta ,2000, Introduction to environmental science and engineering, Oxford & IBH Publishing Co. PVT. LTD New Delhi.

[3] Shun Dar Lin ,2014 ,Water and Wastewater calculations manual 3rd ED. , Mc Graw Hill education , New York

[4] Swades K. Bhattacharya , 1992 ,Urban Domestic Water supply in developing countries ,CBS Publisher & Distributors New Delhi .

[5] Milino R. Gidde and Ravindra K.Lad ,2010 , Environmental engineering-1 3rd ED. Nirali PrakaShan, Pune India.

[6] P. Meenakshi ,2005, Elements of environmental science and engineering, Prentice – Hall of India.

[7] Peter J. Bury Sudan National WASH Plan 2012 ---2016, UNICEF, Sudan.

[8] A.K. Chatterjee, 1998 6th ED. , Water supply , waste disposal and environmental engineering , Khanna Publisher , New Delhi .

[9] T. H . Y . Tebbutt , 1982 , 3rd ED. , Principles of water quality control , Pergamon Press , Oxford .

[10] Mark J . Hammer , 2009 , 6th. ED., Water and Wastewater Technology , Pearson Education publisher, New Jersey U.S.A .

[11] Guidelines for drinking –water quality , volume 2 Health Criteria and other supporting information , 1991, WHO , CBS Publisher & Distributors , New Delhi , India .

6.3 TRAINING COURSE IN DATA ACQUISITION AND ANALYSIS IN WATER MANAGEMENT

6.3.1 Introduction

Accurate and comprehensive water resource data are critical to planners and decision makers at all levels of government, researchers, developers and the business community. Now more than ever, the increasing need to manage our precious natural resources is driving the need for more detailed water and natural resources data for many areas of the state. Sudan is currently facing considerable technical, social, economic, and environmental challenges related to water management. Key to these challenges is lack of available and reliable information for planning design and management of water resources systems. Deterioration of monitoring networks, lack of data and poor quality of existing data are major constraints. There is also lack of capacity in this area and training of professionals is needed. The deficiencies in data acquisition and information management have impacts on all areas of water resources management including urban surface water drainage, groundwater management, irrigation, water supply and sanitation, and integrated water resources management.

Starting professionals, with less than 5 years of related experience, in the water sector in Sudan face many training challenges including lack of specializations in universities in specific tracks of water, lack of formal training policies and opportunities in both government and private sectors, and high rate of brain drains of experienced professionals. These challenges are further exacerbated by the great expansion in graduates from different universities, with little focus on practical knowledge and related courses and a disregard to addressing the actual market needs.

This course is aimed at filling this critical training gap. It focuses on providing foundational understanding on the acquisition and analysis of temporal, textual and spatial data to support water management. Temporal (timeseries) data are those data related to a point in time or period. Examples include streamflows, groundwater levels, and precipitation data. Textual data consists of text-based information such as directories, library bibliographies and inventories. Spatial data are those data related to space which can be shown on a map and are commonly maintained by Geographic Information Systems (GIS).

6.3.2 Objectives of The Course

The objectives of the course are as follows:

1. To provide participants with solid foundational understanding of the role of data management, storage, analysis, and interpretation in water management.
2. To introduce the participants to the principles and application of remote sensing and GIS in water management.

3. To provide participants with hand-on experience in acquiring, analyzing and presenting time series data from local and open access sources.
4. To provide participants with hand-on experience in acquiring, analyzing and presenting spatially distributed data from local and open access sources.

6.3.3 Learning Outcomes

The targeted learning outcomes of the course are as follows:

1. Familiarity with available local and open access sources for temporal, textual, and spatial data.
2. Familiarity with best practices in data management, storage, preservation, and dissemination.
3. Exposure to tools and techniques for data management and analysis.
4. Understanding of the principles and application of remote sensing and GIS in water management.

6.3.4 Training Period

10 working days (2 weeks).

6.3.5 Suggested Topics

Training course topics, allocated time, and suggested schedule is described in the following table.

- Introduction to Data in Water Resources Management.
- Data Management.
- Data Acquisition Methods.
- Design of Monitoring Networks.
- **Field Visit:** Hands-on Experience for Collection of Surface and Groundwater Data.
- Statistical Methods in Water Management.
- **Computer Workshop**: Application of Statistical Methods Using MS Excel.
- **Computer Workshop**: Open Source Tools for Working with Timeseries data.
- Introduction to GIS applications in water management.
- **Computer Workshop:** GIS Applications for Water Management.
- Introduction to Remote Sensing Applications in Water Management.
- Climate Change Data.
- **Computer Workshop:** Group Projects.
- **Computer Workshop:** Project Presentations.
- **Assessment and Evaluation**

6.3.6 Brief Outlines of the Topics

1) Introduction to Data in Water Resources Management.

- Types of data and its application
- Available data sources for Sudan (metrological, streamflow, groundwater, water quality, socioeconomic, etc.)
- Entities responsible for collecting and maintain national datasets
- Challenges in data dissemination in the Sudan compared to sample countries in the world.
- Open data access sources of data.

2) Data Management

- Data Management Principles.
- Best Practices for data storage and dissemination (metadata, databases, audits, governance).
- Data mining.

3) Data Acquisition Methods

- Metrological data acquisition methods and protocols (precipitation, solar radiation, evapotranspiration, etc.)
- Surface water data collection methods and protocols (flow, quality, sediment, etc.)
- Groundwater data collection methods and protocols (water level and quality).
- Data validation, storage, and dissemination

4) Design of Monitoring Networks

- Monitoring and gauging stations in Sudan.
- Design considerations for surface water monitoring.
- Design considerations for groundwater monitoring.

5) Visit: Hands-on Experience for Collection of Surface and Groundwater Data

- Use of flow measuring devices
- Use of water level measuring devices
- Use of water quality sampling devices
- Note-taking practice
- Data processing and validation

6) Statistical Methods in Water Management

- Characteristics of Water Resources Data
- Uncertainty

- Regression
- Correlation
- Trend Analysis
- Graphical Data Analysis

7) Computer Workshop: Application of Statistical Methods Using MS Excel

- Analysis of flow time series data
- Flood forecasting Exercise

8) Computer Workshop: Open Source Tools for Working with Timeseries data

- Introduction to HEC-Data Storage System (DDS).
- Introduction to HEC-DDSVue use to manage, analyze, and display data.
- HEC-DDSVue data input, output, and transfer.
- HEC-DDSVue functionalities for time series analysis.
- HEC-DDSVue graphing capabilities.

9) Introduction to GIS applications in water management

- Introduction to GIS in Water Resources.
- Open Access Sources for GIS Data.
- Digital mapping of water resources information.
- Spatial coordinate systems.
- Hydrologic terrain analysis using digital elevation models.
- River and watershed networks.
- Soil and land use mapping.
- Flood hydrology modeling and flood plain mapping.
- Integration of time series and geospatial data.
- Hydrologic modeling and Information Systems.

10) Computer Workshop: GIS Applications for Water Management

- Introduction to ArcGIS.
- Introduction to Databases in ArcGIS.
- Introduction to Spatial Operations.
- Introduction to Spatial Analyst and Raster/gridded data.
- Introduction to 3-D Analyst and Triangulated Irregular Networks (TINs).

11) Introduction to Remote Sensing Applications in Water Management

- Introduction to Principles of Radiation.
- Mapping of Water Resources.

- Estimation of Hydro-Meteorological Variables (Precipitation, Evapotranspiration, soil moisture, Land use cover, water quality).
- Applications in Water Management (rain-fall runoff, flood forecasting, drought forecasting, irrigation management, groundwater management).
- Open access sources for remote sensing data.

12) Climate Change Data

- Introduction to climate change science.
- Climate change scenarios.
- Climate data portals.

13) Computer Workshop: Group Projects

- Each project covers:
  i. Data acquisition.
  ii. Data validation.
  iii. Data analysis.
  iv. Presentation of findings.
- Example of projects: flood forecasting, drought forecasting, analysis of systematic and random errors.

14) Computer Workshop: Project Presentations

- 10-minute presentation of projects (problem/objective, methods, results, key observations).

6.3.7 Training Methods

Presentations, discussions, exercises, field visits, computer applications.

Table 6.5: *Contact hours for Data Acquisition and Analysis in Water Management Course*

Topic	Time (hours)
Introduction to Data in Water Resources Management	4
Data Management	2
Data Acquisition Methods	4
Design of Monitoring Networks	2
Visit: Hands-on Experience for Collection of Surface and Groundwater Data	6
Statistical Methods in Water Management	4
Computer Workshop: Application of Statistical Methods Using MS Excel	2
Computer Workshop: Open Source Tools for Working with Time series data	6
Introduction to GIS applications in water management	6
Computer Workshop: GIS Applications for Water Management	6
Introduction to Remote Sensing Applications in Water Management	6
Climate Change Data	3
Computer Workshop: Group Projects	6
Computer Workshop: Project Presentations	2
Assessment and Evaluation	1
Total	**60**

Table 6.6: *Data Acquisition and Analysis in Water Management Time Table*

WEEK 1					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Introduction to Data in Water Resources Management	Data Acquisition Methods	**Visit:** Hands-on Experience for Collection of Surface and Groundwater Data	Statistical Methods in Water Management	Open Source Tools for Working with Timeseries data
10:30 - 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Introduction to Data in Water Resources Management	Data Acquisition Methods	**Visit:** Hands-on Experience for Collection of Surface and Groundwater Data	Statistical Methods in Water Management	Open Source Tools for Working with Timeseries data
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Data Management	Design of Monitoring Networks	**Visit:** Hands-on Experience for Collection of Surface and Groundwater Data	Application of Statistical Methods Using MS Excel	Open Source Tools for Working with Timeseries data

WEEK 2					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Introduction to GIS applications in water management	GIS Applications for Water Management	Introduction to Remote Sensing Applications in Water Management	Climate Change Data	Group Projects
10:30 - 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Introduction to GIS applications in water management	GIS Applications for Water Management	Introduction to Remote Sensing Applications in Water Management	Climate Change Data + Group Projects	Group Projects + Assessment and Evaluation
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Introduction to GIS applications in water management	GIS Applications for Water Management	Introduction to Remote Sensing Applications in Water Management	Group Projects	Project Presentations

6.3.8 References

[1] D.R. Helsel and R.M. Hirsch (2002), Statistical Methods in Water Resources, USGS.

[2] S. Adamala (2017), An Overview of Big Data Applications in Water Resources Engineering, Machine Learning Research.

[3] Hussein Ali Salah, et. al. (2014), Analysis of Data Mining Tools Used for Water Resources Management in Tigris River, Advanced Management Science, Vol. 3, No.2, 2014 DOI: 10.7508/AMS-V3-N2-1-10.

[4] M. Ando (2018), Water Quality and Standards, Vol. I - Surface Water Monitoring, Encyclopedia of Life Support Systems.

[5] M. Rosen (2018), Groundwater, Vol. II – Groundwater Monitoring Networks, EOLSS

[6] USGS (2013), National Framework for Groundwater Monitoring in the United States.

[7] ESRI, ArcGIS Pro Reference Manual for Hydrology Tools, available at https://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/an-overview-of-the-hydrology-tools.htm

[8] HEC-DSS and HEC-DSSVue Reference Manual, available at http://www.hec.usace.army.mil

[9] Kumar Reshmidevi (2013), Remote Sensing Applications in Water Resources, Journal of the Indian Institute of Science VOL 93:2.

[10] University of Khartoum (2017), Water Resources of the Sudan, published by the Water Research Center.

CHAPTER 7

7 TRAINING COURSES FOR TECHNICIANS IN THE WATER SECTOR

7.1 TRAINING IN DATA ACQUISITION IN SURFACE AND GROUND WATER

7.1.1 Introduction

Data acquisition in surface and ground water, is essential for design and operation of engineering projects including reservoirs, roads, bridges, navigation, agricultural schemes, drinking water, flood control and management as well as pollution control. There is a great lack of experience in new techniques of data acquisition.

The main role of technicians in the water resources sector, is the data collection of rainfall depths, flow velocity and discharge measurements. In addition to that, technicians are involved in the monitoring of groundwater level fluctuations and well pumping tests.

The main challenges facing data acquisition include but not limited to the following:

- Lack of qualified technicians;
- Limited understanding of new techniques of data acquisition;
- Lack of monitoring of surface water and groundwater;
- Lack of availability of adequate water information systems for surface water and groundwater;
- Limited human resources capacity in measurements, operation and maintenance of hydrometric stations;
- Most of the well-trained technicians are concentrated in the main cities and not the field where they are most needed;
- Lack of training for the new technicians, as well as poor enabling environments.

The proposed training course is designed to introduce the technicians to the modern techniques of data acquisition. It focuses on providing foundational theoretical and practical skills in the field of data acquisition.

7.1.2 Objectives of The Course

The overall objective of the training course is to provide the technicians with the necessary training in data acquisition. The specific course objectives are the following:

1. To promote capacity building through continued training of the technicians in the water resources sector;
2. To adapt relevant technologies and methodologies in the world to contribute to knowledge transfer;
3. To provide the needed knowledge base on major features of data acquisition;
4. To provide an integrated career opportunity in data acquisition;
5. To introduce the technicians to the state-of-the-art in data acquisition as well as numerical techniques and computer applications.

7.1.3 Learning Outcomes

On completion of this course, the trainees should be able to:

1. Understand the basic concepts of data acquisition;
2. Executes the various measurements of surface and ground waters;
3. Acquire the necessary capabilities to handle the problems related to data acquisition;

7.1.4 Training Period

The proposed training period is two weeks, i.e. 10 working days comprising lectures, laboratory experiments and field works.

7.1.5 Suggested Topics

- Introduction.
- Meteorological measurements.
- Flow, levels and velocity measurements.
- Flow computations.
- Hydraulic control structures.
- Bathymetric surveys.
- Suspended and bed load measurements.
- Water quality measurements.
- Field visit to an automatic weather station.
- Groundwater measurements.

- Field visit to a water level station using a radar sensor.

7.1.6 Brief Outlines of the Topics

1) Introduction

- Hydrological Cycle/Parameters (An overview).
- Data acquisition and Transmission.
- Water Resources Information Systems (WIS).
- Critical Requirements of an Effective Water Resources Assessment Program.
- Health, Safety & Environment (HSE) Issues.
- Check list, note-taking and field reports.

2) Meteorological measurements

- Rainfall Measurements
- Other Meteorological Measurements

3) Flow and velocity measurements

- Selection of streamflow measuring method.
- Selection of monitoring site.
- Water Measuring Instruments
  a. Stage Measuring Instruments (Staff Gauge, Automatic Recorders ...etc.).
  b. Velocity Measuring Instruments (Current-meter, float …etc.).
  c. Advanced Flow Measuring Instrument (ADCP).
- Determination of Flow Cross-sectional Area
- Velocity Measurements

4) Flow computations

- Measurement and computation procedure.
- Total Discharge Calculations
  a. Float Method for Velocity Measurements.
  b. The Slope-area Method.
  c. Velocity-Area Method.
- Stage-Discharge Relationship.

5) Hydraulic control structures

- Weirs.
- Flumes.
- Sluice Gates.

6) Bathymetric surveys

- Instruments of Bathymetric Surveys.
- Bathymetric Surveys Procedure.

7) Groundwater measurements

- Groundwater Measurement Instruments.
- Groundwater level Measurements.
- Well Pumping Test.

7.1.7 Training Methods

Presentations, group discussions, exercises, training videos, site visits, field measurements, computer analysis, laboratory experiments.

Table 7.1: *Contact hours for Data Acquisition in Surface and Ground water course*

Topic	Time (hours)
Introduction	2
Meteorological measurements	2
Practical Works: in Meteorological measurements	2
Flow, levels and velocity measurements	2
Practical Works: in Flow, levels and velocity measurements	4
Flow Computations	2
Practical Works: in Flow Computations	4
Hydraulic control structures	4
Laboratory Works: in Hydraulic control structures	4
Bathymetric surveys	2
Practical Works: in Bathymetric surveys	4
Suspended and bed load measurements	2
Practical Works: in Suspended and bed load measurements	2
Laboratory Works: in Water quality measurements	2
Groundwater measurements	4
Practical Works: in Groundwater measurements	6
Group Discussion	2
Field Visit: to an Automatic Weather Station	6
Field Visit: to a Water Level Station using A Radar Sensor	4
Total	**60**

Table 7.2: *Data Acquisition in Surface and Ground water Time Table*

WEEK 1					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Introduction (Theoretical)	Flow, levels and velocity measurements (Theoretical)	Flow computations (Theoretical)	Hydraulic control structures (Theoretical)	Hydraulic control structures (Laboratory)
10:30 -11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Meteorological measurements (Theoretical)	Flow, levels and velocity measurements (Practical)	Flow computations (Practical)	Hydraulic control structures (Theoretical)	Bathymetric surveys (Theoretical)
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Meteorological measurements (Practical)	Flow, levels and velocity measurements (Practical)	Flow computations (Practical)	Hydraulic control structures (Laboratory)	Bathymetric surveys (Practical)

WEEK 2					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Bathymetric surveys (Practical)	Field Visit to an Automatic Weather Station	Water quality measurements (Laboratory)	Groundwater measurements (Practical)	Group Discussion
10:30 - 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Suspended and bed load measurements (Theoretical)	Field Visit to an Automatic Weather Station	Groundwater measurements (Theoretical)	Groundwater measurements (Theoretical)	Field Visit to a Water Level Station using a Radar Sensor
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Suspended and bed load measurements (Practical)	Field visit to an automatic weather station	Groundwater measurements (Practical)	Groundwater measurements (Practical)	Field Visit to a Water Level Station using a Radar Sensor

*7.1.8 **References:***

[1] Elizabeth M. Shaw, 1988, “Hydrology In Practice”, 2nd Edition, McGraw Hills.
[2] Hayes F. C., 1978, “Guidance for Hydrographic and Hydrometric Survey”
[3] Boiten W., 2005, “Hydrometry”, Taylor and Francis, The Netherlands
[4] Chow, V.T., 1959, “Open Channel Hydraulics”, McGraw Hill, New York
[5] Henderson, F.M., 1966 “Open Channel Flow”, Macmillan, New York
[6] Sabhash C. J., 2001, “Open Channel Flow”, John Wiley & Sons

7.2 TRAINING COURSE IN CONSTRUCTION, INSTALLATION, OPERATION AND MAINTENANCE OF URBAN SURFACE DRAINAGE STRUCTURES AND NETWORKS

7.2.1 Introduction

In general, the current situation of storm water drainage structures in major cities in Sudan has deteriorated significantly. Khartoum is the Capital City of Sudan, the geographical area of the City extended beyond an area of 5000 sq. km. The city is located in the heart of Sudan at the confluence of the White Nile and the Blue Nile, where the two rivers unite to form the River Nile, and these rivers subdivided the city into three major parts. Khartoum is characterised by a flat terrain topography that makes the city very much prone to water logging and drainage congestion beside the effects of the flash floods caused by upstream surrounding catchments areas, during rainy season. Khartoum population has grown to over 5,274,321 people (in 2008 census) with increment rate of 2.8 % per year.

The drainage of Greater Khartoum Storm water during the rainy season can be considered as one of the main state's problems at this period of the year. There has been some developmental works by the Ministry of Infrastructure to cater for the drainage and flash flood problems of the city, but considering the fast development scenario and urbanization coupled with population growth, the existing storm water drainage and flash flood protection systems are utterly inadequate due to the following shortcomings:

i. Many of the existing surface drains and flash flood protection structures are inadequate in size thus require maintenance and renovation.
ii. Many areas are not provided with drainage system.
iii. Absence of efficient solid waste management system is contributing to blockage of open surface drains leading to overflows during heavy showers. Stagnation of water as a result of siltation / blockage is creating health related problems due to mosquito breeding, fly nuisance etc.
iv. Rainfall rate variability in term of amount and timing, leads sometimes to exceed the capacity of the drains and natural channels.
v. The Ministry of Infrastructure and the localities, is facing lot of hardship in periodic maintenance of the existing drains.
vi. Due to rapid urbanization and unprecedented pace of growth in the last two decades, the physical status of most of the natural storm water channels or Khors suffer from :
    - Encroachment by the public, thereby narrowing their original natural stream Sections.
    - Slum dwellers / people of weaker sections occupy and reside on the bank of the drains causing obstruction to the free flow of streams & narrowing the flow path.
    - Lack of proper demarcation and fencing of storm water drains.

- The low lands toward rivers' bank which otherwise acted as storm water holding basins & provided natural pathway for discharge to the rivers are gradually converted into homestead lands thereby causing flooding in uplands during heavy shower. These low lands while acting as temporary storm water holding banks also help groundwater recharge.
- Increase in-built up areas and absence of integrated urban watershed management have led to reduction in infiltration capacity and thereby ground recharging problems.

The above shortcomings and, may be others, are causing lack of efficiency of both natural and man-made drainage systems leading to hosting and spreading of large amount of water all over the open space areas along the residential and settlement areas as well as frequent flooding of the city thereby affecting the normal life especially during rainy periods. This has direct affect to the ecological and health situation in the City.

Therefore, the training of technicians in Stormwater Drainage and Flash Flood Protection are considered as main objectives of this course. It should be noted that, there is a high real need for training of technicians and capacity building in construction, operation of urban surface drainage structures and networks.

7.2.2 Objectives of The Course

The objectives of the course are as follows:

1. To provide the participants with basic concepts and elements of the maintenance of surface drainage networks and appurtenant structures.
2. To provide the participants with basic concepts of site preparation and construction urban surface drainage networks and appurtenant structures.
3. To provide the participants with basic experience of site preparation and construction of cross drainage structures.
4. To provide the participants with basic knowledge, experience and practice for Road drainage.
5. To provide the participants with basic knowledge, experience and practice for installation and operation of pumps and pumping stations.
6. To provide the participants with basic knowledge, experience and practice for emergency evacuation of surface water via movable pumps and pumping units.
7. To provide the participants with basic knowledge, experience and practice for the preparation and construction of flood protection dams and their use for water harvesting.

7.2.3 Learning Outcomes

1. Ability to understand shop drawings plans and sections, reinforcement, jointing, etc… prepared for surface drainage networks and appurtenant structures.

2. Ability to prepare the site for constructing the different elements of the design of surface drainage networks and appurtenant structures.
3. Ability to understand shop drawings plans and sections, reinforcement, jointing, etc… and prepare for construction of cross drainage structures.
4. Ability to understand shop drawings plans and sections, reinforcement, jointing, etc…and prepare for construction of road drainage structures.
5. Ability to understand shop drawings plans and sections, reinforcement, jointing, etc…and prepare installation and operation of pumps and pumping stations
6. Ability to understand and prepare for emergency evacuation of surface water via movable pumps and pumping units.
7. Ability to understand and prepare for the preparation and construction of flood protection dams and their use for water harvesting.

7.2.4 Training Period

15 working days (3 weeks) including three field visits

7.2.5 Suggested Topics

- Drainage structures of channels.
- Drainage structures of roads.
- Pumps and pumping stations.
- Screens and pumps
- Intake structures in water supply systems.
- Water harvesting structures and maintenance
- Measurements and quality control
- Exercises group work and field visit
- Basics of the construction, installation, operation and maintenance of urban surface drainage structures and networks.

7.2.6 Brief Outlines of the Topics

1) Drainage structures of channels

- Drainage open channels (rectangular, trapezoidal, circular, triangular, Gutter….).
- Drainage closed conduits (pressurized pipes, circular pipes, Box pipes, Elliptical pipes).

2) Drainage structures of roads

- Road longitudinal drainage (Grate inlet in sag and on grade, Curb inlet in sag and on grade, Ditch inlet in sag and on grade, Slotted drain inlet in sag and on grade combined inlet in sag and on grade).
- Road cross drainage culverts (circular, parabolic, box, corrugated, single, multiple cells, tapered inlet, "Conc. Sq edge. Wall" = Concrete pipe with square edged inlet and headwall:
  "Conc. Groove. Wall" = Concrete pipe with groove end at inlet and headwall
  "Conc. Groove. Proj" = Concrete pipe with groove end projecting at inlet
  "CMP. Headwall" = Corrugated metal pipe with headwall at inlet
  "CMP. Mitered" = Corrugated metal pipe mitered to slope at inlet
  "CMP. Projecting" = Corrugated metal pipe projecting at inlet

3) <u>Pumps and pumping stations</u>

- Grouping of Pumping stations
- Pumps, Pump well
- Setting of pumps
- Characters of the pump setting
- Capacity of Pumping stations
- Pressure measurement instruments
- Pipe system in the pump house
- Valves
- Auxiliary facilities

4) <u>Exercises group work and field visit</u>

- First field visit to detention pond and pumping station for drainage in Omdurman.
- Second field visit to pumping station and weirs for drainage in Khartoum.
- Third field visit to Khartoum North Water treatment and supply station.

5) <u>Basics of the construction, installation, operation and maintenance of urban surface drainage structures and networks</u>

- Definition of Urban drainage system as one of the most important infrastructure development
- Different methods and techniques for preparation and execution of longitudinal urban drainage structures.
- Different methods and techniques for preparation and execution of urban surface cross drainage structures.
- Risk and different methods and techniques for preparation and execution of emergency evacuation certain urban areas.
- The role of dams in reduction of flash floods

7.2.7 Training Methods

Presentations, discussions, exercises, training videos, site visit and field work, laboratory training flow, level, pressure measurements.

Table 7.3: *Contact hours for Drainage Structures and Networks Course*

Topic	Time (Hours)
Drainage open channels (rectangular, trapezoidal, circular, triangular, Gutter….)	8
Drainage closed conduits (pressurized pipes, circular pipes, Box pipes, Elliptical pipes)	8
Road longitudinal drainage(Grate inlet in sag and on grade, Curb inlet in sag and on grade, Ditch inlet in sag and on grade, Slotted drain inlet in sag and on grade combined inlet in sag and on grade)	8
Road cross drainage culverts (circular, parabolic, box, corrugated, single, multiple cells, tapered inlet, "Conc. Sq edge. Wall" = Concrete pipe with square edged inlet and headwall	8
Pumps and Pumping stations, water proofing and emergency operation	8
Intake structures and water supply systems	6
Water harvesting structures, operation and maintenance in emergency	8
Measurements and quality control, concrete repair	8
Exercises and Group work	16
Field visits	12
Total	**90**

Table 7.4: *Drainage Structures and Networks Time Table*

WEEK 1					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Drainage open channels	Drainage open channels	Drainage closed conduits	Exercises and Group work	Road longitudinal drainage
10:30 - 11	**Break**	**Break**	**break**	**break**	**break**
11 - 1	Drainage open channels	Drainage closed conduits	Drainage closed conduits	Road longitudinal drainage	Road longitudinal drainage
1 - 1:30	**Break**	**Break**	**break**	**break**	**break**
1:30 - 3:30	Drainage open channels	Drainage closed conduits	Exercises and Group work	Road longitudinal drainage	Road cross drainage culverts

WEEK 2					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Road cross drainage culverts	Exercises and Group work	Pumps and Pumping stations, water proofing and emergency operation	Intake structures and water supply systems.	Field visits
10:30 - 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Road cross drainage culverts	Exercises and Group work	Pumps and Pumping stations, water proofing and emergency operation	Intake structures and water supply systems.	Field visits
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Road cross drainage culverts	Pumps and Pumping stations, water proofing, emergency operation	Pumps and Pumping stations, water proofing and emergency operation	Intake structures and water supply systems.	Field visits

WEEK 3					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Exercises and Group work	Water harvesting structures, operation and maintenance in emergency	Measurements and quality control, concrete repair	Measurements and quality control, concrete repair	Field visits
10:30 - 11	**Break**	**Break**	**Break**	**Break**	**Break**
11 - 1	Exercises and Group work	Water harvesting structures, operation and maintenance in emergency	Measurements and quality control, concrete repair	Exercises and Group work	Field visits
1 - 1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30 - 3:30	Water harvesting structures, operation and maintenance in emergency	Water harvesting structures, operation and maintenance in emergency	Measurements and quality control, concrete repair	Exercises and Group work	Field visits

7.2.8 References

[1] Chow, V. T. 1959. Open-Channel Hydraulics. McGraw-Hill, Inc. (the classic text)

[2] French, R. H. 1985. Open-Channel Hydraulics. McGraw-Hill Book Co.

[3] Mays, L. W. editor. 1999. Hydraulic design handbook. McGraw-Hill Book Co.

[4] Norman, J. M. 1985. Hydraulic design of highway culverts. HDS-5 (Hydraulic Design Series 5). FHWA-IP-85-15. NTIS publication PB86196961. Obtainable at http://www.ntis.gov.

[5] Streeter, V. L., E. B. Wylie, and K. W. Bedford. 1998. Fluid Mechanics. WCB/McGraw-Hill. 9ed.

[6] Manual No. 1110-2-3102: GENERAL PRINCIPLES OF PUMPING STATION DESIGN AND LAYOUT Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000- 1995

[7] Model drainage Manual, 2000 Metric, American association of state Highway and Transportation Officials.

7.3 TRAINING COURSE IN WATER & WASTEWATER QUALITY MONITORING AND ANALYSIS

7.3.1 Introduction

Raw surface water quality in Sudan is unique with respect to its extreme turbidity during rain and floods season, consequently the water quality management and treatment is challenging and require special handling. Although most of the year our professionals can achieve the required effluent standards, however, during the high turbidity season most of the time the water supply quality is bellow standards, from some water treatment plant effluents. Wastewater treatment in large modern treatment plants is not yet the state of practice in Sudan. One of the main obstacles is the lack of trained personal in the monitoring and management of such systems. The failure, and the abandonment, of Soba Biolack system (Over 15 Million euros in cost) is an evidence for this shortage among other reasons. This short course is designed to address the lack of training in these two treatment sectors.

The course provides a comprehensive overview of and practical insights into the various processes that are involved in the evaluation of drinking water quality, as well as water and wastewater treatment. The course covers topics of basic water microbiology and chemistry, biological treatment processes, as well as biological, chemical and physical water quality parameters, the measurement of these parameters, and laboratory training on the procedure for testing these parameters. The course will ultimately empower the participants to make more informed decisions around the appropriate method of testing, equipment and procedure selection that will aid professionals in the fields water quality monitoring and water and wastewater treatment. The course includes a day visit at a water treatment facility and hands on analytical laboratory training.

The short course in Water & Wastewater Quality Monitoring and Analysis is specifically designed to update you on current and some new methods of sampling, handling, and analysis.

7.3.2 Objectives of The Course

The objectives of the course are as follows:

1. To provide the participants with a sound knowledge in the water and wastewater characterization.
2. To consolidate the knowledge of the participants in the field water and wastewater treatment processes and targeted pollutants.
3. To provide the knowledge of the parameters of water quality.
4. To provide the participants the analysis and the analytical tools for the assessment of water quality.

7.3.3 Learning Outcomes

After successfully completing this course, the participant will be able to:

1. make decision on quality parameters to be tested on a water sample for a specific use.
2. make decisions regarding choice of the best sampling and analytical methods for a given water quality assessment plan.
3. select the appropriate test procedure and equipment to be used.
4. able to analyze and assess the acceptability of test results
5. assess the extent of pollution of a specific water or wastewater samples.

7.3.4 Training Period

10 working days (2 weeks) including a field visit.

7.3.5 SUGGESTED TOPICS

- Water supply sources (Surface & Groundwater supply)
- Wastewater Sources
- Health aspects of water supply and sanitation
- Drinking Water Standards
- Wastewater Effluents Standards
- Water Chemistry and parameter testing
- Microbiology and testing in water Treatment
- Wastewater Microbiology and significance testing
- Organic content of wastewater and parameter testing
- Sampling practices to avoid contamination
- Sample labelling, handling, storage and transportation

7.3.6 Training Methods

Presentations, discussions, exercises, training videos, site visits, field work, laboratory analysis.

Table 7.5: *Contact hours for Water & Wastewater Quality Course*

Topic	Time (Hours)
Water supply & Wastewater sources	2
Health aspects of water supply and sanitation	1
The Drinking Water Standards	2
Wastewater Effluents Standards	1
Physical Characteristics of Water & Wastewater	2
Laboratory Testing Physical Parameters	4
Jar Testing in Water Treatment for the coagulation process	2
Laboratory Jar Testing	4
Water Chemistry	2
Laboratory Testing Chemical Concentrations	4
Microbiology and testing in water Treatment	2
Laboratory Microbiology testing in water Treatment	4
Wastewater Microbiology and significance testing	1
Organic content of wastewater	1
Laboratory Organic content of wastewater, parameter testing	4
Organic content of wastewater	2
Laboratory Organic content of wastewater, parameter testing	4
Visit to a laboratory in a water treatment plant	6
Advanced Laboratory testing	6
Sampling practices to avoid contamination	2
Sample labelling, handling, storage and transportation	4
Total	**60**

Table 7.6: *Water & Wastewater Quality Time Table*

WEEK 1					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Water supply & Wastewater sources	Physical Characteristics of Water & Wastewater	Jar Testing in Water Treatment for the coagulation process	Water Chemistry	Microbiology and testing in water Treatment
10:30 -11	**Break**	**Break**	**Break**	**Break**	**Break**
11—1	Health aspects of water supply and sanitation + Wastewater Effluents Standards	Laboratory Testing Physical Parameters	Laboratory Jar Testing	Laboratory Testing Chemical Concentrations	Laboratory Microbiology testing in water Treatment
1—1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30—3:30	The Drinking Water Standards	Laboratory Testing Physical Parameters	Laboratory Jar Testing	Laboratory Testing Chemical Concentrations	Laboratory Microbiology testing in water Treatment

WEEK 2					
Day / Theme	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
8:30 - 10:30	Wastewater Microbiology and significance testing + Organic content of wastewater	Organic content of wastewater	Visit to a laboratory in a water treatment plant	Advanced Laboratory testing	Sampling practices to avoid contamination
10:30 -11	**Break**	**Break**	**Break**	**Break**	**Break**
11—1	Laboratory Organic content of wastewater, parameter testing	Laboratory Organic content of wastewater, parameter testing	Visit to a laboratory in a water treatment plant	Advanced Laboratory testing	Sample labelling, handling, storage and transportation
1—1:30	**Break**	**Break**	**Break**	**Break**	**Break**
1:30—3:30	Laboratory Organic content of wastewater, parameter testing	Laboratory Organic content of wastewater, parameter testing	Visit to a laboratory in a water treatment plant	Advanced Laboratory testing	Sample labelling, handling, storage and transportation

7.3.7 References

[1] Metcalf of eddy, Inc. Wastewater Engineering, Treatment and Reuse 2003 4th Ed., Tata McGraw-Hill Publishing Company Limited.

[2] Mark J. Hammer, Water and Wastewater Technology, 6th Ed. 2009, PHI Learning Private Limited New Delhi.

[3] A.K Chatterjee, Water Supply, Waste disposal and Environmental Pollution engineering 1998, 6th Ed., Khanna. Publishers Delhi.

[4] T.H.Y. Tebbutt, 3rd Ed. 1983, Principles of water quality control, Pergamon Press.

[5] W.H.O, 1984 Guidelines for drinking water quality Volume 2, Health Criteria and other supporting information, CBS Publishers & Distributors Delhi.

[6] A.C. Twort, 2nd Ed., 1974, Water Supply, Cox and Wyman, London, Fakenham and Reading.

[7] John C. Crittenden, R. Rhodes, David W., Kerry J., George Tchobanoglous, 2012, 3rd Ed., MWH's Water treatment principles and design, John Wiles & Sons, Inc.

CHAPTER 8

8 MONITORING AND EVALUATION FRAMEWORK

8.1 INTRODUCTION

A well-designed monitoring and evaluation framework is essential to assessing how the training course is achieving its stated objectives and targeted outcomes. The insights gained through the monitoring and evaluation will help further improve the training materials, instruction methods, refine the targeted groups, and improve the overall learning outcomes.

The proposed framework includes the following components:

- Pre-course assessment
- Coursework
- Post-course assessment
- Continuous monitoring

The outcome of the monitoring and evaluation report will be summarized in formal assessment report.

8.2 PRE-COURSE ASSESSMENT

A pre-course assessment will collect demographic and educational background information on the participants. It will assess their motivation for participation. It will also establish a baseline of their level of understanding of topics to be covered in the course. This foundational information will help gauge the contribution of the course towards their career development and general interest in this topic.

The pre-course assessment will include the following items:

A. Professional information: (years of experience, field of study, field of practice, etc.)

B. Demographic information: (age, gender, geographic area of practice, etc)

C. What is the one primary reason why you chose to take this course?

D. I’m familiar with topics covered in this course.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

E. The topics covered in this course apply to my daily job duties.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

8.3 COURSE WORK

The instructor-assigned quizzes, classwork, and projects will provide feedback on students’ level of understanding of the concepts presented. It will help the instructor(s) adapt their teaching methods to enhance the learning experience and the outcomes. No official scores will be provided to students, rather, the instructor(s) will use the results of the quizzes, classwork, and projects to evaluate the learning outcome for the course participants overall.

8.4 POST-COURSE ASSESSMENT

A post-course assessment will evaluate participants views about the course, instructor(s), and learning outcomes. Combined with the pre-course assessment, valuable information can be gained on how well the course met the expectations of the students, and how to further improve the training materials, instruction methods, and refine the targeted groups.

The post-course assessment will include the following items:

A. The course was well organized.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

B. The workload for this course was appropriate.
   1. Strongly Disagree

2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

C. The course materials were clear and useful.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

D. The instructor(s) used class time effectively.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

E. The Instructor(s) presented course material in a clear manner that facilitated understanding.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

F. The instructor(s) encouraged student participation in class and treated students with respect.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

G. This course prepared me to apply the topics to my daily job duties.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

H. This course stimulated my interest in this subject. I will seek additional opportunities to advance my knowledge on these topics.
   1. Strongly Disagree
   2. Disagree

3. Neutral
4. Agree
5. Strongly Agree

I. I would recommend this course to others.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

J. What are the strengths and weaknesses of this course?

K. How could the course be improved?

8.5 CONTINUOUS MONITORING

One (1) year following the completion of the course, a follow-up short assessment will help evaluate the endurance of the learning outcomes. It will also gauge the impact of this training course on the career development of the participants.

A. I'm familiar with topics covered in this course.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

B. I apply the topics covered in this course to my daily job duties.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

C. I'm interest in this course subject. I have sought to seek additional opportunities to advance my knowledge on these topics.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

D. My career trajectory has been affected by this course.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

E. I have shared the topics learned in this course with my colleagues.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

8.6 COURSE ASSESSMENT BY PARTICIPANTS' ORGANIZATIONS

Additional feedback on the course design and learning outcomes will be obtained from participants' organizations group that will include public and private sector practitioners. The purpose of this assessment is to gain insights on how to further improve the course content and training materials to ensure relevancy to the needs of the public and private water sector.

The post-course assessment will include the following items:

A. The course contents are relevant to my organization.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree
   5. Strongly Agree

B. The workload for this course was appropriate to prepare participants to apply learned concepts.
   1. Strongly Disagree
   2. Disagree
   3. Neutral
   4. Agree

5. Strongly Agree

C. The course materials were clear and useful as reference.
    1. Strongly Disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly Agree

D. I/we will implement some of the topics learned in this course to improve practices in my organization.
    1. Strongly Disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly Agree

E. I would recommend this course to others in my organization.
    1. Strongly Disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly Agree

F. What are the strengths and weaknesses of this course?

G. How could the course be improved?

8.7 SUCCESS INDICATORS

To measure the effectiveness and performance of the HCD program the following indicators could be used:

1- Number of trainees trained compared to the targeted numbers.
2- Number of partnerships established with stakeholders' institutions.
3- Satisfaction of the trainees and successful completion rate.
4- Extent of advancement in performance of the trainees.
5- How the concepts being taught in training are being implemented within the stakeholder's institutions.

It is important to look at the M&E Framework and success indicators suggested by the other centres and reach an agreement on a unified M&E Framework and success indicators.

GENERAL REFERENCES

- A. Adam and B. Elmonshid (1996). The Sudan Water Resources and their Management (Country Paper). Proceedings of the World Bank Sub-Saharan Africa Water Resources Technical Workshop. Nairobi, Kenya.

- A. Elmufti (2002). National Legislation: Requirements for the Implementation of International Agreements at the National Level-Keynote Paper (Arabic). Proceedings of the National Workshop on Requirements for the Implementation of International Agreements at the National Level. Khartoum, Sudan.

- Abdo G.M,, (2017), Training Need Assessment in Water Resources Management in Sudan, Water Research Centre, University of Khartoum.
-

- Abdo G.M .,(2013), Training Need Assessment in Water Resources Management in Sudan with reference to SDG6 and IHP-VIII, UNESCO Khartoum, Water Research Centre, University of Khartoum.

- Abdo, G.M., and Salih, A.M., (2011). Water Resources Management in Darfur, Faculty of Engineering Journal, University of Khartoum

- Abdo, GM, and Salih, A.M, (2012). Challenges Facing Groundwater Management in Sudan., A presentation in the University of Khartoum, Engineering Conference held in 2012.

- Biedler (2013-204), Africa Water Sector Human Capacity Needs: Scoping exercise.

- MIWR (1992). The Sudan Strategy of Water Resources in the National and Regional Levels (Arabic). MIWR Report. Khartoum, Sudan.

- MIWR (1995). Water Resources Act of 1995 (Arabic). Khartoum, Sudan.

- MIWR (2007). Integrated Water Resources Policy and Strategies. Khartoum, Sudan.
- MIWR, 2000, Training Needs Assessments, FAO Regional Project GCP/RAF/ 286/ITA.

- Eltom O., A. Elmufti, H. Musnad, M. Dingle, H. Ali, M. Siddig, I. Elsadig, A. Salih, M. Ghanim (2000). National Water Policy of Sudan. Draft Final. Khartoum, Sudan.

- Permanent Joint Technical Commission on Nile Waters (1961). Annual Report for the period 1960-1961. PJTC, Khartoum, Sudan.

- Salih, A. M. A. 1993, “Manpower Development Role in the Water Sector”, National Seminar on “Efficient Water use and Conservation, Sudan Natcom of UNESCO, 21-22 April 1993, Khartoum – Sudan.

- Seifeldin Abdalla (2001). The Long Term National Agricultural Strategy (2002-2027): Nile Waters Utilization (Arabic). Report submitted for Ministry of Agriculture and Forests, Khartoum, Sudan.

- Seifeldin Abdalla (2002). Water Policy in Relation to Food Security in the Sudan. Paper presented on the international day for food security under the theme of "water is the backbone for food security", Ministry of Agriculture and Forests, Khartoum, Sudan.

- Seifeldin Abdalla, (2005). Baseline and National Water Policy Needs Assessment Study. Study submitted for the NBI Water Resources Planning and Management Project, Water Policy Component, water policy formulation and implementation process. Addis Ababa, Ethiopia.

- Water Sciences for Peace and Sustainable Development in the Eastern Nile: Perspective of Future Cooperation, Final Report of the Conference, UCO, Egypt.

- Yousra, A & Magdoline, M (2009), Climate Change and Water Resources in Sudan, Final year Project, Department of Civil Engineering, Khartoum University, Sudan.

ANNEXES

Annex 1. List of participants (Consultation Workshop)

NO.	Name	Institution	Email	Telephone
1	Dina M. Belal	Uof K	dbelal@hotmail.com	0923086076
2	Gamal M. Abdo	Uof K	Gabdo2000@yahoo.com	0122123825
3	Muna M. Musad	UNISCO Chair WR	munamusad72@gmail.com	0122184416
4	Elsadig Sharfi	WRC	elsadigsharfi@gmail.com	0912397754
5	Ahmed Eltayeb Elhassan	NWRC, MWRIE	Ahmed_eltayeb2000@yahoo.com	0912140215
6	Mohmed Akode Osman	Uof K	makode@yahoo,com	0912301150
7	Wafaa Sid Ahmed	UNESCO IHP	-	0920944833
8	Babiker I. Barsi	Uof K	babiker.barsi@gmail.com	0912132885
9	Atif Ahmed Abdallah	Kenana engineering	atif.obeid@gmail.com	0912224682
10	Elfadil A. Azrag	UofK	elfadilazrag@yahoo.com	0911801512
11	Abdalla M.T. Shigidi	Sudan university	shigidieses.sd.com	0912305529
12	Ishraga S. Osman	Uof K	essokrab@hotmail.com	0912230519
13	Ali Ahmed Abdallah	WRC	Ali.ahmed.9526@gmail.com	0999626999
14	Mohamed A. Khadam	U of K	adamkhadam1947@gmail.com	0912901306

NO.	Name	Institution	Email	Telephone
15	Hamid Omer Ali	UNEP	hamidomer122@gmail.com	0912211588
16	Kamaledin E. Bashar	Omderman Islamic University	basharke@hotmail.com	0122184007
17	Abdeen M. Ali		abdeensalih@gmail.com	0964478802
18	Mohammed Ombadi	University of California	mombadi@uci.edu	+19499810969
19	Abdelgadir Abdin Salih	UNESCO	ab.salihounsco.org	0966672831
20	Zakeeia Mohammed	Ministry of agriculture	zokazakria@yahoo.com	0918346180
21	Adil Mohamed Elkhidir	UofK	adil_elkhidir@yahoo.com	0123047907
22	Eatidal Elrayah Mohamed	DWSU	eatidalmym@gmail.com	0918021756
23	Maha Abdelgader	UMST	Maha.abdelraheem@Yahoo.com	0911684586
24	Walid Hashim	UofK	Waleedhashim83@gmail.com	0912316839
25	Abdelrahman Saghyroun	Hydrology Centre MWRIE	Hydro.diu@gmail.com	0123494480
26	Elham Ahmed Elhussain	WRC	Elham_ahmed19910@hotmail.com	0912537311
27	Azza Nabiel Babikir	WRC	azzanabiel@hotmail.com	0923606223

Annex 2. List of participants (Validation Workshop)

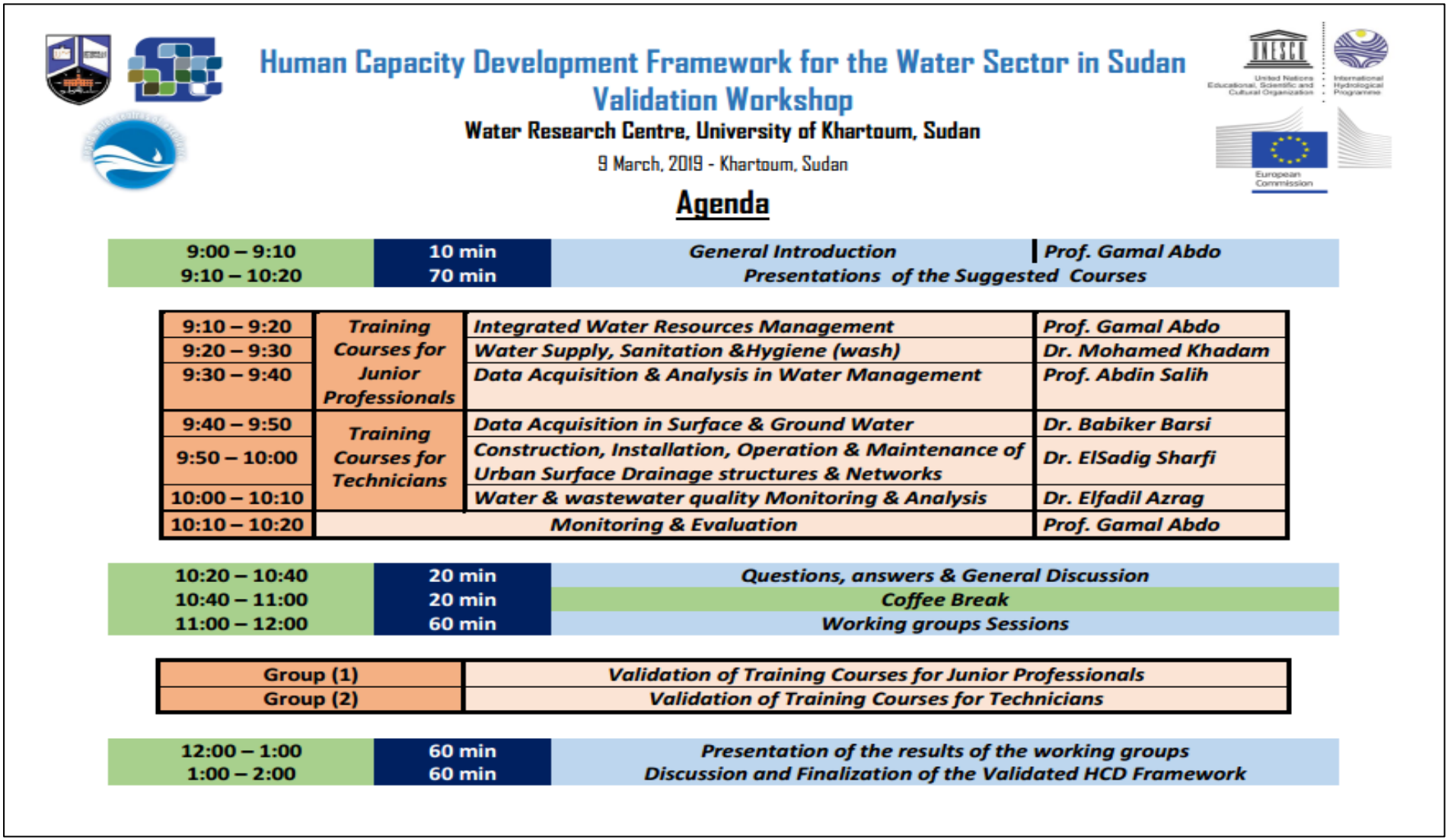
NO	NAME	Institution	Email	Telephone
1	Yousif Hummaida Ahmed	Civil Engineering Department, University of Khartoum	y.hummaida@uofk.edu	0903946400
2	Abdelgadir Abdin Salih	UNESCO	ab.salih@unesco.com	0966672831
3	Mohamed Khalafalla Ahmed	Sudan National Commission for UNESCO (NATCOM)	mkhaali@yahoo.com	0912942699
4	Omer Faisal Yousif Sukkar	SES	omersukkar@gmail.com	0912549760
5	Adil Mohamed Elkhidir	University of Khartoum	Adil_elkhidir@yahoo.com	0123047907
6	Ahmed Mohamed Tahir	Khartoum state sanitary co-operation	Ahmedtahir73@gmail.com	0912189771
7	Mohammed Eltayb Hassan	Kenana Engineering & Technical Services (KETS)	mohamed.abdelgader@kenana.com	0901232595
8	Atif Ahmed Abdalla Obeid	Kenana Engineering & Technical Services (KETS)	Atif.obeid@gmail.com	0912224682

NO	NAME	Institution	Email	Telephone
9	Michael Magdy Mounin	University of Khartoum	Michael_madgy@yahoo.com	0912975295
10	Mohamed Mustafa Abbas	UNESCO-RCWH	m-mustafa@unesco-rcwh.sd	0912328495
11	Hatim Elbadri	UNESCO-RCWH	Hatim2e@hotmail.com	0912356217
12	Ahmed Mohamed Adam	MWRI & Electricity	Ahmoadam293@gmail.com	0912320485
13	Osman Eltom Hamad	MWRI & Electricity, Water Resources Technical Organ (WRTO)	oehamad@hotmail.com	0912549751
14	Mohammed Abdelshafie	IOM	mabdelshafie@iom.int	0922406733
15	Osman Mustafa Ahmed	MWRI & Electricity, Water Resources Technical Organ (WRTO)	omaburi@hotmail.com	0912910034
16	Abdelrahman Saghayroon Elzain	Dams Implementation Unit - MWIE	Hydro.diy@gmail.com	0123494480
17	Mansour Ahmed	Merowe Dam	Mordo576@yahoo.com	0123494394
18	Salah Ahmed Abdalla	Faculty of Engineering, University of Khartoum	saabdalla@uofk.edu	0912305803
19	Elfadil A. Azrag	University of Khartoum	elfadilazrag@yahoo.com	0911801512
20	Mohamed A. Khadam	University of Khartoum	adamkhadam1974@gmail.com	0912901306

NO	NAME	Institution	Email	Telephone
21	Gamal Abdo	University of Khartoum	gabdo2000@yahoo.com	0122123525
22	Muna Mohammed Musnad	UNESCO-Chair in Water Resources	Munamusnad72@gmail.com	0122184416
23	Sana Ibrahim Ahmed	University of Khartoum	Sana.shalgam@gmail.com	0906240509
24	Ahmed ELtayeb Ahmed ELhassan	National Water Research Centre MOWRIE	ahmed-eltayeb2000@yahoo.com	0912140215
25	Ammar Ali Mohammed	MWRIE-DIU	Ammarali.mohammed@yahoo.com	0912357329
26	Waled Hashim	UofK-WRC	Waledhashim83@uofk.edu	0912316839
27	Mohamed Omer Ibrahim SidAhmed	Water Research Centre	mokabashi@uofk.edu	0912334896
28	Maha Abdelgaffar	UMST	maha.abdelraheem@yahoo.com	0911684586
29	Elsadig Sharfi	University of Khartoum	elsadigsharfi@gmail.com	0912397754
30	Amged Osman	University of Khartoum	Amged.Abdelatif@uofk.edu	0123022996
31	Babiker I.Barsi	University of Khartoum	Babiker.barsi@gmail.com	0912132885
32	Wafaa Sidahmed	NATCOM UNESCO	Wafaa-natcom2009@yahoo.com	0912119778
33	Eatidal Elrayah	DWDT	Eatidalrym@gmail.com	0918021756
34	Abdin Mohmed Ali	Water Research Centre	abdeensalih@gmail.com	0964478802
35	Dina Mohammed Belal	University of Khartoum	dbetal@hotmail.com	0923086076
36	Ahmed Musa Siyam	UNESCO-Chair in Water Resources	amsiyam@hotmail.com	0912286077
37	Maab Albager Hassan Altayeb	Water Research Centre, University of Khartoum	maabalbager@gmail.com	0122166868
38	Amal Ibrahim Ahmed Mohammed	Water Research Centre, University of Khartoum	amal1911ahmed@gmail.com	0903334842

NO	NAME	Institution	Email	Telephone
39	Salma Osman Mahgoub Ahmed	Water Research Centre, University of Khartoum	salmaelfeel@gmail.com	0929087196
40	Awad Negmeldin Awad	Water Research Centre, University of Khartoum	awad96najm@gmail.com	0999744781
41	Mugahid Abdalla Omer	Water Research Centre, University of Khartoum	mojahed.a.omer@gmail.com	0901689718
42	Malaz Abd Alrahim	Water Research Centre, University of Khartoum	malazraheem896@gmail.com	0127336164
43	Shadia Mahmoud Alfaras	Water Research Centre, University of Khartoum	-	0919402413
44	Sahar badawi	Water Research Centre, University of Khartoum	Saharbadawi94@gmail.com	0923770826
45	Azza Nabiel	Water Research Centre, University of Khartoum	azzanabiel@hotmail.com	0923606223

Annex 3. Validation Workshop Agenda



Human Capacity Development Framework for the Water Sector in Sudan
Validation Workshop

Water Research Centre, University of Khartoum, Sudan

9 March, 2019 - Khartoum, Sudan

Agenda

9:00 – 9:10	10 min	*General Introduction*	*Prof. Gamal Abdo*
9:10 – 10:20	70 min	*Presentations of the Suggested Courses*	

9:10 – 9:20	*Training Courses for Junior Professionals*	*Integrated Water Resources Management*	*Prof. Gamal Abdo*
9:20 – 9:30		*Water Supply, Sanitation &Hygiene (wash)*	*Dr. Mohamed Khadam*
9:30 – 9:40		*Data Acquisition & Analysis in Water Management*	*Prof. Abdin Salih*
9:40 – 9:50	*Training Courses for Technicians*	*Data Acquisition in Surface & Ground Water*	*Dr. Babiker Barsi*
9:50 – 10:00		*Construction, Installation, Operation & Maintenance of Urban Surface Drainage structures & Networks*	*Dr. ElSadig Sharfi*
10:00 – 10:10		*Water & wastewater quality Monitoring & Analysis*	*Dr. Elfadil Azrag*
10:10 – 10:20	*Monitoring & Evaluation*		*Prof. Gamal Abdo*

10:20 – 10:40	20 min	*Questions, answers & General Discussion*
10:40 – 11:00	20 min	*Coffee Break*
11:00 – 12:00	60 min	*Working groups Sessions*

Group (1)	*Validation of Training Courses for Junior Professionals*
Group (2)	*Validation of Training Courses for Technicians*

12:00 – 1:00	60 min	*Presentation of the results of the working groups*
1:00 – 2:00	60 min	*Discussion and Finalization of the Validated HCD Framework*

Annex 4. Photos from the Validation Workshop

General Session

Working Group (1) Session

Working Group (2) Session