Republic of Sudan

Ministry of Water Resources, Irrigation and Electricity

Federal Ministry of Health

Sudan Drinking Water Safety Strategic Framework

(SDWSSF)

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ال سودان فى ـ ال شر ب

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The process leading to the development of the Sudan Drinking Water Safety Strategic Framework was funded by the Qatar Fund for Development and the World Health Organization (WHO), with financial contributions also from UNICEF. The Core Team who managed and facilitated the process included: Federal Ministry of Health (FMoH); Drinking Water and Sanitation Unit (DWSU), Ministry of Water Resources, Irrigation and Electricity (MoWRIE); WHO; the United Nations Children's Fund (UNICEF); and RedR Sudan.

Foreword

Statements will be inserted here by the Ministers for MoWRIE and FMoH (2 pages)

Contents

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- FMoH – Environmental Health; Health Promotion; Emergency Health Affairs (Epidemiology)
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- Ministry of the Environment, Natural Resources and Physical Development (MoENRPD)
- Sudanese Standards and Metrology Organisation (SSMO)

State Ministries, State Water Corporations and Localities:

- Localities – Khartoum, Kassala Rural, El-Fasher/Zamzam
- State MoH – Khartoum, Kassala, White Nile, North Darfur, East Darfur, West Darfur, Central Darfur, South Darfur and the Environmental Sanitation and Hygiene Promotion Project (ESHP)
- State Water Corporations (SWC) – Khartoum, Kassala, White Nile, North Darfur, East Darfur, Central Darfur, South Darfur

Communities, Refugee and IDP camp communities:

- Alagaya refugee camp residents and water treatment plant staff, White Nile
- Rural community water yard caretaker in Kassala Rural Locality
- Zamzam internally displaced persons camp residents, Health and Water Committees and water yard caretakers, North Darfur

Laboratories (including those within Ministries and State Water Corporations)

- Drinking Water and Sanitation Training (DWST) Centre laboratory, MoWRIE – Khartoum
- Groundwater and Wadis laboratory, MoWRIE – Khartoum
- Khartoum University, Environmental Health Laboratory
- State MoH Central laboratories – Khartoum; Kassala; East Darfur; South Darfur
- National Public Health Laboratory, FMoH - Khartoum
- SWC laboratories – Central Lab Khartoum at Mogran WTP; Burri Water Treatment Plant and laboratories, Khartoum; Central Lab, Kassala; Central Lab at Kosti Treatment works, White Nile; WES Lab East Darfur; WES Lab South Darfur; WES lab West Darfur; WES Lab Central Darfur

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- Airba
- Airwan Co.
- Bannaga Consult
- Co. Pact Company
- HACCP Co.

- National Company for Manufacturing Water Equipment
- NewTech
- Rasd Tech Company
- SIPCO Co.
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- Wagtech Projects

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- Khartoum:
  - Action on Disability and Development (ADD)
  - RedR Sudan
- South Darfur:
  - Ahmassar
- North Darfur:
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  - Assist
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Acronyms

AAU	Alzaem Alaazhari University
AC	Asbestos cement
AfDB	African Development Bank
AWD	Acute Watery Diarrhoea
CBI	Community Based [Development] Initiative
CBO	Community based organisations
CEHA	WHO Regional Centre for Environmental Health Actions
COR	Commission for Refugees
CPDD	Continuous Professional Development Directorate, FMoH
CSO	Civil Society Organisations (NGOs, CBOs, FBOs)
DFID	Department for International Development, UK Government
DG	Director General
DRR	Disaster risk reduction
DWI	Drinking Water Inspectorate
DWQ	Drinking water quality
DWS	Drinking water safety
DWST	Drinking Water and Sanitation Unit Training Centre
DWSU	Drinking Water and Sanitation Unit, MoWRIE (previously known as PWC)
EH	Environmental health
FAO	Food and Agriculture Organisation
FBO	Faith based organisation
FGD	Focus group discussion
FRC	Free residual chlorine
FMoH	Federal Ministry of Health
GDP	Gross Domestic Product
GWD	Groundwater and Wadis Directorate, MoWRIE
HAC	Humanitarian Aid Commission
HACCP	Hazard analysis critical control point
HDPE	High density poly ethylene
HP	Hygiene promotion / Health promotion
HP	Hand Pump
HPLC	High Performance Liquid Chromatography
H_2S	Hydrogen Sulphide
HTH	High test hypochlorite
HWTS	Household water treatment and safe storage
HYWY	High yield water yard
IDP	Internally displaced person
INGO	International non-governmental organisation
IOM	International Office for Migration
ISO	International Standards Organisation
IWRM	Integrated water resources management
JICA	Japan International Cooperation Agency
JMP	Joint Monitoring Programme, WHO/UNICEF
KAP	Knowledge, attitude and practice
KPI	Key performance indicator
LYWY	Low yield water yard
M&E	Monitoring and evaluation
MDG	Millennium Development Goals
MF	Membrane Filtration
MIC	Ministry of International Cooperation
MICS	Multi-Indicator Cluster Survey

MIS	Management information system
MLSB	Membrane Lauryl Sulphate Broth
MoE	Ministry of Education
MoENRPD	Ministry of the Environment, Natural Resources and Physical Development
MoFNE	Ministry of Finance and National Economy
MoWRIE	Ministry of Water Resources, Irrigation and Electricity
MoWSS	Ministry of Welfare and Social Security
MP	Motor pump
MPN	Most Probable Number
NERC	National Environmental Research Council
NaDCC	Sodium dichloroisocyanurate
NGO	Nongovernmental organisation
NPHL	National Public Health Laboratory, FMoH (formerly known as STAK)
NSHC	National Sanitation High Committee
O&M	Operation and maintenance
PAC	Polyaluminium Chloride
PoU	Point of use
PPE	Personal protective equipment
PTA	Parents and Teachers Association
RCF	Refugee Consultation Forum
RedR	Register of Engineers for Disaster Relief
RSF	Rapid sand filter
S&H	Sanitation and hygiene
SDG	Sustainable Development Goals
SDW	Safe drinking water
SDWSSF	Sudan Drinking Water Safety Strategic Framework
SHCC	School Health Coordination Council
SME	Small and medium sized enterprises
SMoUDPI	Ministry of Urban Planning and Infrastructure – at State level (in some States the title 'Infrastructure' may be replaced by 'Public Utilities' or 'Construction')
SNSHSF	Sudan National Sanitation and Hygiene Strategic Framework
SSF	Slow Sand Filter
SSMO	Sudan Standards and Metrology Organisation
SWC	State Water Corporation
SWM	Solid waste management
TAG	Technical Advisory Group
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
uPVC	Un-plasticised Poly Vinyl Chloride
UWA	Urban Water Authority
UW4D	Urban Water for Darfur
WASH	Water, sanitation and hygiene
WES	Water and Environmental Sanitation [Project]
WHO	World Health Organization
WTP	Water treatment plant

Key acronyms that have been used throughout the report:

- SDW – Safe drinking water
- DWS – Drinking water safety
- DWQ – Drinking water quality

Sudan data:

Sudan has 18 States, 182 Localities and 3 or more Administrative Units per Locality

Terminology and definitions

The following terminology has been adopted by the WHO/UNICEF Joint Monitoring Program (JMP)[1] or used by the Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF).

Table 1 - Terminology and definitions

Terminology and definitions as adopted by the WHO/UNICEF JMP	
Drinking water quality	A measurement of the presence of physical, chemical, biological or radiological constituents in drinking water, with reference to benchmark values, in a sample of water collected from a particular location.
Drinking water safety	The risk posed by use of a particular drinking-water source over extended periods. Measurement of water safety requires assessment of risk management in addition to water quality monitoring.
Water safety plan (WSP)	A WSP is a systematic risk assessment and risk prevention approach encompassing all steps in the water supply system from the catchment to the consumer.
Basic drinking water	An improved drinking water facility is defined as a source or delivery point that by nature of its construction, or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter. The following are considered as improved drinking water facilities: Piped drinking water; Supply on premises; Public taps/standposts; Tubewell/borehole; Protected dug well; Protected spring; Rainwater. Packaged water is considered improved if households use an improved water facility for other domestic purposes. Households are considered to have a basic water facility when they use an improved facility with a total collection time of 30 minutes or less for a roundtrip, including queuing.
Universal	Implies all exposures and settings including households, schools, health facilities, workplaces etc.
Equitable	Implies progressive reduction and elimination of inequalities between population sub-groups.
Access	Implies sufficient water to meet domestic needs is reliably available close to home.
Safe	Safe drinking water is free from pathogens and elevated levels of toxic chemicals at all times.
Affordable	Payment for services does not present a barrier to access or prevent people meeting other basic human needs.
Drinking water	Water used for drinking, cooking, food preparation and personal hygiene.
For all	Suitable for use by men, women, girls and boys of all ages including people living with disabilities.
Terminology as adopted for the SNSHSF	
Hygiene	The conditions and practices that help to prevent the spread of diseases and maintain health and dignity.
Hygiene promotion	A planned, systematic approach which encourages and enables people to take action and adopt safe hygiene practices and behaviours to prevent diseases and protect health.
English words for Arabic terms	
Zeer	A traditional clay pot used for storing drinking water (alternatively spelt as *Zir* or *Zyr*).
Wudu	Ablution, washing before prayer.

[1] WHO & UNICEF (2015, draft) *JMP Green Paper: Global monitoring of water, sanitation and hygiene post-2015*, Joint Monitoring Program, WHO & UNICEF; and UNICEF and WHO (2017) *Safely managed drinking water – thematic report on drinking water 2017*

1. Executive summary

Introduction to the Drinking Water Safety Strategic Framework

The aim of the Sudan Drinking Water Safety Strategic Framework (SDWSSF) is to provide strategic direction to the scaling up of access to safe drinking water (SDW) across Sudan. This will be through providing drinking water systems that are appropriately designed which effectively protect the drinking water at all times to minimise faecal contamination and elevated levels of toxic chemicals; and through ensuring that treatment processes are effective and sustainable.

The SDWSSF has been developed through a participatory and consultative process jointly led by the Ministry of Water Resources, Irrigation and Electricity (MoWRIE) and the Federal Ministry of Health (FMoH), it has involved representatives from Federal, State, Locality and community levels, across ministries and sectors (Health, Water and Environment) and has included representatives from government, civil society organisations, the private sector, higher education institutions, the UN and other development partners. The process has been financed by the Qatar Fund for Development and the World Health Organization (WHO), with some financial contributions also from UNICEF. The process has been supported by a core team consisting of the FMoH, MoWRIE, WHO, UNICEF and RedR Sudan.

An overview of the components of the SDWSSF can be seen in **Fig 1**.

Importance of drinking water safety

The need to increase attention on the safety of drinking water, rather than just the quantity has been acknowledged globally through the commitment to the Sustainable Development Goals (SDGs). SDG 6.1 focuses on achieving universal and equitable access to **safe** and affordable drinking water for all, and SDG 6.2 focuses on **improving water quality by reducing pollution**. The need for increased attention on drinking water safety (DWS) in Sudan has also been clearly illustrated by the AWD outbreak of 2016/17, which highlighted gaps and challenges being faced in ensuring DWS. See the box below for definitions of drinking water quality and drinking water safety[2].

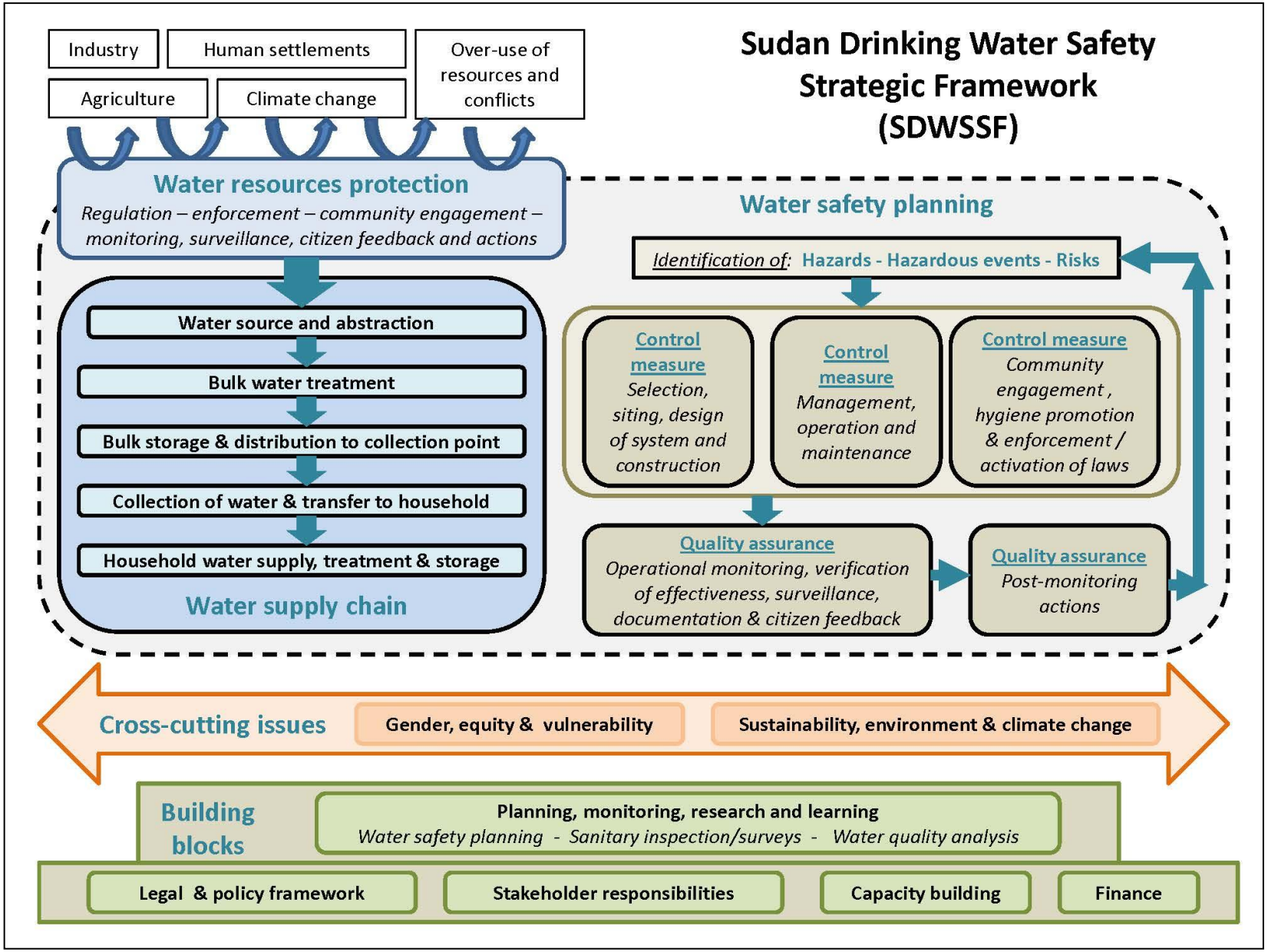
Drinking water quality (DWQ) = A measurement of the presence of physical, chemical, biological or radiological constituents in drinking water, with reference to benchmark values, in a sample of water collected from a particular location.

Drinking water safety (DWS) = The risk posed by use of a particular drinking-water source over extended periods. Measurement of water safety requires assessment of risk management in addition to water quality monitoring.

Access to SDW is critical for human health, dignity and economic development. It also contributes to the attainment of a number of human rights including, but not limited to: survival, attaining an adequate standard of living, health, education and gender equality. The safety of drinking water has a direct impact on a range of diseases and illnesses and increasing access to SDW contributes to improving child, maternal and neonatal nutrition and reducing morbidity and mortality. It increases the time that is spent in school and work, due to less time off due to sickness and looking after the sick and it reduces the workload burden, particularly on women and girls. Accessible water supply facilities can also contribute to ensuring health, dignity and quality of life for people with disabilities and mobility limitations and well sited and functioning facilities can also contribute to reducing vulnerabilities to violence for women and girls and in some cases men and boys, particularly in conflict zones. There is clear evidence that the child stunting rate increases with both a reduction of access to improved water sources and with higher levels of open defecation in the States across Sudan[3]. It is estimated that the Benefit-Cost-Ratio is 4.0 (i.e. for every 1 USD spent on water supply that 4.0 USD is gained[4]).

[2] UNICEF and WHO (2017) *Safely managed drinking water – thematic report on drinking water 2017*
[3] WFP and UNICEF (2016) *The case for investment in nutrition in Sudan*, February 2016
[4] Hutton, G. (2015) *Personal communication*, based on work undertaken for the World Bank in 2015

Fig 1 - Sudan DWS Strategic Framework



Hazards and risks

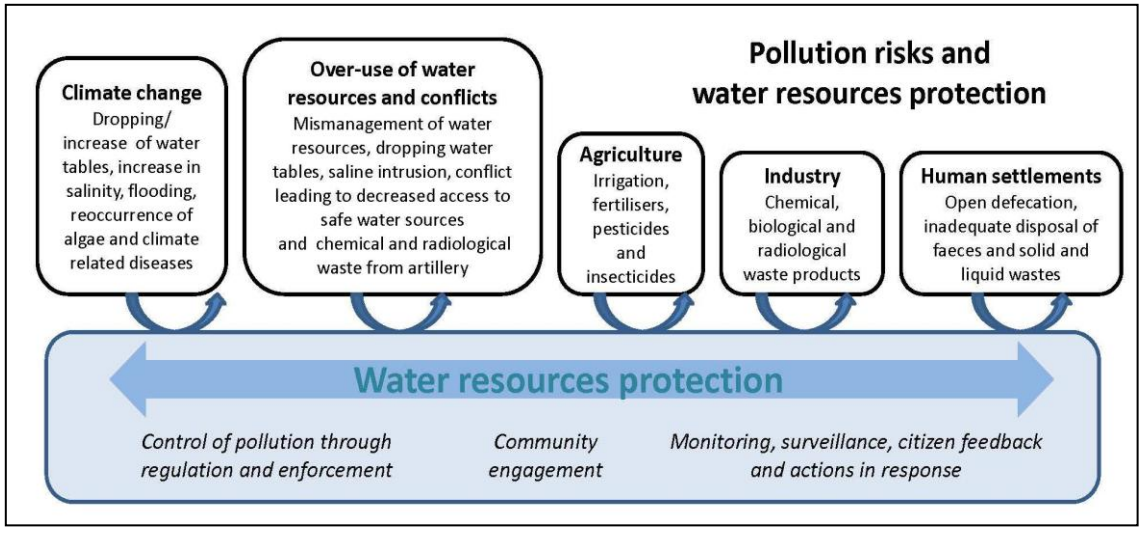
The Multi-Indicator Cluster Survey (MICS, 2014) indicated that an average of 68.0% of people have access to an improved water sources in Sudan, with an average of 63.8% and 78.3% in rural and urban areas respectively. Access varies greatly across the States from 27.7% in Gedaref and 32.7% in White Nile, to 88.9% in Gezira and 93.8% in the Northern States. Only 4.1% of households who use an unimproved water source use an appropriate water treatment method.

Hazards from drinking water may come from naturally occurring chemicals in the water or from external pollutants. These may occur due to: natural fluctuations in weather conditions; inadequate protection, siting, design and construction; inadequate management or operation and maintenance (O&M); or inadequate community engagement, communication and/or enforcement. In different areas of Sudan, problems are related to health risks, challenges for treatment or acceptance to consumers - with physical parameters such as turbidity, pH and temperature; or chemical parameters such as Fluorides, Nitrates, Chlorides, Total Dissolved Solids, Sulphates, metals, pesticides, insecticides, fertilisers, or petroleum products. Microbiological or biological hazards include a range of bacteria, viruses and protozoa, as well as algae. Examples of health based risks include AWD, Giardia, Shigella, Typhoid, Hepatitis A and E and Fluorosis.

Key challenges – in the sustainable supply of safe drinking water

Protection, selection, siting, design of system and construction – Sudan has over 38,000 water sources including groundwater, surface water and rainwater, with some cases including water that needs to be desalinated. Open defecation and poor management of wastes from human settlements including from septic tanks, wastes from industry and agriculture all pose challenges for DWS, as does the over-use of water resources, conflicts over water and climate change. See **Fig 2**.

Fig 2 - Pollution risks and water resources protection



Particular challenges are faced seasonally for the treatment of surface water due to the exceptionally high turbidity during the rainy season (up to 35,000 NTU), as most water treatment plant (WTP) systems were not designed effectively to deal with such high levels. WTPs in urban areas are aging and not all are fully functioning and the State Water Corporations (SWCs) find it difficult to afford the required chemicals for water treatment. Some refugee and internally displaced persons (IDP) camps and communities are using "compact units" which consist of all treatment processes combined into one compact system. However, due to population increases, sometimes these may be operating for many more people than they were designed for. Sudan regulations and guidelines recommend painting the insides of drinking water storage tanks, including those used in bottled water factories. Sudan does not however currently have processes for certifying the safety of non-toxic paints for use for rust prevention or waterproofing.

Management and operation and maintenance – Many of the piped networks are old and there are high levels of leakage. Repairs to the network tend to be reactive to complaints and to be only temporary fixes using rubber straps, rather than lasting solutions. Water supply tends to be intermittent, which risks the inflow of contaminants, and the lack of water meters in the networks and at households means that accurate leakage rates are not fully known. Some of the old asbestos piped networks are being replaced, but many still remain. Water yards and distribution points are sometimes poorly designed leading to ponding of water on the ground at collection points, which also poses contamination risks. Maintenance does not tend to be prioritised and not all SWCs know the actual cost required to maintaining a system effectively. Communities may also find it challenging to operate slow sand filters, which also struggle with high turbidity of water and many communities are still using open sources such as dams or *hafirs* with no water treatment. A number of examples were seen where no residual chlorine has been found at household level. This may be due to the water not being chlorinated correctly, inadequate chlorine levels for the heat and contamination levels, or the chlorine having lost its strength due to poor storage.

Community beliefs, engagement, hygiene promotion and enforcement / activation of laws – A number of community beliefs exist related to DWS, such that any water that is flowing is clean and also that chlorine is poison and can lead to disease or a person becoming infertile. These beliefs can become barriers to the acceptance of SDW. Most communities have not been involved in water safety planning and have had limited engaged in the issue of DWS, although their engagement has been increased during the AWD outbreak. In some communities, including in camps, there are Health and WASH Committees which are engaging in this issue. Some hygiene promotion efforts have included issues related to DWS and information is included in the FMoH health messages for schools, although it is reported to not be well integrated into the school curriculum. The use of the traditional clay pot or *Zeer*, poses challenges to DWS because traditionally the users share a cup and dip it into the pot to take water, both of which pose contamination risks. Some degree of enforcement of laws is occurring and it is reported to have been initiated by a range of stakeholders including State MoH, Localities and the Drinking Water and Sanitation Training (DWST) laboratory in the MoWRIE. It is reported that a number of water points have been shut down and private owners forced to chlorinate their water during the AWD outbreak.

Operational monitoring, verification of effectiveness, surveillance, documentation and citizen feedback -

A range of monitoring forms exist across stakeholders, some of which are clearly well used and others not so regularly or do not exist. There does not seem to be a consistency in formats across key institutions and there is also a risk that some results may be completed based on what is expected rather than the reality. Some WTPs are undertaking regular tests to optimise the dosage of chemicals, but not in all. The MoH and Locality water safety teams are trying their best to undertake their role of surveillance of DWS but they are incapacitated by very few staff (commonly only one or two per State and one per Locality); very limited access to vehicles, with some only getting out when they can travel in partner organisation vehicles; and limited access to funds. Some systems exist for citizens to complain to the SWC when there are problems, but a lack of trust that the SWC will act, often leads to people employing a private technician instead to remedy the problem. A recent study (2016/17) by the FMoH[5] of 55 bottled water factories across six states identified that there are multiple gaps and water quality risks. Only 34.5% of the factories had registration certificates, 23.6% of the factories do not sterilise their bottles before filling them and 40% of the factories fill and cap them manually; but at the same time 78.2% of the factories have no process for the sterilisation of the workers' clothes; and 45.5% of workers do not sterilise their hands before entering the halls. As a result *E.coli* or other microbiological contaminants were found in 16.4% of the samples tested.

Key challenges – Cross-cutting issues

Gender, equity and vulnerability – People who are chronically ill, older people, children and newborns are particularly vulnerable to the risks from unsafe drinking water, which can lead to disease or death. The MICS

[5] Karrar, A.N.A and Yousif, A.E. (2017) *Survey to Assess the Quality & Safety of Bottled Water in Sudan, 2017*, General Directorate of Primary Health Care, Environmental Health and Food Control Department, Water Quality and Safety Section, Federal Ministry of Health, Sudan

(2014) identified that in rural areas where households are less likely to have water on their premises, women are most likely to collect drinking water, then men, then girls and then boys. In urban areas men are more likely to collect water and then women and then boys and then girls. Challenges can be faced for people with disabilities or mobility limitations in reaching and carrying SDW from a distance and women and girls in particular can be vulnerable to violence when away from home collecting water, although this can also pose a challenge for men and boys particularly in conflict areas. Limited access to water supply can lead to conflicts, including in areas where there are both nomadic and sedentary populations. Many nomadic communities still use open water sources from dams or *hafirs*, which are also shared with their animals; and communities with large numbers of cattle, may be resistant to the protecting of shallow wells through the installation of a hand-pump, as they are more time consuming to use.

Sustainability, seasonality, environment, climate change and disaster risk reduction – There is a lack of sustainability of water supplies due to lack of attention and priority to on-going maintenance, the turnover of staff and poor quality spare parts. DWS is affected by the changing seasons and climate change, with increases in turbidity or algae which require additional treatment, and dropping water tables. Flooding can lead to damage to water sources and supply systems with ingress of pollutants. The viability of the main vibrio that causes the AWD in Sudan is also affected by the combination of temperature, salinity and pH and is transmitted mainly through drinking water or the eating of contaminated drinking food. There is a need to strengthen disaster risk reduction (DRR) to respond to the range of humanitarian contexts that Sudan faces, including disease outbreaks and the movement of people, whether refugees, IDPs or returnees, and their changing needs, as well as those of the host populations.

Key challenges – Building blocks

Legal and policy framework – It is estimated that 52 laws in Sudan make reference to drinking water and sanitation. A number of key laws, acts, regulations and standards have relevance to DWS with the most important ones being the: Environmental Health Law, 2009; Water Resources Code, 1995; Environmental Conservation (Protection) Act, 2001; Local Government Laws, 2003 and 2016; Regulations on DWS Control, 2014; Regulations of License of the Exploitation of Groundwater, 2014; and the Sudanese Drinking Water Quality Standards, 2016. The strategies and policies with most direct relevance to DWS include the Environmental Health Strategic Plan, 2015-16 and the Water, Sanitation and Hygiene (WASH) Sector Strategic Plan, 2012-16. The Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF) (2017) and is still in the process of being finalised. A review is underway of the policies and laws for Sudan with relevance to WASH. The documents noted above have a range of useful requirements related to DWS, but also some overlaps and gaps, including in relation to the institutions that are and are not responsible for the approval of the use of water sources for drinking. There are currently no Sudan specifications for drinking water related equipment and chemicals, so sometimes international or British Standards are referred to, particularly for construction.

A number of guidelines exist which are of relevance to DWS including: 14 technical manuals (only in English) by the MoWRIE/Drinking Water and Sanitation Unit (DWSU); a number by the FMoH including a Manual on Drinking Water Quality and Safety (2016); a new set of Emergency WASH Guidelines to complement the existing ones (to be published 2017); and the School Health Guidelines, 2016. Although these guidelines include a range of useful information, a number of gaps and inconsistencies have also been identified, which need to be aligned in future updates. The existing chlorination guidelines are being updated.

Stakeholder responsibilities – Challenges related to stakeholder responsibilities have included a lack of clarity on some responsibilities, including over who should undertake surveillance, can approve the use of water sources for drinking and also who can enforce, including in relation to bottled water factories. Currently separate monitoring activities are being undertaken in relation to bottled water companies by the Sudanese Standards and Metrology Organisation (SSMO), the FMoH and the DWST laboratory/ MoWRIE, with no coordination between them. The MoH at all levels and the Localities have clear responsibilities for the approval of water for drinking purposes and enforcement in relation to food and drink related outlets including bottled water producers, but for the MoWRIE and the SWCs the legal authority for the same is not

clear. This poses some challenges for the approval of water sources for drinking water because the SMoHs and Localities do not currently have laboratories with the capacity to prove compliance with Sudanese DWQ standards. Responsibilities for the key stakeholders have been grouped in an overview diagram (see **Fig 3**) around the areas of: a) Environmental protection of water resources; b) Control of water resources and supply of safe drinking water; and c) Surveillance of safe drinking water and enforcement and sanitation and hygiene promotion. The private sector undertakes a range of roles in Sudan from the provision and supply of equipment, water quality testing consumables and chemicals, and small scale ice and bottled water sellers, to technical construction services and advisory services. Major challenges that are faced by the private sector include: a lack of knowledge on the laws, regulations and standards of Sudan; challenges with accessing foreign currency; late payment of contracts and no contingency for inflation; high import taxes and problems with getting items cleared through customs in a timely manner.

Financing and advocacy – The World Bank estimates that 1.96% of GDP would need to be spent annually between now and 2030 for Sudan to reach the SDG on achieving universal access to safe drinking water (on-plot, continuous and safe water supply) and 0.22% annually to reach the target of reaching universal access to basic drinking water supply (Joint Monitoring Programme (JMP) 'improved water' but within 30 minutes of the home roundtrip). There is a lack of prioritisation and budget allocated to DWS in Sudan from government, development partners and other actors, which results in a range of the challenges noted above, including a lack of chemicals and ineffective treatment, and inadequate logistics and limited staff for DWS surveillance. Some SWCs have confirmed they do not know the real costs of effective maintenance to sustain their services and the water tariffs being collected are highly inadequate to cover the real costs of the services (including the costs for salaries and allowances; operation and maintenance; and depreciation). It is estimated that the cost recovery ratio for the SWC services in 4 main towns in the Darfur States were between 45% to 66% for three of the four towns and 95% for the other (data from Jan-March 2017)[6]. It has also been established in the same four Darfur towns and in Port Sudan that the low tariff effectively disadvantages the poorest members of the community the most, as they pay significantly more through purchasing water from water vendors than if they had been able to have a household supply by pipe. The poorest members of the community may pay up to 20 times the amount that households pay that have a piped supply for the same volume.

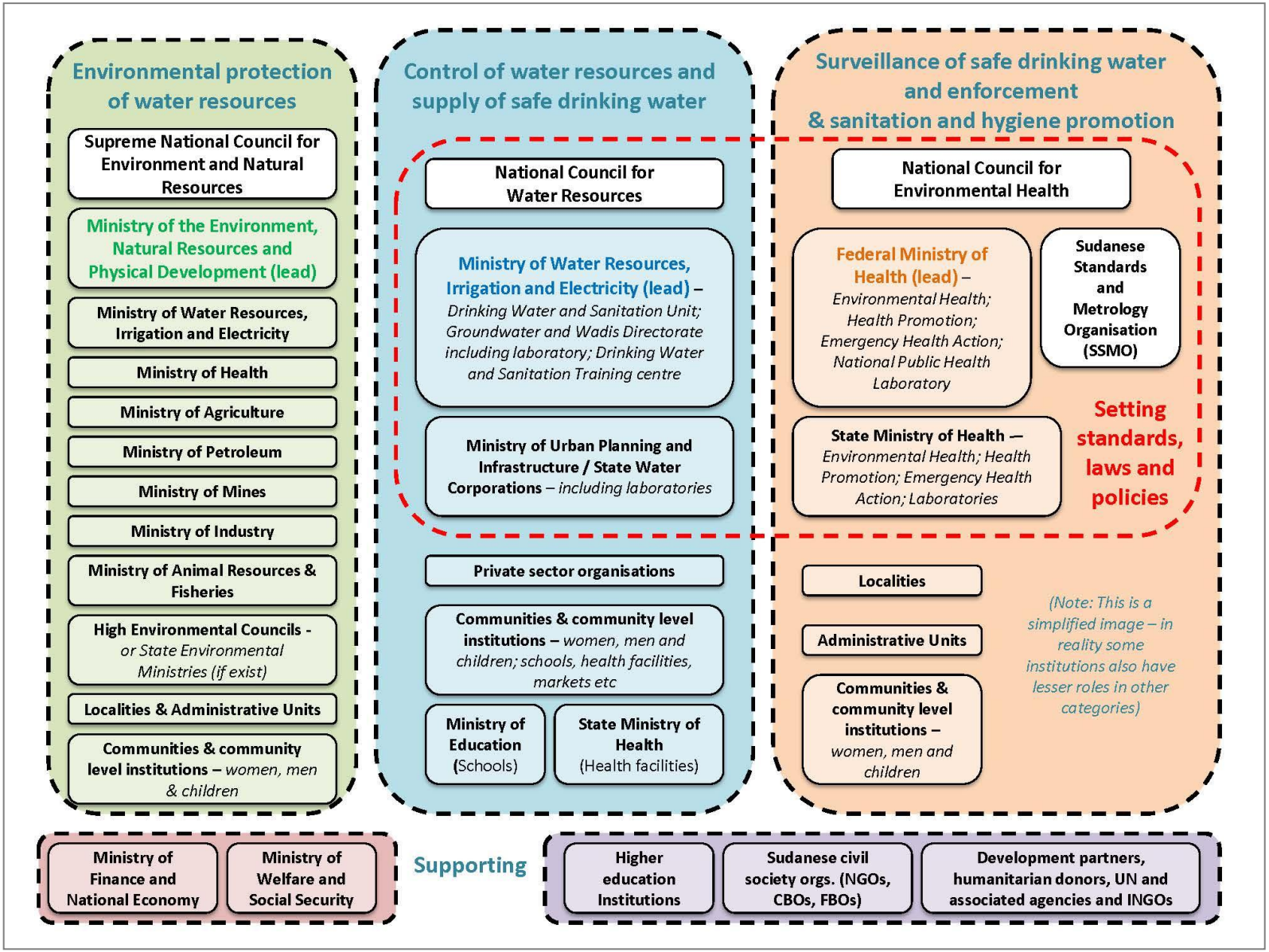
Planning, monitoring, research and learning – Water safety plans (WSPs) which identify and respond to risk factors for DWS are not yet widely implemented in Sudan, although recently a number of staff at Federal, State and Locality levels have been introduced to WSPs and a few WSPs have been trialled. 270 participants were also trained by the FMoH on the use of the FMoH DWQ and Safety Manual 2016, which includes the use of sanitary inspections/surveys. Examples were seen where monitoring was being undertaken and results reported from SMoH and Localities to a SWC for action during the AWD outbreak. Some monitoring of hygiene and water quality at household level is occurring, although this does not seem to be widespread practice. There are multiple and overlapping databases that record both water sources and water quality, across institutions and levels, although some are not currently active and some are being updated. The strongest database from the perspective of DWS is the spreadsheet based mapping system implemented by the FMoH/SMoH with the support of WHO. This includes information on the source, sanitary inspection / risk scores and water quality data.

Capacities and capacity building –

The teams working specifically on DWS in the FMoH, SMoH and Localities are small, tending to only be one or two staff with no access to their own vehicles and limited financial resources. Salaries for Environmental Health Professionals at all levels, staff within the SWCs and for university lecturers also tend to be low, which leads to a high turnover of staff, including those who leave for the Gulf States. A number of laboratories have five or more staff, but this varies across institution and location.

[6] Urban Water Administration Offices (2017) *Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala*

Fig 3 - Categories of stakeholder responsibilities for DWS



There are many DWQ laboratories in Sudan, including the central laboratories for the FMoH, the MoWRIE / Groundwater and Wadi's Directorate (GWD), the SSMO and the National Environmental Council at Federal level, with some laboratories of other Ministries being used for specific contaminants (such as related to mining, petroleum or radiological contaminants). Most SWCs and SMoH have some form or laboratory or access to field testing equipment, but not all is currently used. Some Localities have access to field equipment. The capacity of laboratories in terms of laboratory space, equipment and staff varies significantly across institution, location and level. Major challenges are being faced for the purchase of and maintenance of equipment, the purchase of consumables (for some labs) and access to logistics to be able to take samples. Only two laboratories in the country have the ability to test for pesticides and insecticides.

A range of departments across universities and higher education institutions provide training on DWS (for example: Public Health; Environmental Health; Water Resources Engineering; and Environmental Engineering), but they may face challenges to provide adequate opportunities for students to gain practical and laboratory experience due to large numbers of students and limited laboratory access and equipment. A number of students have completed projects related to DWS which could potentially be better used by the sector. The DWST in the MoWRIE runs training on DWQ as well as a range of other courses, including one on the maintenance of drinking water systems which appears to be the only such course in the country. The FMoH Continuous Professional Development Directorate (CPDD) also runs training courses, including one on DWQ and surveillance, usually given to SMoH or Locality level Public Health Officers. A number of INGOs and UN agencies also support training, including some that have recently started to train on WSPs.

Vision and purpose of the SDWSSF

Vision of the SDWSSF: All people in Sudan have sustainable access to and use safe drinking water, contributing to the upholding of a range of human rights and the longer term prosperity and development of Sudan.

Purpose of the SDWSSF: To contribute to scaling up access to SDW across Sudan in development, humanitarian and transitional contexts through:

1. Providing clear strategic direction, leading to increased harmonisation of approaches by all stakeholders across sectors, including government, non-governmental organisations and the private sector.
2. Increasing understanding of the cross-sectoral responsibilities and the contributions related to the supply, monitoring and sustainability of SDW to upholding a range of rights for the people of Sudan, including, but not limited to, rights to: education, health, nutrition, dignity, gender equality and economic development.
3. Encouraging increased collaboration, partnerships and engagement across sectors, resulting in increased commitment, resources, learning and strengthened capacities of all stakeholders.

Strategic objectives

The following are the strategic objectives (SO) of this strategic framework. Under each SO a number of strategies have been developed - these can be seen in **Sections 5 to 7**.

A - Control measures for DWS

Supply – Protection, selection, siting, design of system and construction

1. To improve the protection of water resources
2. To select, site, design and construct systems that maximise the safety and sustainability of drinking water supplies for the population of Sudan, including populations in refugee and IDP contexts

Supply - Management and operation and maintenance

1. To strengthen management processes and commitment and action on operation and pro-active maintenance that will underpin the availability of sustainable SDW for the population of Sudan

Demand - Community engagement, hygiene promotion and enforcement/ activation of laws

1. To strengthen hygiene promotion with, and community engagement of, the population of Sudan to facilitate actions to improve sustained access to SDW at household level
2. To increase the effectiveness of the process of enforcement/ activation of laws / activation of laws to act as a motivator for drinking water suppliers to improve the consistency of SDW in Sudan

Quality - Operational monitoring, verification of effectiveness, surveillance, documentation and citizen feedback

1. To strengthen commitment to monitoring, evaluation, surveillance and documentation
2. To increase regular practice and quality of monitoring, evaluation, surveillance and documentation

B – Cross-cutting issues

Gender, equity and vulnerability

1. Ensure that SDW supplies respond effectively to the needs of all people in Sudan, particularly women and girls, people with disabilities or mobility limitations and those who may be disadvantaged or in marginalised or particularly vulnerable situations

Sustainability, seasonality, environment, climate change and disaster risk reduction

1. To increase the sustainability and safety of drinking water systems, including from the effects of climate change across the seasons, and improving SDW related behaviours
2. To protect the environment through effective design, siting and management of drinking water systems
3. To strengthen DRR to improve sustained access to SDW during times of humanitarian crisis

C – Building blocks

Legal and policy framework

1. To update and strengthen the overall coherence of the legal and policy framework for SDW in Sudan

Stakeholder responsibilities

1. To clarify the institutional responsibilities for SDW across Ministries and between all stakeholders and strengthen inter-sectoral coordination
2. To maximise the potential of the private sector of different types and sizes in the supply of SDW in Sudan
3. To create an enabling environment and strengthen regulation of the private sector involved in the provision of SDW in Sudan

Financing and advocacy

1. To significantly increase the political commitment for DWS in Sudan including increase in investment and financial allocations for the provision of SDW in Sudan
2. To increase commitment and action to ensure adequate finances are available for operation and maintenance of drinking water systems
3. To identify and propose new financial resources for SDW in Sudan, with the participation of and from communities, from across sectors, the private sector, from micro-finance and through cross-subsidies

Capacities and capacity building

1. To build the capacity of the professionals of the future to work in SDW at all levels using an array of capacity building approaches to train, coach and mentor, through the provision of resources and equipment and through the development of systems which will enable the capacities to be utilised
2. To strengthen the capacities of the existing training and educational institutions which train sector professionals on DWS
3. To utilise the knowledge and skills of the higher education institutions to undertake applied research, assessments and evaluations related to SDW, whilst also updating the knowledge of the lecturers

2. Introduction

2.1 Aim of the framework

The aim of the Sudan Drinking Water Safety (DWS) Strategic Framework (SDWSSF) is to provide strategic direction to the scaling up of access to Safe Drinking Water (SDW) across Sudan. This is to ensure that when drinking water is provided that the system is appropriately designed and the drinking water is effectively protected at all times to minimise faecal contamination and elevated levels of toxic chemicals; and that treatment processes are effective and sustainable.

The table which follows highlights the differences between drinking water quality and drinking water safety.

Fig 4 - Drinking water quality versus drinking water safety

Drinking water quality	A measurement of the presence of physical, chemical, biological or radiological constituents in drinking water, with reference to benchmark values, in a sample of water collected from a particular location.
Drinking water safety	The risk posed by use of a particular drinking-water source over extended periods. Measurement of water safety requires assessment of risk management in addition to water quality monitoring.

The need to increase attention on DWS rather than just the quantity of drinking water supply has been acknowledged globally as the world has moved into the period of the SDGs. The need for increased attention on DWS has also been illustrated by the AWD outbreak of 2016/17, which highlighted the gaps and challenges being faced in ensuring DWS across Sudan. This SDWSSF is a longer term framework that will complement the 5-year WASH sector strategy (under preparation 2017), the Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF) (under finalisation 2017) and the Environmental Health Strategic Plan (2016) by providing more detail on the specific strategies for strengthening DWS.

2.2 Structure of the framework

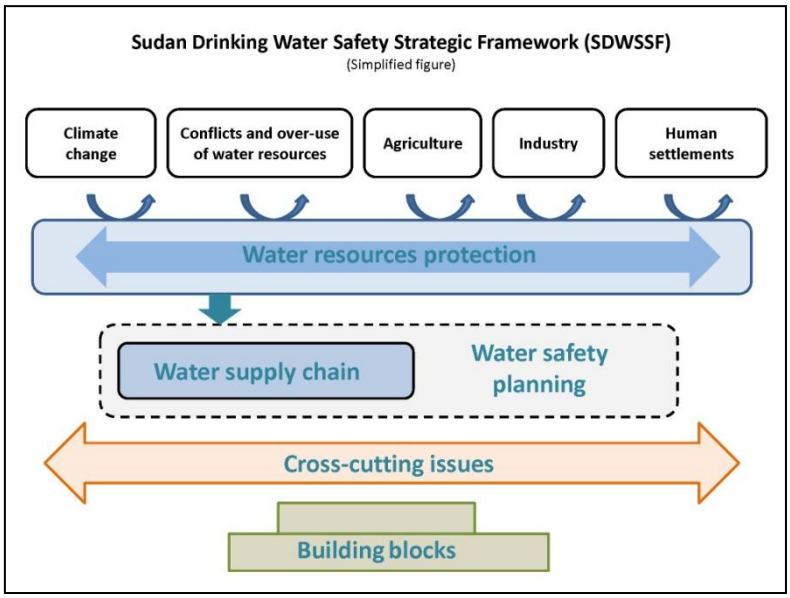
The SDWSSF has been structured around the elements indicated in the overview diagram - **Fig 1 & 5**:

- **Water resources protection** – From a range of pollutants and misuse
- **The elements of the water supply chain** - From source to point of use (whether in the household or at institutional levels)
- **The elements of water safety planning** - From identification of hazards and hazardous events and risks to control measures, to monitoring, verification, surveillance, citizen feedback and post-monitoring actions
- **Cross cutting issues** – Gender, equity and vulnerability; and sustainability, seasonality, environment, climate change and disaster risk reduction
- **Building blocks** – Planning, monitoring, research and learning (including water safety plans (WSPs), sanitary inspection/ survey and water quality analysis); Legal and policy framework; Stakeholder responsibilities; Capacity building; and Finance

The strategic framework is structured:

- **Section 3** – Current situation of DWS in Sudan
- **Section 4** – Vision, purpose and principles of the SDWSSF
- **Section 5** – Strategies – DWS in Sudan - Control measures
- **Section 6** – Strategies – DWS in Sudan - Cross-cutting issues
- **Section 7** – Strategies – DWS in Sudan - Building blocks

Fig 5 - Simplified Sudan Drinking Water Safety Strategic Framework (SDWSSF)



In the annexes:

- **Annex I** – Stakeholder responsibilities
- **Annex II** – Practical strategies for improving DWS along the water supply chain
- **Annex III** – Reference for consistency of guidelines related to DWS
- **Annex IV** – References

The SDWSSF is also supported by a contextual analysis report which provides evidence of why the strategies identified in the SDWSSF are needed. This report is summarised in **Section 3**.

2.3 The importance of investing in DWS in Sudan

Access to SDW is critical for human health, dignity and economic development. It also contributes to the attainment of a number of human rights, including but not limited to: survival, attaining an adequate standard of living, health, education and gender equality. Increasing access to SDW contributes to improving child, maternal and neonatal nutrition and reducing morbidity and mortality. It increases the time that is spent in school and work, due to less time off due to sickness and looking after the sick and it reduces the workload burden, particularly on women and girls. Accessible water supply facilities can also contribute to ensuring health, dignity and quality of life for people with disabilities and mobility limitations and well sited and functioning facilities can also contribute to reducing vulnerabilities to violence for women and girls and in some cases men and boys, particularly in conflict zones.

In relation to health, the safety of drinking water has a direct impact on diseases such as: Acute Watery Diarrhoea (AWD), Shigella, Amoebic dysentery, Giardia, Guinea worm, typhoid, polio, Hepatitis A and E and fluorosis. It also can lead to *methaemoglobinamia* (blue baby syndrome) in young babies (caused by nitrates and nitrites) and potentially poisoning from arsenic (although it is not confirmed if this is a problem in Sudan). Poisoning of different kinds can also occur due to the toxins from blue-green algae or other contaminants such as metals, pesticides, insecticides or fertilisers.

There is clear evidence that the child stunting rate also increases with both a reduction of access to improved water sources and with higher levels of open defecation in the States across Sudan[7]. It is estimated that the Benefit-Cost-Ratio is 4.0 (i.e. for every 1 USD spent on water supply that 4.0 USD is gained)[8].

[7] WFP and UNICEF (2016) *The case for investment in nutrition in Sudan*, February 2016
[8] Hutton, G. (2015) Personal communication, based on work undertaken for the World Bank in 2015

2.4 Global commitments and measurements of SDW

2.4.1 Sustainable Development Goal targets

The move from the Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDG) has brought an increased focus on the safety of drinking water as well as access, equity, universal coverage and 'leaving no-one behind'[9]. The most relevant targets are highlighted in the box below.

SDG target 6.1 – By 2030, achieve universal and equitable access to **safe** and affordable drinking water for all

SDG target 6.3 – By 2030, improve water quality by **reducing pollution**, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially reduce the number of people suffering from water scarcity.

Other targets that access to SDW have relevance to include: Reducing poverty and achieving universal access to basic services (1.1 and 1.2); ending all forms of malnutrition (2.2); ending preventable child deaths, combating neglected tropical diseases and waterborne diseases, and achieving universal health coverage (3.2, 3.3, 3.8 and 3.9); providing safe and inclusive learning environments (4a); ending violence against women and girls and reducing gender inequality (5.2 and 5.4); ensuring adequate, safe and affordable housing for all (11.1) and reducing deaths caused by disasters (11.5).

The JMP has also developed a service ladder to facilitate improved monitoring of safely managed drinking water during the SDG era. See **Fig 6**.

Fig 6 - JMP drinking water ladders for the household, schools and health facilities

Service level	Definition
Safely managed	Drinking water from an improved water source which is located on premises, available when needed and free of faecal and priority contamination
Basic	Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing
Limited	Drinking water from an improved source where collection time exceeds over 30 minutes for a roundtrip to collect water, including queuing
Unimproved	Drinking water from an unprotected dug well or unprotected spring
No service	Drinking water collected directly from a river, dam, lake, pond, stream, canal or irrigation channel

JMP drinking water ladder for the household

Advanced service	To be defined at national level (e.g. water is available when needed, accessible to all, free from contamination, etc)
Basic service	Water from an improved source is available at the school
Limited service	There is an improved source but water is not available at the time of survey
No service	No water source or an unimproved source

JMP drinking water ladder for schools

Advanced service	To be defined at national level (e.g. water is available when needed, accessible to all, free from contamination, etc)
Basic service	Water from an improved source is available on premises
Limited service	There is an improved source, but it is not on premises or water is not available
No service	No water source or an unimproved source

JMP drinking water ladder for health facilities

[9] The information in this section has been sourced from: WHO & UNICEF (2015, draft) *JMP Green Paper: Global monitoring of water, sanitation and hygiene post-2015*, Joint Monitoring Program, WHO & UNICEF; and UNICEF and WHO (2017) *Safely managed drinking water – thematic report on drinking water 2017*

2.4.2 International Health Regulations, 2005

The SDWSSF supports efforts to reduce the risk of diseases that may be transmittable across country boundaries and that are reportable under the International Health Regulations, 2005 (IHR, 2005).

2.4.3 Drinking water safety versus drinking water quality

Drinking water quality is defined by the JMP as: *'A measurement of the presence of physical, chemical, biological or radiological constituents, with reference to benchmark values, in a sample of water collected from a particular location'.*

Whereas **drinking water safety** is defined as: *'The risk posed by use of a particular drinking-water source over extended periods. Measurement of water safety requires assessment of risk management in addition to water quality monitoring'.*

The JMP also recognises that:

- Contamination of water can be highly variable in time and hence brief contamination risks can be missed with routine surveillance, but still have serious public health outcomes.
- The indicator for faecal contamination, *E.coli*, is more easily inactivated in treatment than some other pathogens and hence the absence of *E.coli* does not guarantee safety.
- Improved sources are more likely to be free of microbiological contamination than unimproved sources.
- Water can become contaminated after the point of supply and before the point of use in the household.
- Some households use multiple sources of water.

The WHO Guidelines for Drinking Water Quality, 2011, promoted a framework for DWS. This consisted of three key tools:

1. **Target setting** – Setting national standards for contaminants that have concentrations that have the greatest health impact.
2. **Water safety plans** – WSPs are a systematic risk assessment and risk prevention approach encompassing all steps in the water supply system from the catchment to the consumer.
3. **Independent surveillance** – The surveillance of water quality at critical points in the system provides an independent assurance that the WSP is appropriate and that the chosen barriers are correctly implemented and effective in ensuring that the water quality is meeting the national standards.

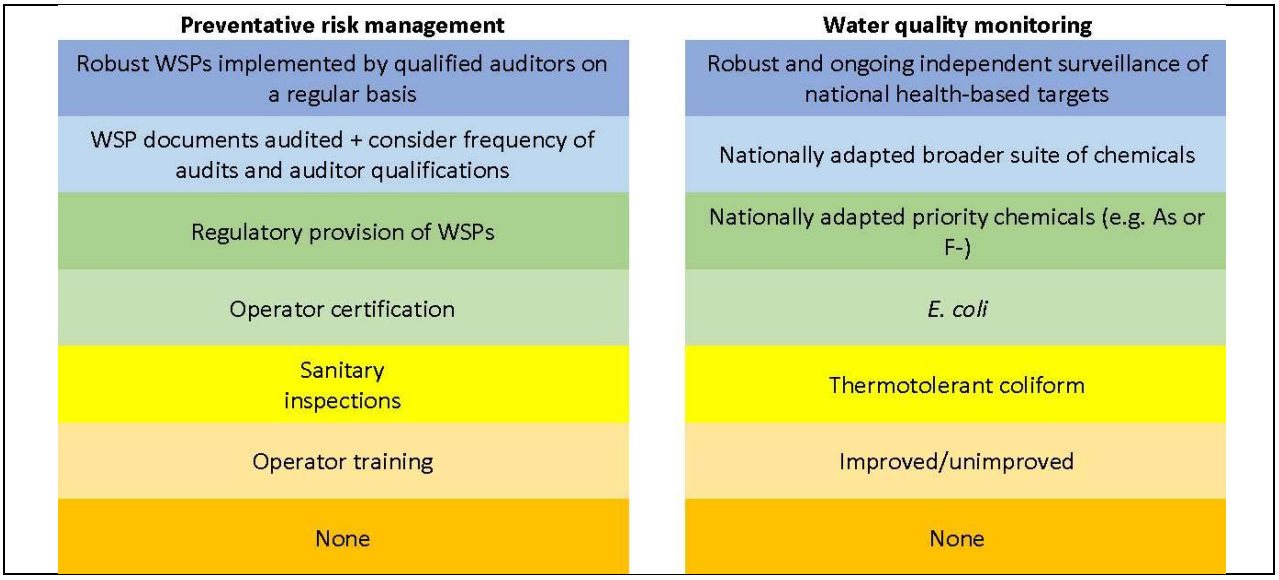
Emerging water safety ladders have also been established for preventative risk management and water quality monitoring. See **Fig 7**.

The measurement of safety managed drinking water poses a number of methodological challenges that all countries and the JMP will be tackling and refining over time as the world progresses through the period of the SDGs.

2.4.4 Water safety plans (WSPs)

A wide range of documentation and guidance materials have been developed by WHO and the International Water Association (IWA) along with other organisations on WSPs and a wide range of examples of how plans have been used in different countries and contexts exist.

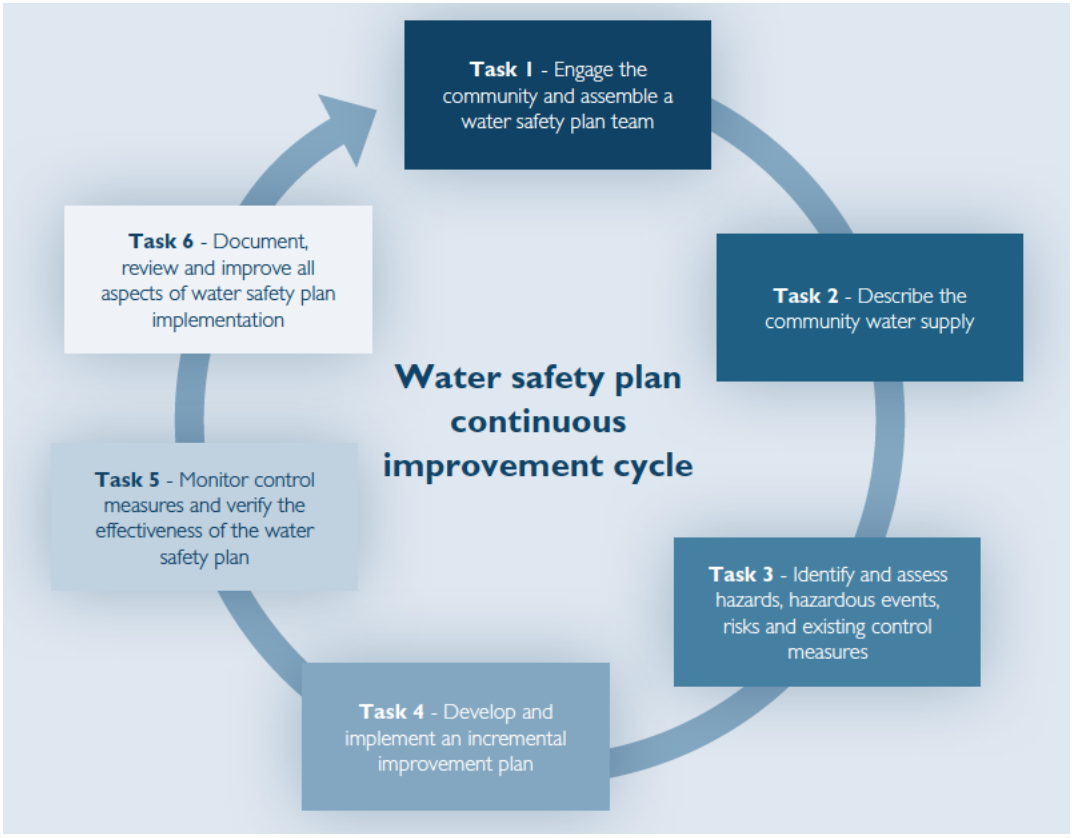
Fig 7 - Emerging JMP water safety ladders for preventative risk management and water quality monitoring



The WSP incorporates 6 key tasks and can be used for large scale water corporation managed water supply systems to community-based supplies[10]. See **Fig 8** – for the standard 6 tasks undertaken as part of WSPs.

Each of these tasks has been integrated onto different elements of this SDWSSF.

Fig 8 - Water safety planning – 6 tasks



[10] WHO and IWA (2009) *Water Safety Plan Manual, Step-by-step risk management for drinking-water suppliers; and* WHO and IWA (2012) *Water Safety Planning for Small Community Water Supplies; Step-by-step risk management guidance for drinking-water supplies in small communities*

3. Current situation of DWS in Sudan

3.1 Sudan context

The Republic of the Sudan is the third largest country in Africa with a land area of 1,886,860 square kilometres and a population of 39,598,000 million with an annual growth rate of 2.4% (Central Bureau of Statistics estimated data, 2016). It has borders with 7 countries: Egypt, Libya, Chad, Central African Republic, Eritrea, Ethiopia and South Sudan and is split into 18 States, each sub-divided into *Mahalias* / Localities, each sub-divided again into Administrative Units.

The majority of the population in Sudan embraces Islam, with a smaller proportion embracing Christianity and African traditional religions. Sudan has wide cultural diversity with hundreds of different groups that speak hundreds of different languages and dialects, many of which are native to Sudan.

Whilst much of Sudan is peaceful, it also faces multiple humanitarian emergencies of varying kinds, including conflicts, refugees, internally displaced persons (IDPs), disease outbreaks, floods and droughts. The area of Sudan with the largest population affected by humanitarian emergencies is the Darfur Region, following conflict related displacements occurring in North, Central and Eastern Darfur.

In November 2017, the data for people in need affected by emergencies estimated at:

- People in Need: 5.8 million
- Internally Displaced Persons (IDPs): 2.3 million
- Refugees: 1.2 million
- Returnees: 301,000
- Residents: 1.95 million

Locations for most IDPs, refugees and returnees include:

- **IDPs -** the majority in: Central, East, North, South and West Darfur; but others also in: South Kordofan; West Kordofan; Blue Nile; Sennar; Red Sea; Khartoum and White Nile.
- **Returnees from Chad, South Sudan and Ethiopia** – in: South, North, East, Central and West Darfur; as well as in Blue Nile, Sennar and White Nile
- **Refugee arrivals from South Sudan –** Most in Khartoum, White Nile, West Kordofan, East Darfur and South Kordofan; but also some in: Abyei, Red Sea, Blue Nile, Northern, Gezira, River Nile, Gedaref, Sennar, North Kordofan and Kassala

Data from UNHCR[11] indicates that in 2017, there have been 182,100 refugees arriving from South Sudan until the 31st August 2017. These have arrived to the following States in order by largest numbers: White Nile, East Darfur, South Darfur, South Kordofan, West Kordofan and North Darfur.

The situation is complex with combinations of protracted and new emergencies in rural and urban contexts and with challenges in accessing some areas, particularly in Central Darfur.

In order to ensure appropriate targeting and design of interventions, it is critical to understand the variations in situation for the poorest versus richest households, between States and between rural and urban contexts. In general a child from a rural household in the poorest wealth quintile, is more likely than their urban peers or those from higher wealth quintiles to: a) not have been born at a health facility, b) to practice open defecation, c) not have access to improved water and sanitation facilities, c) to die before they are 5, d) be malnourished, e) not go to school, f) to be illiterate, and g) to be married before they are 19 years old[12].

[11] UNHCR (2017) *Sudan – Refugees from South Sudan*, 31 Aug 2017
[12] i.e. up until they are 18 years old

3.2 DWS in Sudan – Hazards, hazardous events and risks

3.2.1 Hazards

The MICS survey (2014) indicated that an average of 68.0% of people has access to an improved water sources in Sudan, with an average of 63.8% to 78.3% in rural and urban areas respectively. Access varies greatly across the States from 27.7% in Gedaref and 32.7% in White Nile, to 88.9% in Gezira and 93.8% in the Northern States. Access for people in the poorest wealth quintile is estimated at 45.5% and the highest wealth quintile at 96.0%.

Only 4.1% of households who use an unimproved water source use an appropriate water treatment method; only 40.9% have a dedicated place for hand-washing and 25.8% have a dedicated place as well as access to water and soap. 43.4% of the population have water (improved or unimproved) on their premises, 19% have to walk for less than 30 minutes to collect water, 31.4% walk longer than 30 minutes and 6.2% don't know.

Groundwater, surface and rainwater are all used in Sudan. The main sources of pollution for surface water sources are from open defecation, sewage effluents from septic tanks, human activities involving the use of pesticides and fertilisers and industrial effluents and wastes. The main sources of contaminants for deep groundwater come from natural sources, some intensified by depleting groundwater levels which have concentrated natural contaminants. Shallow groundwater (from Wadis) is also polluted by septic tanks particularly in urban areas, or in some cases, through boreholes being used for the disposal of sewage. Other risks come from inappropriate siting near to waste disposal areas and disposal of hazardous wastes including electronic wastes, and poor waste management from slaughterhouses, which may leach into the groundwater.

A range of challenges are faced from water quality parameters and contaminants in different locations and different water sources across Sudan. These pose risks to health, acceptability to the consumer or the challenges for water treatment. They include:

- **Physical** – Turbidity, temperature and pH
- **Chemical** – Fluorides, Nitrates, Nitrites, Ammonia, Sulphates, Total Dissolved Solids, Chlorides, Iron, Bromium, mercury and other metals, pesticides, insecticides, fertilisers and petroleum products[13].
- **Microbiological** and **biological** – Faecal contamination (bacteria, viruses and protozoa) – a wide range contributing to the diseases indicated in **Section 3.2.3;** as well as algae, including blue-green algae for certain months of the year[14].
- **Radiological –** Some risks in Darfur and North/South Kordofan.

3.2.2 Hazardous events

Table 2 - summarises the hazardous events applicable to Sudan along the drinking water supply chain. The likelihood of these different events will vary depending on whether the drinking water supply is from an urban WTP or network, or the source is in a rural area. The user water collection and handling habits can pose some of the largest risks to DWS

[13] It is not clear if Arsenic also exists in groundwater in Sudan, due to limited testing.

[14] Fathelbari, M.O (2014) *Algal Removal Strategies and Treatment Options in Drinking Water Bodies (River Nile), Khartoum State – Sudan, July 2014*, Final Paper, 37th International Postgraduate Course on Environmental Management for Developing and Emerging Countries, Technical University of Dresden

Table 2 - Possible hazardous events related to DWS in Sudan

Water source and abstraction	Bulk water treatment	Bulk storage and distribution system to collection point	Collection of water and transfer to household	Household water supply, treatment and storage
Related to natural fluctuations: 1. Flooding leading to contamination of source 2. Seasonal turbidity variations (surface sources and shallow wells) Related to poor selection, design, siting or construction: 3. Poorly designed abstraction point, lack of protection or damage to / cracks in abstraction structure 4. Latrines or septic tanks nearby, high water tables and sandy soils Related to inadequate management, operation and maintenance: 5. Over abstraction / over capacity of borehole 6. Surface water inlets blocked with weeds 7. Inlet pipe to surface water source gets damaged, access is difficult for repair 8. Animals accessing water source 9. Lack of ability to test quality of source water (lack of equipment, consumables, loss of staff)	Related to natural fluctuations: 1. Flooding leading to damage of water treatment plants Related to poor selection, design or siting: 2. Poorly designed treatment process – including ineffective dosing methods Related to inadequate management, operation and maintenance: 3. Lack of or inappropriate use of chemicals 4. Chemical strength degraded and lack of check 5. Turbidity too high at point of chlorination 6. Limitations in operator knowledge, capacity, or errors 7. Short circuiting in tanks 8. Power failures 9. Poor maintenance of treatment units 10. Treatment units out of action due to damage or need for repair and no alternative 11. Build up of bio-films or algae 12. Disposal of sediments in a way that risks contamination of the source	Related to natural fluctuations: 1. Flooding leading to flooding of underground tanks or damage to the network Related to poor selection, design, siting or construction: 2. Poorly designed water storage units with inadequate protection from pollution or with increased difficulty for cleaning 3. Intermittent or low pressure supply leading to inflow of contaminants in pipes 4. Air blocks in pipeline resulting in reduced velocity, due to bad initial design and/or pipe laying, or no consideration of design when tapstands /extensions added later – leading to reduced flow and people going to alternative potentially less safe sources 5. Water hammer and excessive flow at taps resulting in tap damage and water wastage, due to bad initial design or lack of means to reduce pressure at tapstand 6. Lack of properly constructed valve chambers making repair more challenging 7. Collection points are located in areas where some people (such as women, girls or minority groups) do not feel safe to collect water – leading to them taking water from unsafe sources Related to inadequate management, operation and maintenance: 8. Poor O&M of storage, pipelines and collection points 9. Illegal connections **Pipes:** 10. Leakage of pipes 11. Ineffective pipe repairs due to lack of knowledge, inadequate numbers of isolating valves to allow pipe drying (for PVC pipes) or suitable pipe bonding equipment (for PE pipes) 12. Corrosion of pipes 13. Irregular, poor or non-existent cleaning of pipes (including due to lack of appropriate equipment) **Tanks:** 14. Rusting and leakage of tanks 15. Cracks and build up of sludge or other contaminants in tanks 16. Ingress of runoff through inspection covers **Distribution point:** 17. Ponding of water around tapstands and pipes	Related to natural fluctuations: 1. Flooding leading to flooding of or reducing access to collection points 2. Conflict leading to reducing access to water collection points Related to poor selection, design, siting or construction: 3. Taps giving water do not match the opening of the containers used for collection and transfer (e.g. handpump spout larger than jerry can, thereby wasting water and ponding of water) 4. Buckets used to abstract water from shallow wells Related to inadequate management, operation and maintenance: 5. Containers for collection and transfer are contaminated by stagnant water at collection or abstraction points 6. Pipe at source for filling donkey carts is contaminated (e.g. falls on ground) Related to inadequate community engagement and enforcement/ activation of laws: 7. Containers for collection and transfer are uncovered (including missing lids or caps) 8. Containers are not cleaned 9. Containers are used for multiple purposes 10. Donkey carts and tankers transferring water and are not cleaned or maintained	Poor selection, design, siting or construction: 1. No first flush discharge device for rainwater harvesting 2. Poor design of underground water tanks leading to cracks and contamination Inadequate management, operation and maintenance: 3. Poor hand hygiene when handling drinking water 4. Lack of cleaning of containers 5. Lack of use of household water treatment options 6. Poor maintenance of household water treatment equipment (such as not replacing filters) 7. Corrosion of pipework and storage containers, cracks and leaks Related to inadequate community engagement and enforcement/ activation of laws: 8. Storage in wide-mouthed or uncovered containers (even dedicated dipping cups can lead to contamination)

3.2.3 Risks

The following risks exist in Sudan in relation to unsafe drinking water:

- **Health-based risks – sickness and in some cases death from:** AWD, Shigella, Guinea worm[15], Amoebic dysentery, Giardia, Typhoid, Polio, Hepatitis A and E, fluorosis, *methaemoglobinamia* in young babies (caused by nitrates and nitrites) and poisoning from toxins from blue-green algae or other contaminants such as metal, pesticides, insecticides or fertilisers.
- **Other risks:** Loss of time that could be spent on income generating or other productive activities; loss of time from schooling; malnutrition, stunting and wasting; and increased opportunities for violence against women and girls (if they cannot easily access safe water sources and instead seek out more remote but less safe sources).

Data from the FMoH for the first 9 months of 2017 indicates that the number of reported cases was: a) Typhoid - 108,246 (no deaths); b) Dysentery – 153,420 (no deaths); and Hepatitis E – 2,359 (21 deaths).

An example was shared from a SWC that one challenge they face is people who have cancer come to the SWC to say that their cancer is caused by the water supply. The SWC feel they have no ability to prove this argument as incorrect as they do not have the ability to test for complex chemicals in their water supply.

See **Section 3.4.2** -for an overview of the impact of seasonality, environment, climate change and disasters on these risks.

3.3 DWS in Sudan – Supply chain

3.3.1 Water sources and abstraction

The two main water sources used in Sudan are groundwater and surface water including from the White, Blue and River Nile. Groundwater is abstracted in Sudan from hand dug wells and boreholes, with handpumps, motorised pumps, or by hand by rope and bucket. Some urban areas rely entirely on groundwater, such as Kassala Town in Kassala State. Spring water is also utilised in some areas and in rural areas rainwater is also collected from earth dams or *hafirs* and some households also collect water from roofwater harvesting.

FMoH data on water sources (and some treatment processes) across Sudan (2017) identify that the following numbers of water sources exist: artesian wells (1,297); Dams (78); Rivers/canals (857); Hafirs (1,651); Handpumps (12,218); Wells (shallow and boreholes) (20,703); Sand filters (1,800); Public networks and water treatment units (1,800); Broken sources (93); and Total number of water sources (38,833).

Some efforts are being made to protect water sources (for example the requirement for the tannery in Khartoum to install its own WTP) but this task is a cross-sectoral responsibility and needs significantly more attention, including related to the regulation of industry and agricultural practices. Social and environmental impact assessments are required under the Water Resources Act, 1995, but are not yet widely prepared.

An integrated water resources management (IWRM) approach is supported by the Ministry of Environment, Natural Resources and Physical Development, UN Environment and specific programmes, such as those funded by DFID.

Examples of challenges for DWS related to groundwater: High levels of fluoride, nitrates / nitrites and sometimes sulphates; contamination of hand dug wells that are not protected; resistance of some communities, particularly in pastoral areas to cover and protect hand dug wells, because queuing for water from a handpump is more time consuming when also drawing it for livestock than using separate buckets; lack of maintenance of abstraction systems such as handpumps and motorised pumps; dropping water tables due to climate change or due to over abstraction; pollution of groundwater sources from septic tanks

[15] Sudan is in the process of being verified as Guinea-worm free

and pit latrines. Open defecation that happens in areas of shallow groundwater is reported to be commonly done under trees because of the shade they provide. This can lead to pollution of the groundwater, as more trees may be present where the groundwater is shallowest.

Examples of challenges for DWS related to surface water: Very high turbidity and challenges for its removal and getting down to 5 NTU for effective chlorination, a difficult problem which is unique to countries along the Nile and other big rivers; speed of blocking of slow sand filters (SSFs); high sludge volumes to dispose of from WTPs; the changing water levels and blockage by weeds with difficulties to access to repair damaged inlet pipelines leaving water supply systems out of action; in some watercourses algae blooms occur in specific months of the year (in Khartoum, December to February is considered the period where there is the highest proliferation of algae of various types due to Eutrophication)[16], posing a challenge for consumer satisfaction (due to taste and smell), removal and treatment, although it is not clear of the scale of this problem across different areas of Sudan or how serious the risk. Solid wastes disposed of around water sources can contaminate the water source, including recharge ponds for groundwater.

Examples of challenges for DWS related to rainwater: High levels of turbidity and pollution in water collected in earth dams and *hafirs*; lack of protection of earth dams and *hafirs* with animals and humans both entering the water and drinking from the same water source; poor water storage for rainwater harvesting and lack of mechanism to dispose of the first flush of roof water to remove the pollution from deposits from the roofing and guttering structures.

3.3.2 Bulk water treatment

Urban WTPs

Common water treatment processes used in Sudan include: aeration; coagulant dosing using Polyaluminium Chloride (PAC) and flocculation; rapid sand filters; and chlorination using either solutions of powdered chlorine or chlorine gas. Some WTPs have been functioning for a number of years, even as long as a 100 years and new plants are under construction. Some are being funded by external donors, such as JICA, and others through a system of loans, such as from Saudi Arabia (example shared in White Nile State). A new high tech WTP has recently been constructed in Khartoum, Manara, on a Build Operate and Transfer basis and is currently being managed by a British Company in conjunction with Sudanese counterparts. This has automated sampling and reading of results which are fed to a computer system. The plant also is reported to get water to < 1 NTU, which is unusual in other plants. There is also another new plant being constructed in Khartoum, Soba, which will have a pre-sedimentation process before the main treatment. Desalination is also common in some States with both public and private desalination plants. Water from desalination plants is the only source of water during the hot and dry season in Red Sea State.

Examples of challenges for DWS related to urban WTPs: Poorly designed treatment processes; the use of less effective dosing methods, such as use of solutions of dissolved powdered chlorine, which it is reported do not distribute evenly throughout the water supplied; manual controls for dosing of coagulants and chlorine posing challenges for establishing accurate dosages; some WTPs do not have equipment for testing the water quality, including establishing the optimal dosage for the water treatment chemicals; lack of preventative maintenance of the treatment units and connecting pipework; lack of regular desludging and cleaning of the tanks; limited finances for the purchase of PAC and chlorine and reliance on UN agencies and other development partners for chlorine; limitations in laboratory equipment for water quality testing for monitoring of the influent and effluent turbidity, pH and chlorine residuals; limited access or use of Jar Testing equipment to establish the required dosage of coagulant; build up of biofilms of algae and associated problems (such as increased frequency of clogging of the filters, increase in dose of coagulant and chlorine, increased electricity expenditure for more regular back-washing and taste and smell problems)[17]; disposal of

[16] Fathelbari, M.O (2014) *Algal Removal Strategies and Treatment Options in Drinking Water Bodies (River Nile), Khartoum State – Sudan, July 2014*, Final Paper, 37th International Postgraduate Course on Environmental Management for Developing and Emerging Countries, Technical University of Dresden

[17] Same reference as above

sludge back into the main water source downstream of the abstraction point (for example back into the Nile rivers); and the fouling of Reverse Osmosis membranes in the Eastern States where water is saline.

Rural WTPs

Slow Sand Filters (SSFs) are common treatment processes in rural areas. They may treat water from a stream, perennial river, irrigation canal, *hafir* or dam. They may need pre-treatment from the river bed through infiltration, horizontal roughing filtration, vertical roughing filtration and plain sedimentation. They need trained operators to operate and maintain the system. Compact water treatment plants have been used in refugee camp situations in White Nile and the National Company for the Manufacture of Drinking Water Equipment is currently testing locally made compact water treatment plants, simplified for increased sustainability and use for small communities, such as those with *hafirs*.

Examples of challenges for DWS related to rural WTPs: High turbidity of the source water to be treated by SSFs, leading to the need for effective pre-treatment; limited maintenance of SSFs and lack of clarity of who is responsible for their maintenance; a particular challenge expressed in Kassala as to how to dose for long pipelines from over 48 or 60 km to ensure adequate chlorine residuals at all stages of the pipeline; limited use of household water treatment processes for the effluent from a SSF; and reliance on UN agencies and other development partners for chlorine supply; and it is reported that the chlorine supply has been significantly less than the needs.

3.3.3 Bulk storage and distribution network to collection point

Leakage and maintenance:

Many of the piped networks are old and in some areas it is estimated that up to 45% of the water supplied may be lost through leakage. Figures are only general estimates because in most areas water meters are not installed that would allow accurate calculations. Only leakage that appears on the surface is known. Some piped networks are in the process of being replaced. Much maintenance is only temporary using rubber straps and not all problems are responded to.

In the Urban Water for Darfur Project (UW4D)[18], Key Performance Indicators (KPIs) have been introduced which include those on leakage, time for repairs to be undertaken and cost recovery. In the project areas meters and valve chambers have been installed and a team is on stand-by to respond to the maintenance of large pipes, with the community being left to be responsible for smaller pipes. In White Nile some old networks are being replaced by the SWC as a pre-condition to the construction of a new WTP.

Storage tanks:

Storage tanks are often of welded steel plate, but brick, plastic and fibreglass are also used. Tanks are widely painted inside, including those that are fibreglass, as well as water tankers; and underground tanks made of brick and cement that are used in urban areas in the Kordofan States, where water is scarce and hence is stored for several weeks. Fibreglass tanks were widely used in the 1970s but after 10 years fibres were seen to have got into the water and people were having reactions / rashes from using the water. Both fibreglass and plastic tanks need to be in the shade and in the very hot weather, it has been observed that water can gain a smell from the plastic.

The MoWRIE/DWSU (2009, draft) technical guidelines and manuals make a recommendation for the standardisation of raised water tanks for water yards and that these are to be painted internally with bitumous non-toxic paint. The DWQ and Control Regulations 2014, also recommend the painting of the inside of storage tanks, but do not state they should be non-toxic. Epoxy paints are manufactured in Sudan and recently a company has also started to trial bitumous paints. There is currently no process for certifying the non-toxic nature of paints or for waterproofing materials for the inside of drinking water tanks. One national company noted that the company which supplies the epoxy paints said it was tested by the SSMO,

[18] Urban Water Administration Offices (2017) *Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala*

but the SSMO indicated that there are no producers of the paints/waterproofing products in Sudan, so this would need more clarification. The SSMO has a Technical Committee for paint more generally as well as a separate Technical Committee for drinking water. The national company has also tried to get one of the paints tested themselves by a University laboratory, but this is their own initiative and the process for testing is not specified in national standards. However the cost of the epoxy paints is high against standard paints – for example the cost for a 25m^3 tank would be 10-15 times the cost (for example SDG 10,000 for the epoxy paints versus 600 to 1,000 for normal paints). This would be an influencing factor leading to most people using standard paints which may be toxic, in addition to the fact that there is a lack of clear certification, guidance and enforcement. There are also no laboratories in Sudan that can test for Volatile Organic Compounds (VOCs).

During the AWD outbreak (2017) sometimes, chlorination is being undertaken of donkey carts and tankers or when a storage tank is filled. The well keeper is paid an incentive by the MoH or employed by the Locality.

Examples of challenges for DWS related to bulk storage and distribution to collection points:

- **Pipeline design:** The pipelines may have poor designs with inadequate numbers of isolating valves to allow for pipe drying (for PVC pipes) or lack of equipment for pipe bonding (for PE pipes); poorly designed valve chambers; air blocks (which can reduce flow leading to people using other sources); water hammer or excessive pressure at tapstands (leading to wastage); some supplies are intermittent which increases the risk of inflow of pollutants when the water pressure drops (including from sewage pipes, septic tanks etc.); there may be illegal connections; and the volume of water may not be adequate for the number of users, leading to the users resorting to more polluted sources.
- **Distribution system maintenance:** Many of the distribution systems have old pipes, including Asbestos cement and PVC and there may be corrosion and high levels of leakage; regular monitoring and preventative maintenance does not appear to be happening; it appears that most maintenance is done in response to customer complaints and then the repairs tend to be temporary fixes using rubber strips, which are not replaced; the SWC's may not have the required equipment for identification of leaks and repairs; the distribution network maintenance teams may not have access to vehicles which is then difficult for moving materials and equipment; and the SWC may not take responsibility for repairing the pipelines with consumers being expected to organise and pay for repairs themselves, even for main pipelines (although a report from the UW4D Project indicated that all complaints were responded to within an average of 4 hours)[19]. This also includes in IDP camp contexts.
- **Water yards and distribution points:** Basic design gaps – such as lack of cement drainage curtains and drainage channels to move the wastewater away from the source; inadequate maintenance of the water distribution points with no-one taking responsibility to prevent ponding or unblocking soakaways, etc; poor design of water points including tap and platform design and inadequate drainage and soakaways, leading to ponding and muddy surrounds risking contamination of containers.
- **Water tanks:** They may be old and corroded and there may be ingress of pollutants from inappropriately designed or damaged inspection covers. Also there is a risk that sometimes companies quote for structures, such as raised water tanks, with inadequate thickness of steel and inadequate sized foundations to cut costs. It has been reported that failures have occurred, which is life-threatening considering the huge weights involved in raising large water tanks into the air.

The following box highlights two different options on attitudes to maintenance as described by a stakeholder in Sudan who has worked on maintenance issues.

[19] Urban Water Administration Offices (2017) *Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala*

Attitudes to maintenance – option 1:	Attitudes to maintenance – option 2:
You have a 10 tap water point. Each tap breaks down one by one, but nothing is done about it as still there are other taps that are functioning. No spares are kept for repairs. In the end all ten taps are broken and the cost of repairing it has now become more significant. Requests are now made to outside agencies to help fund the replacement of the tapstand.	You have a 10 tap water point. You keep basic spares handy at all times. As soon as one tap is broken you mend the water point. In this way the water points is kept fully functional with all taps working and it lasts for a long time with minimal costs for maintenance.

It has been observed that the attitude to maintenance in Sudan can often be as per option 1, including in relation to drinking water supplies. This has a significant effect on the sustainability and safety of supplies.

3.3.4 Collection of water and transfer to household

Water containers for transfer to the household tend to be plastic containers with or without lids. Some containers have lids fixed to the container with string. Some are cleaned and others dirty with a build up of algae inside. Some are brittle and cracked with some plastic containers being repaired using melted plastic. It is reported that gravel is used to clean the inside of the containers.

Examples of challenges for DWS related to the collection of water and transfer to the household: Water containers may have wide tops or no caps; where water is collected by donkey cart or tanker, the water may be contaminated during the process of collection; and the pipe at the source for the filling of the donkey cart or tanker may become contaminated by falling on the ground.

Khartoum State MoH noted that all donkey cart owners need to be registered and that they undertake regular training and monitoring of the donkey cart owners and their carts. The Regulations on DWS Control, 2014, also states that all donkeys need veterinary certificates and the operators need up to date health certificates. Some chlorination is being undertaken at the water yard for the water being put into the water tankers.

3.3.5 Household water supply, treatment and safe storage (HWTS)

HWTS:

Not much HWTS is currently undertaken in Sudan, but what HWTS is undertaken in Sudan is reported to be mainly undertaken by women. The MICS, 2014 – states that the Sudan average percentage of household members in households using unimproved drinking water sources who also use an appropriate household treatment method:

- Total of the population is 4.1% - of this which is split: None – 70.9%; Let it stand and settle – 22.4%; Strain through a cloth – 4.0%; Boil – 2.2%; Add bleach / chlorine – 1.3%; Use water filter – 0.8%; Solar disinfection – 0.2%; and Other – 1.4%
- Variations included: Urban/ rural - Urban 3.7% and rural – 4.2%; across States – from 11.5% in Gezira and 8.5% in Red Sea State to almost zero in South Kordofan; and across wealth quintiles – 2.9% of poorest households to 7.0% of richest

It is reported that the following have been used in Sudan (noting that not all are approved by the FMoH as appropriate treatment methods): Boiling; Storage / sedimentation including in *Zeers*; and use of local materials such as: Alluvial (clay) in the north; Groundnut; Moringa [and possibly Neem]; Trees (*Mohved*, *Kadara*[20]); Nana plant / Mint; Cardamom; oil put on top of the water after boiling; Lemon; and putting in sunlight for a few hours. A PhD student at Gezira University studied traditional water treatments (two seeds and one type of root). A few rapid HWTS activities have also been supported as part of the AWD response: such as the use of chlorine tablets; PUR sachets; and a few hundred Lifestraw.

[20] The spelling of these tree names may vary

HWTS has been included briefly in the water treatment related MoWRIE/DWSU (2009, draft) technical guidelines and manuals, but is not generally being taught on the Environmental Health courses in universities in Sudan.

Storage in the household:

Water in the household either tends to be stored in plastic containers, in ceramic *Zeers* or in tanks, including underground tanks constructed of bricks and cement. For *Zeers* a shared cup is often utilised that is dipped into the container.

Drinking water quality in the household:

Testing of the water quality at the household does not appear to be common, but in a number of cases where results were available, the free residual chlorine was found to be zero. This may be due to inadequate chlorination for the ambient temperature and the level of contamination throughout the supply chain due to reduction in strength of the chlorine, or chlorination not being undertaken to save costs. Two examples of this include draft data from a study under the UW4D project, where 32 of 47 households tested had water that was considered contaminated. Data sheets from the State MoH in North Darfur also indicated no residual free chlorine in households in an IDP camp.

3.3.6 Beliefs, community engagement, hygiene promotion, citizen feedback and enforcement/ activation of laws

Community beliefs, community engagement and hygiene promotion:

Good practice related to DWS, particularly at community and household level requires effective communication and dialogue to inform and motivate people to undertake positive DWS practices. There are some beliefs that the chlorine will have negative effects such as making people sterile, that it will affect Wudu and prayer, it will lead to disease or that it is poisonous. These can act as a de-motivator for utilising chlorinated water. In addition some people believe that if water is running it is not contaminated. Reticence to use chlorinated water varies in different communities and areas across the country.

It was reported that in one Locality in White Nile State has piped water, many people prefer to take water from donkey carts that get water from the river because it is cheaper. Likewise in East Darfur State and the southern part of South Darfur State, the main water source is groundwater. However during the rainy season the boreholes are closed as *hafirs* are preferred for animal and domestic use, which are also free of charge. People also prefer surface water to other sources such as groundwater if it has too high salinity.

It is understood that it is not common for the community to be informed if the drinking water supplied by the SWCs does not meet the required quality standards, for example if the turbidity is too high to make the chlorination effective. Therefore they will not know if they need to undertake a household treatment such as boiling. As there is also very little HWTS in Sudan, it is also assumed that very little communication has been undertaken on this issue in the past.

The FMoH and SMoH utilises a number of approaches including the 'Healthy City Approach'[21] and has the 'Community Based Development Initiatives Programme' (known as CBI)[22]. The CBI programme looks at communities as partners, with a facilitation role by the outside agencies and supports a bottom-up approach. A manual exists on 'Community Empowerment Guidelines in Water and Environmental Sanitation' by FMoH, MoWRIE and UNICEF (no date). These guidelines have sections on: water sources and protection methods; on water storage in the household including good practice in using *Zeers* and keeping the water hygienic; and household water treatment and storage.

[21] WHO Regional Office for the Eastern Mediterranean (1997) *Healthy Cities, Guidelines for the Development of Healthy Cities Projects and Activities,* WHO-EM/PEH/501/E/L

[22] FMoH (2005) *National Strategy for Community-based Development Initiatives Programme (CBI),* Sudan, Directorate General of Primary Health Care, FMoH

Hygiene promotion in relation to DWS has been integrated into the AWD campaigns. This has included persuading people to accept chlorine in their drinking water even though some people are reticent. Other activities that have been undertaken include: training with donkey cart owners on personal hygiene, how to use the chlorine tablets and how to clean the water tank and jerry cans; engaging students, the youth, Women's Union during hygiene promotion; sessions with the media; and the use of drama, culture and undertaking activities in market places.

DWS may be integrated into general health or hygiene promotion activities that involve a component of WASH, but the quality of information may vary. For example saying *"you must drink safe water",* may not be enough as people may not know what safe water is.

It is not clear how much attention has been given to ensuring that people who may be vulnerable or disadvantaged are being reached through the communication methods used and how much they are being encouraged to engage in the processes related to DWS.

WASH and Health Committee and community volunteers:

The roles of the WASH and Health Committees related to DWS may include (as described in *Zamzam* camp, North Darfur): Raising awareness of the community; follow-up on the safety of water in sources and households (using a pooltester and observation); chlorination of water sources in camp; to ensure chlorination and jerry can and storage container is clean and covered; if big problems they ask the WES team for help; if small problems – the committee is prepared to maintain and buy the spares from a local market; a tariff is collected for motorised schemes and if there is a problem for handpump then they undertake a collection for repair.

Hygiene promotion is often undertaken by community committees and volunteers with no incentives. This is usually a strategy used to support sustainability, but this may be challenging for the time inputs required, particularly during outbreak situations. They also may not have an official location to meet and appreciate having capacity building to be able to undertake their tasks.

Institutional DWS and being role models:

Some examples have been seen where sector institutions and health facilities have gaps in their practice related to hygiene and DWS. For example, in a WES compound in an AWD affected area, drinking water was stored in *Zeers* with a shared cup; and in another compound the water supply point had leaking pipework with stagnant water ponded underneath and no soap for hand-washing in the toilets. There is a need to ensure that sector professionals and institutions *"don't ask people to do what you are not doing"* and be effective role models. See the **Section 3.3.7.2** for more details of DWS in institutions.

Citizen feedback/ complaints:

There is a Consumer Protection Society that has been involved in the MoWRIE led bottled water committee. Consumers can phone the SWC to report leakages and other problems such as a smell or colour in the water. Some of the feedback is acted upon but not all. But it is common that citizens often do not expect the SWC to respond and undertake repairs to networks so they use the private sector to resolve them themselves.

> One stakeholder commented that: *"It is essential to change the engagement of communities – wake them up to the responsibilities of the SWCs and demand the SWCs to act, not to just go to the private sector to get problems resolved"*

Establishing some form of publicly accessible records of the complaints/ requests made and the follow up actions by the SWC with dates, could be a useful tool both to encourage increased attention on problems by the SWCs and also to encourage an increased level of demand from citizens.

The Japan International Cooperation Agency (JICA) has supported the establishment of websites for the DWSU, Khartoum SWC and the DWST and there are plans to expand the establishment of websites for other SWCs. It is proposed that these can be tools for the sharing of good practice and also to enable users to be able to access information on what is happening in relation to their water services.

One key step to be able to assist the community to demand their rights is to clarify the system of accountability at all levels and the specific responsibilities of all stakeholders. The community must also be engaged at each step as well as the Locality and community leaders. Suggested community leaders who it would be positive to ensure are involved include the: Women's Unions, religious leaders and the Youth Union. A Public Committee already exists which is a government structure at community level, which involves the Women's Union and youth, and they already discuss development related issues such as water and health. But it has been noted that the Public Committee are not always trusted to act in the citizen's best interests.

Enforcement/ activation of laws:

Examples of enforcement/ activation of laws happening in relation to DWS have been shared by the FMoH, MoWRIE/DWST and GWD, State MoH and Localities. Examples of the challenges with enforcement/ activation of laws include: Long processes to enforce that lead to punishments; low punishments at the end of the process; it is not fully clear who is responsible for enforcement/ activation of laws; enforcement/ activation of laws is particularly weak between Ministries (for example between the MoH and the water or other related ministries and State Water Corporations); and the Localities do not always take care of this area (as they may have constraints such as lack of access to vehicles, water quality testing equipment and staff which impacts on their ability to enforce).

Enforcement/ activation of laws related to water supply is mentioned in several Acts (related to Environmental Health; the Environment; Water Resources; Sudan Penal Code; and the Act to set up the SSMO), which adds to the lack of clarity over who is responsible and for what. In relation to legal authority for enforcement:

- The Ministry of Health at all levels (Federal, State and Locality) has clear legal responsibilities for enforcement in relation to drinking water under the Environmental Health Act, 2009 and associated regulation, including for the approval of water for use for drinking and for the monitoring and enforcement in relation to bottled water and ice producers.
- The MoWRIE and SWCs have clear responsibilities for the approval for abstraction of water resources under the Water Resources Code, 1995 and associated regulation, but it is not clearly specified that they have authority for the approval of the use of water resources specifically for the purpose of drinking water, or that they have a role in the monitoring and enforcement in relation to bottled drinking water producers. The EH Act, 2009, Clause 8 says *"Must for anyone working in the field or drinking water in the various levels of government to abide by the conditions and regulations of the following: (A) To confirm the validity of drinking water and pollution-free networks in accordance with the approved specifications".* But it is not clear if this refers to the supply of drinking water from their own systems, or they can approve the use of water for drinking? The Regulations for DWQ and Control, 2014, specify that the establishment of any project of drinking water should receive a licence from the *'competent health authority'.*
- A range of stakeholders are considered as 'Competent Authorities' under the Environmental Conservation (Protection) Act, 2001, for the purposes of protecting the environment and also are able to enforce, including citizens who can bring civil actions.
- Under the Local Government Law, 2003 (temporary) and the Local Government Act, 2016, the Localities have the power to prepare 'Local Orders' and to enforce against these and from the side of health have the powers to undertake surveillance of drinking water and validate / guarantee the water is not polluted. They also have the power to monitor and ensure that food and drink places have licences.

The situation where the SWCs are not clearly legally authorised to certify water sources fit for drinking poses challenges in the situation where the MoH and Locality laboratories below Federal do not have the capacity to test for the full range of physical, chemical and microbiological parameters needed to establish if drinking water is fit for drinking. Therefore potentially some formal transfer of power for this approval process may

be required, at least until the point at which the State MoH laboratories have the capacity to approve water for drinking.

3.3.7 Specific contexts

3.3.7.1 Packaged/bottled water

The Regulations for DWS Control, 2014 has sections on bottled water and ice factories. It covers issues such as guidance on the building design and upkeep, cleaning and toilet facilities. It notes that the production line must be mechanised, that workers should have health cards and that the product should be registered at the MoH and bacteriological and chemical analysis undertaken. But: it does not mention the treatment processes required including disinfection; and it mentions painting the inside of the water tanks to facilitate the cleaning, but does not specify using non-toxic paints. For the ice factory the guidance is similar, but in addition it adds: the ice shall be colourless and free from bubbles, the melted water should be according to the Sudanese standards for drinking water and should have residual chlorine according to the Sudanese standards for drinking water. It also notes that the warehouse should be a suitable temperature for ice preservation, and that water tanks, pumping pipes and packing equipment should be cleaned with a disinfectant with chlorine daily. For both it also has a general provision that the inspector can enter and carry out an inspection to any place of work in preparation, selling, manufacturing, packaging or storing drinking water and take lab samples for testing. It does not mention about the requirements for the manufacture and handling of ice by small private sector suppliers, such as those who deliver ice by bicycle.

The Regulations for DWQ Control, 2014 specifies that the 'competent health authority' has the key role in the regulation of bottled water companies, but it is not clear how much they have been involved in all processes related to regulation, as the engagement with the packaged/bottled water industries in Sudan seems to currently be fragmented. There is a committee on bottled water established by the MoWRIE involving the Consumer Protection Society, which meets monthly but does not involve the FMoH. The FMoH and WHO also separately undertook a survey of bottled water across six States in 2016/7. The DWST in Khartoum also reports undertaking testing of the water in bottled water factories, particularly to check for Bromide; and the FMoH also issues certificates related to water quality from bottled water factories. The Sudan Standards and Metrology Organisation (SSMO) notes that it has the power from the President to close down bottled water factories if they don't meet the Sudan DWQ standards and so also has a role. It's Factory Inspectorate in Khartoum undertakes inspections and has a database of bottled water factories. But there is currently no unifying or coordinating committee to oversee the regulation of packaged/ bottled water or ice production companies.

Survey to assess the quality and safety of bottled water in Sudan, 2017[23]

A study of the bottled water factories across six states (by FMoH supported by WHO), found a range of problems with the factories. The study visited 55 factories: Khartoum (25), Gezira (4), Gedaref (3), Red sea (10), North Kordofan (8) and South Darfur (5). From the factories visited: 34.5% took their water from the urban water network, 58.2% from an internal well, 3.6% direct from the River Nile or the sea, and 3.6% from outside the factory. 98.2% have some form of water treatment. 10.9% have carbon filters, 9.1% have sand and 69.1% both carbon and sand. 83.6% have chlorine added. 60% have exposure to UV and 60% have Ozone gas added.

Examples of the problems found include:

- Only 34.5% of factories had product registration certificates, only 54.5% test the drinking water daily, only 54.5% had laboratory records available, 14.1% of factories do not have specialized personnel in the laboratory

[23] Karrar, A.N.A and Yousif, A.E. (2017) *Survey to Assess the Quality & Safety of Bottled Water in Sudan, 2017*, General Directorate of Primary Health Care, Environmental Health and Food Control Department, Water Quality and Safety Section, Federal Ministry of Health, Sudan

- 16.4% had positive results for microbiological tests, i.e. were contaminated (had either *E.coli*, Thermotolerant coliform or *Staphyloccocus Aurelus* present)
- 14.5% of the factories the raw water storage is underground reservoir which can expose them to contamination and in 27.3% of the factories the cleanliness level around the water storage is bad
- 23.6% of factories do not sterilize the bottles before filling and 40.0% of factories both fill the water and cap the bottles manually
- The general cleanliness of the factory was considered bad in 32.7% and medium in 32.7%, 10.9% of water bottling factories do not have toilets, 25.5% of factories do not have adequate number of toilets and the condition and cleanliness of 34.5% of the toilets were considered bad
- 34.5% of factories have workers without a medical fitness certificate, 63.6% of factories have workers without uniforms, 78.2% have no process for sterilisation of their clothes, 65.5% have no process for sterilisation of workers before entering the water processing halls and 45.5% of workers do not disinfect their hands before entering the halls

Other challenges for DWS related to packaged/bottled water:

- It is reported that there is no systematic follow up.
- It is not clear that nationwide and State-wide databases exit for packaged water companies (except for the city of Khartoum).
- There is currently no advisory information or capacity building for bottled drinking water producers in Sudan.

3.3.7.2 Schools, health facilities and other institutions

The Regulations for DWS Control, 2014, do not mention schools, health facilities or other institutions. The National School Health Strategy, 2016-20 (Draft) and the National Guidelines for Implementation of an Effective School Health Programme, 2003-16 (draft) include a few points related to DWS. These relate to issues such as: establishing water points relevant to the number of staff and students; providing SDW; that teachers can be trained on water chlorination with tablets; and a number focussing on hand-washing, promoting good practices, availability of toilets and solid waste disposal. No mention is made of ensuring adequate drainage or how to reduce the risks of water pollution, how to prevent contamination related to sharing cups, for example, or the responsibilities of the Parent-Teachers Association.

It is also reported that the school curriculum does not include DWS[24]. The FMoH has produced a health messages document for schools that is used while children are in the morning queue and includes messages on using safe drinking water and contamination of drinking water. Examples of posters by Relief International have included DWS into general health promotion for mothers of children who are malnourished which are used at their health facility and supplementary feeding centre. Using unsafe water can be particularly dangerous for children who are malnourished.

There is a need to check on the constant availability of soap and on the need for children, patients and visitors to bring their own cups for use for drinking water. Schools, health facilities and other institutions should be integrated into the standard surveillance routines for DWS and also DWS should be integrated into the inspection routines of school and health facility inspectors and management committees.

A number of projects have been undertaken by students at the University of Khartoum related to the drinking water situation in schools in Sudan, but details are not known. The MoE, FMoH and UNICEF intend to undertake a mapping of schools in 2017, which will include this element.

[24] Although the curriculum was not viewed

3.3.7.3 Nomadic communities

Most nomadic communities are drinking raw surface water, often directly shared with their animals, for example in ponds, dams or *hafirs.* In areas where there are conflicts between farmers and nomadic communities, access to safe water supplies may also not be possible due to the conflict and there may be risks of fighting over the use of the water source. There is a need to increase engagement with the Ministry responsible for animal resources as part of the solution moving forward.

3.3.7.4 Humanitarian contexts

Issues of specific importance to humanitarian contexts include: Changing numbers of displaced populations including refugees, leading to water systems that are being used to supply much larger numbers of people than they were designed for, leading to people to look for alternative sources; inadequate funds for drinking water; high density of populations living in camp contexts may lead to pit latrines being placed near to water points or storage tanks; inadequate access to chemicals for sustaining water treatment – at all times but particularly during outbreaks; if people feel the water points are not safe to visit in conflict situations this may lead them to seek and use less safe water supplies; and challenges to access to water supplies for on-going monitoring and water treatment in conflict areas.

3.4 DWS in Sudan - Cross-cutting issues

3.4.1 Gender, equity and vulnerability

Examples of gender, equity and vulnerability related issues which might affect access to SDW: People who are chronically ill, older people, children and newborns are particularly vulnerable to the risks from drinking unsafe water supplies, which can lead to disease or death. If women and girls (in particular, but also including men and boys) do not feel safe collecting water at specific water points, it may lead them to look for alternative sources, including those that may be less safe. If safe water supplies break down or are not provided on a constant basis, women and girls may have to walk to more remote locations to collect water from open sources, putting them at increased risks of violence. Women and girls are most likely to be the people who collect water, but may have the least say over how: a) a water supply is designed, b) where water points are sited, c) how the systems are managed, or d) how household money is spent, including on water storage or household water treatment equipment or chemicals. People who have a disability or mobility limitations, such as older people, may find it difficult to reach and queue for water supplies, particularly if there are long queues. In *Zamzam* camp the Health and WASH Committees said that family members help people who may be vulnerable and can't afford to pay for drinking water as the community is close-knit and they take care of their relatives, but the problem is with transportation when the near-by water source is out of action. Older people and people with disabilities may also face difficulty using a handpump. Men and boys may not be targeted for hygiene promotion campaigns, leading to gaps in their knowledge of safe water handling. The poorest people may also not be able to buy enough soap and household water treatment equipment or consumables. It is also not clear how much consideration has been made in the methodologies for communication and engagement that people who are particularly vulnerable, marginalised or disadvantaged are involved in and benefit from DWS activities.

MICS data (2014) indicates that in rural areas women are more likely to collect drinking water than men, but in urban areas men are more likely to collect it than women. Adults are more likely to collect water in both contexts than children. It also shows that the lower the wealth quintile (where more households are likely to not have water on the premises), the more likely women will be the people more likely to collect drinking water than men; and the more likely that girls will be expected to collect drinking water rather than boys. In the highest wealth quintile men are more likely to collect water than women and boys more likely than girls.

Refer also to **Section 3.3.7.4** for information on the humanitarian context.

3.4.2 Sustainability, seasonality, environment, climate change and disaster risk reduction

Sustainability - The sustainability of water sources, treatment process, water supplies and monitoring and remedial action will all significantly affect on-going access to safe water. Examples of current problems include: the poor maintenance of water sources, treatment works, distribution systems and supply points; lack of access to adequate water treatment chemicals on an on-going basis; income generated by water supply services, not covering the cost of their O&M and replacement; major gaps in the on-going monitoring and remedial action related to water supply systems; turnover of staff, including staffs that are responsible for water quality monitoring; broken laboratory and field equipment and gaps in access to consumables such as buffers on an on-going basis.

Seasonality, environment and climate change – Water safety is affected by the changing seasons, for example with increased risks of flooding of water sources in the rainy season. The changing climate and environmental conditions may affect water safety in the following ways: changing the seasonal patterns; dropping water tables leading to reduced yields, changing concentrations of naturally occurring chemicals in water sources and leading to increased conflicts and population displacements; infiltration of pollutants into water sources or poorly maintained water pipelines can occur from blocked drains, piles of solid waste, poorly disposed of faecal wastes or chemical effluents from industries; flooding also poses significant risks for the contamination of water sources; the changing weather and chemical effluents from industries may change the nutrient consistency of water bodies such as the Nile and lead to increases in algae blooms risking the release of toxins and increasing the pressure on water treatment process plants; the changes in temperature, salinity and zooplankton blooms in surface water sources (which can be linked to the *El Niño* phenomenon) can lead to the re-emergence of main bacteria that causes the AWD in Sudan as a viable vibrio. This can then be transmitted to humans when surface water is drunk without treatment and can lead to the start of an outbreak. Increasing temperatures also lead to people drinking more water and hence being at higher risk of being affected by contaminants.

Sudan is part of a number of regional initiatives such as the Nile Basin Initiative and the Global Environmental Monitoring Service. The Ministry of Environment, Natural Resources and Physical Development (MoENRPD) and the Higher Council for Environment and Natural Resources have also published a National Adaptation Plan for Sudan[25]. This specifies recommendations by state related to water resources to respond to the issue of climate change. These relate to undertaking geophysical studies, increasing the range of water resources, repairing water points and monitoring water resources.

For more details on possible increases in hazards due to climate change and control measures refer to the WHO document on WSPs and climate change[26].

Disaster risk reduction (DRR) – Because of the range of humanitarian contexts that Sudan faces as well as on-going challenges from environmental degradation and climate change, there is a need to strengthen DRR (including early warning systems, emergency preparedness and also to consider climate change whilst undertaking WSPs[27]). The current AWD outbreak has highlighted a number of gaps that influence DWS, including the lack of clarity on institutional responsibilities, lack of access to logistics for water safety monitoring and repair of supplies and networks and inadequate access to water treatment chemicals. Strengthening DRR and emergency preparedness would lead to more effective responses when new outbreaks, flooding or displacement contexts occur again in the future.

[25] Sarour, M. E. M. E. (2009) Adequate safe water and sanitation for all; A legal system to protect water and sanitation in Sudan, November 2009, *Workshop on Water and its Relation to Health and Sanitation Organisation*, General Secretariat of the Council of Ministers
[26] WHO (2017) *Climate-resistant Water Safety Plans*: Managing health risks associated with climate variability and change
[27] WHO (2017) *Climate-resistant Water Safety Plans: Managing health risks associated with climate variability and change*

3.5 DWS in Sudan - Building blocks

3.5.1 Legal and policy framework

Codes/Laws/Acts[28]:

It is reported that there are 52 laws that have reference to water and sanitation in Sudan including criminal law, although to prosecute against criminal law takes time to go through the courts. Some laws and regulations in Sudan mention a number of aspects related to DWS but with some gaps / limitations. The MoWRIE is currently leading a project on Water Sector Reform funded under the African Development Bank and hence a number of the water sector laws, regulations and associated strategies and policies are likely to be updated in the coming few years.

A summary of the current strengths and gaps in key laws, policies and strategies includes:

- **Environmental Health Law, 2009** – Very brief mentions of preventing pollution of water sources, the need to validate drinking water against standards and that employees working on drinking water must disclose that they have good health. Clause 8 says: *"Must for anyone working in the field or drinking water in the various levels of government to abide by the conditions and regulations of the following: (A) To confirm the validity of drinking water and pollution-free networks in accordance with the approved specifications".* No other mentions included. It includes punishments for violation of the law by imprisonment for a period of not less than 1 year or fines or both. It establishes the National Council for Environmental Health.
- **Water Resources Code, 1995** – This document establishes the *"National Council of Water Resources"* and has powers to define the general policy related to water resources including the *"prevention of the effects of natural disasters caused by droughts and floods, protection of those resources against pollution and deterioration of them, of an integrated and balanced manner, with other natural resources, thereby ensuring maximum benefit and achieve the desired coordination and cooperation with the other competent agencies".* In particular it specifies that: *"The overall supervision of the withdrawal of water from the Nile, other rivers, streams and groundwater for irrigation, drinking, industry, hydraulic power generation, sanitation and other as well as the distribution and use of water, including the identification of cultivated land area, the installations set up for various uses, the protection of streams and water against pollution by sewage, industrial and agricultural chemicals and treatment of streams water in coordination with the Supreme Council for Environment and Natural Resources and the competent authorities".* The MoWRIE has the power to issue permits for the withdrawal of water. Penalties under this Act should not exceed 6 months imprisonment or a fine or both.
- **The Environmental Conservation (Protection) Law, 2001** - This establishes the Supreme Council for the Environment and Natural Resources, identifies 'the competent agencies' to protect the environment and includes punishments for polluters of water involving suspending projects or revoking the licence. The competent agencies include a wide range of actors including citizens who can bring civil actions.
- **Local Government Law, 2003 (temporary) and Local Government Act, 2016** – The Local Government Act, 2016 notes that the Local Council may issue local orders which have the force of law and any local order approved by the Local Council shall include a penalty for the gradual violation of the administrative warning to the fine to imprisonment and may include heavier penalties in the case of continuous violations. The Local Government Law 2003 (temporary) instructs that the authorities for small towns must cooperate with the Localities and that the Local Government has jurisdiction of:
    - Engineering Matters: The establishment and protection of drinking water facilities and sewerage [or drainage?] in rural areas.

[28] Code = a specific type of action made by the legislature that covers a complete system of laws; Act = an enactment / a statute / a bill / a regulation which has passed through several legislative steps and which has become law. Acts if passed become laws; Law = rules and guidelines set up by social institutions to govern behaviour. They are made by government officials.

- Health and hygiene: Monitoring / surveillance of drinking water, ensuring its validity, securing its sources and preventing pollution; plan and implement projects related to environmental health; health related awareness raising; cleaning, constructing public toilets and monitoring the healthy environment in housing, agriculture and industry; and watching and observing [monitoring] places where people prepare, drink, sell and show food and monitor the employees and ensure they have a license.

- **School Health Act, 1974 –** States that the Directorate Council should: "*Ensure the good quality of environmental health in which the students or pupils live, whether in hostels, classrooms, areas of study or training"* and *"Ensure that there are adequate conditions for health and safety against the hazards of electricity, wells or sports or housing hazards*".

- **Other legislation that has clauses of relevance to DWS[29] includes** - **The Constitution, 2005; Public Health Law, 2008; Food Control Law, 1973** – has particular relevance to packaged / bottled water; **Khartoum Water Corporation Law, 2009; Pesticides and Pest Control Products Act, 1994; The Sudan Penal Code, 1991 / Criminal Law; Anti-terrorism Act, 2001**; and the Act for the establishment of the SSMO, 2007 and the **Law of Standards and Metrology, 2008**.

Penalties for violations of the laws vary greatly from simply the loss of a licence to 20 years imprisonment under the Anti-terrorism Act for an act that seriously damages the aquatic environment and exposes people's lives to risk.

Regulations:

- **Regulations of DWS Control, 2014** (FMoH) – This document is the key regulation related to drinking water in Sudan. It provides guidance on various aspects: the selling of potable water; health specifications for the worker and means of transportation (*karo*); and specifications for buildings where bottled water and ice are produced and some regulations on how they should be operated and the health conditions of the workers. They could be improved in a few areas, such as specifying the need to only use non-toxic paints for painting storage tanks, to be more explicit about the requirements for disinfection of drinking water and the cleaning of the machinery and to clarify requirements to prevent pollution from sewage sources. It does not specifically include the handling of ice by small ice sellers.

- **Regulations *of License of Exploitation of Groundwater*, 2014 (which came into effect 2016)** – It requires *"Any person who wishes to obtain a license to exploit the groundwater, develop the groundwater well, develop the groundwater well, clean it up, increase its capacity, increase its diameter or test its productivity by means of a digger or any means of installing a pump must submit an application to the competent authority according to the following: a) A study of technical, environmental and economic feasibility according to the indicators determined by the competent authority; b) Certificate of registration of the company or partnership or work name according to the laws governing it; c) Indicating that he owns the land or a valid lease for the required license period; and d) Accreditation of the competent authority upon the conclusion of any contract requiring the drilling of underground wells".* It also notes that the license shall be valid for two years and then renewed each year. Penalties under this regulation revolve around issuing warnings and withdrawal of the license.

Standards:

- **Sudanese Drinking Water Standards by the Sudan Standards and Metrology Organisation (SSMO), 2016** – The Sudanese Drinking Water Standards appear to have been established based on the structure and parameters of the WHO 2004 and 2011 Guidelines. The WHO Guidelines have since been updated (latest version is 2017) and some of the parameters have been removed from the hazardous lists and new ones have been added. In addition the groupings of the parameters have been changed. Comparison between the SSMO standards, 2016, and the WHO guidelines, 2017, also indicates that

[29] Summary taken from: Sarour, M. E. M. E. (2009) Adequate safe water and sanitation for all; A legal system to protect water and sanitation in Sudan, November 2009, *Workshop on Water and its Relation to Health and Sanitation Organisation*, General Secretariat of the Council of Ministers

quite a few of the Sudanese maximum permissible levels are lower than the WHO guidelines, which indicates that the Sudanese standards are stricter than the WHO ones. This is permitted in the WHO guidelines, where the WHO guideline level is not realistic for specific countries. The rationale provided as to why some of the Sudanese standards are stricter than the WHO guidelines include that: a) The SSMO studies a range of international and other government drinking water standards before making a decision (such as WHO, Food and Agriculture Organisation (FAO), International Standards Organisation (ISO)), rather than only the WHO guidelines; and b) Sudan is very hot and hence people drink more water, so the levels have been proposed to compensate for this. The WHO guidelines are established based on an assumption that an adult will drink 2 litres of water a day with 50% of this being assumed to be boiled or in food. In very hot climates people may drink double this amount. So making some guideline levels stricter may be appropriate for some parameters. WHO however notes that it is only for some parameters (such as Fluoride or Arsenic) that it may be appropriate for modifying the levels based on the climate and volume of water drunk. This is because the proportion of such chemicals coming from drinking water is relatively high. But for many parameters where a person's intake from drinking water is very small compared to other sources, it is not felt that adjustment is necessary. It also notes that for some parameters it isn't physically possible to measure them below a certain level. Hence these issues should also be considered when next updating the Sudanese DWQ standards.

- The Sudanese DWQ standards were updated in 2016, but by October 2017, a number of key institutions with responsibilities for DWS did not know that the updated final versions existed and did not have copies (including the DWS teams in the FMoH and MoWRIE and key teams in the national drinking water quality labs associated with both Ministries). The SSMO has technical committees that meet weekly, including one on drinking water, which is the committee that establishes the updated standards. Members are from the SSMO, FMoH, WHO, University of Khartoum Faculty of Public and Environmental Health and the Higher Council of the Environment and Natural Resources. However, some key teams and staff are not represented on the committee, such as those from the MoWRIE GWD laboratory; FMoH DWS team members; and the MoWRIE/DWSU representative responsible for DWS.
- **Standards for equipment and chemicals** – Sector stakeholders noted that in the 1980s the Rural Water arm of government used to have standards for water troughs and towers, but today these are not used. Those who do use standards for design, construction or equipment would tend to use British Standards (and previously American standards but this is now less common). The SSMO has noted that they have some standards, but these have not yet been seen and no sector stakeholder has mentioned knowing about them during the process to establish the context. The MoWRIE/DWSU has a series of 14 technical guidelines (2009, draft and in the process of being updated) that are sometimes referred to as standards. They don't intend to include detailed specifications for equipment or designs, such as for water tower structures. Two specifications for water treatment chemicals were shared by Khartoum SWC, but it is not clear whether these are only used in Khartoum State or if they are Sudanese specifications applicable to the whole of Sudan. One of the challenges noted by stakeholders is the poor quality of spares available in the local market, which has an impact on sustainability.

<u>Policies & strategies:</u>

- The **25-year strategy for Sudan, 2007** – This has clauses related to reducing the pollution of water supplies.
- **Sudan's National Health Policy, 2017-2030 (draft as of September 2017)** - Under the section on Health Sections Functions, environmental health services are mentioned and that environmental factors are responsible for almost 60% of all disease in Sudan. It notes that according to the local governance act that environmental services are the responsibility of localities, which has resulted in the negligence of environmental health at federal level. [However this is not specifically mentioned in the Local Government Law, 2016]. It has policy statements related to environmental determinants of health and working on developing resilient systems and communities, but it doesn't specifically mention anywhere drinking water or DWS.

- **WASH Sector Strategic Plan, 2012-2016** – Includes some reference to pollution of groundwater and the Nile and confirms the *'polluter pays principle'* (both in alignment with the policy). **It highlights particular issues for pollu**tion with the younger sediment basins and also the increase in population pressure along the Nile and the lack of sewerage / agriculture drainage water treatment that the water related health risks are increasing. It also highlights that 'safe water handling and reuse' is part of community based hygiene and sanitation promotion and this is one of the six components of the rural sanitation and hygiene approach. The urban approach focuses on the role of the water corporations and highlights the old infrastructure and poorly functioning water treatment systems. It discusses the drinking water standards and the need for monitoring and enforcement and includes recommendations for an MIS integrated with a GIS system. Hence some elements relevant to water safety are touched upon in various sections. When updating the strategic plan it would be positive to ensure that water safety is strengthened, including integrating the need for WSPs at each level.
- **National Environmental Health Strategic Plan, 2015-19** – It includes three priority actions related to drinking water management: 1) Strengthen and establishment of water quality monitoring and surveillance system at 15 states; 2) Strengthen advocacy and promotion activities in water safety, sanitation and hygiene; and 3) Strengthen monitoring, surveillance and evaluation system. These are supported by a number of specific actions related to assessment, reporting, mapping, supporting establishment of regional laboratories, capacity building, supervision, advocacy and awareness raising and campaigns.
- **Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF) (final draft)** – This includes a strategic objective on water safety *'To improve water safety across Sudan through the protection of sources, water surveillance and treatment and capacity building'*. The strategies include those related to the development of WSPs at all levels; increased attention on the protection of water resources; strengthen water surveillance systems, including using sanitary inspections, water quality testing, monitoring and record keeping; supporting the use of water treatment including point-of-use systems; and undertaking capacity building.
- **The National School Health Strategy, 2016-20 (draft) –** DWS is mentioned briefly in three strategies: 1) Establish/improve water supply in all schools (at least installation of handpumps); 2) Safe reservation of water & promote a community based chlorination system; and 3) Improve source of water in health facilities in catchment areas. More emphasis should be placed on ensuring water safety in future strategies. For example, focussing on water source and supply protection, WSPs, sanitary inspections, training of teachers and pupils on how to safely handle drinking water and what mechanism is going to be used for access to cups for taking the drinking water.
- **Multi-Year Humanitarian Strategy, 2017-19 –** This strategy has outcomes related to affected populations (affected by natural or man-made disasters, displaced populations, refugees, returnees and host communities) receiving assistance and basic services; and that vulnerable populations have improved nutrition status and increased resilience. It emphasises linking to development programming and establishing durable solutions and contributing to peace building and social cohesion. It also emphasises the importance of the cross-cutting issues protection, accountability, gender and age-sensitive programming, the consideration of climate change and the protection of the environment.

Except for the SNSHSF, none of the above legal and policy related documents mention the need to prepare WSPs, although a few documents mention elements of the plans through strengthening monitoring and surveillance. Refer to **Section 3.3.6** for observations on enforcement/ activation of laws.

Guidelines:

There are currently four main sets of guidelines of most relevance to DWS:

- **A – MoWRIE/DWSU set of 14 'Technical Guidelines and Manuals' (supported by UNICEF)** – Include a range of relevant guidance related to DWS, but with a few minor gaps and inconsistencies. These will be remedied when they are soon to be updated under the Water Sector Reform project.

- **B – WASH sector emergency guidelines (new guidelines supported by UNICEF/REDR)** – There are a few of the WASH sector emergency guidelines that are in the final stages of preparation that are specifically relevant to DWS, particularly those related to: WSPs, O&M and water sources. A couple may benefit with a minor reformatting to make them more accessible (for example for the checklists) – for discussion.
- **C – FMoH supported chlorination and water safety guidelines (supported by FMoH, WHO, GAVI etc)** - The FMoH Manual on Water Quality and Safety is well targeted at the practical tasks of the public health inspector, but there are a few areas where it needs to be updated or could be refined. There were some technical errors in the existing chlorination documents, so it is agreed that these should be dropped and new ones prepared.
- **D – FMoE and FMoH Guidelines for School Health Programme (supported by UNICEF)** – DWS is integrated into the provision of a healthful, integrated, safe and supportive school environment, but the integration is limited and should be strengthened in future versions.

3.5.2 Stakeholder responsibilities

3.5.2.1 Challenges related to stakeholder responsibilities

Challenges related to institutional responsibilities for DWS include: The institutions with responsibilities in relation to DWS cut across Ministries and sectoral areas (such as: water, health, environment, agriculture, livestock, industry, education); in some areas the division of roles seems to be working better than others, but there seems to be a lack of consistency in understanding of roles and responsibilities. The AWD outbreak (2016/17) has highlighted gaps in understanding on responsibilities. It does not appear to be fully clear who is responsible for enforcement/ activation of laws and if the Locality is the main institution that is responsible to enforce, then the limitations in their ability to test a number of water quality parameters, leads to a weakness in the system in relation to DWS. Through a process of decentralisation, responsibilities have over the years been handed down from States to Localities to communities for the management of water supplies, but at the moment most communities are not involved much in the dialogue on DWS. There is limited coordination and collaboration between Development Partners, including in critical areas such as support for improving operation and maintenance.

3.5.2.2 Coordination bodies

Coordination bodies that have some responsibility for DWS include: the National Committee on Water Safety; the National Sanitation and Hygiene Committee; the WASH Sector coordination mechanism (humanitarian); the National AWD Committee; and there is a Technical Committee under the SSMO which meets weekly and which has representatives from the FMoH, universities and other experts; and the Refugee Consultation Forum (RCF), WASH Technical Advisory Group (TAG).

Gaps in coordination have been seen in relation to: The monitoring, certification of acceptance that a source can be used for drinking water purposes, and enforcement/ activation of laws related to the packaged/ bottled water industry; and in relation to overlapping focus of databases and MIS systems.

3.5.2.3 Stakeholder responsibilities

The following Councils have legal responsibilities related to DWS[30]: National Council for Water Resources; Supreme Council for Environment and Natural Resources; National Council for Environmental Health; and the National Council for Civil Defense. The agricultural and mining sectors also have roles in the protection of water resources and linkages should also exist with the animal/livestock sector.

Fig 3 - provides a simplified overview of the split of responsibilities into three key categories:

[30] Summary taken from: Sarour, M. E. M. E. (2009) Adequate safe water and sanitation for all; A legal system to protect water and sanitation in Sudan, November 2009, *Workshop on Water and its Relation to Health and Sanitation Organisation*, General Secretariat of the Council of Ministers

- **Environmental protection of water resources:** Lead Ministry – Ministry of the Environment, Natural Resources and Physical Development (MoENRPD)
- **Control of water resources and supply of safe drinking water:** Lead Ministry – Ministry of Water Resources, Irrigation and Electricity (MoWRIE)
- **Surveillance of safe drinking water and enforcement and sanitation and hygiene promotion:** Lead Ministry – Federal Ministry of Health

The overall coordination of the WASH sector is by the MoWRIE / DWSU.

In addition, **Fig 3** also identifies the key institutions which have the key responsibilities for setting standards, laws and policies in relation to DWS. Refer to **Section 3.3.6** for observations on institutional responsibilities for enforcement and the gaps which exist in this area. For further details of the responsibilities of each stakeholder refer to **Annex I.** In addition **Section 3.5.2.4** elaborates further on the private sector's roles in DWS in Sudan.

3.5.2.4 Private sector engagement

The private sector already undertakes a range of roles that impact on DWS in Sudan. Private sector actors may be of a wide variety of types and scale.

Private sector roles in Sudan include: provision of water supply equipment – such as pumps, pipes, taps, water storage tanks, water treatment plants and associated equipment and materials; construction personnel – providing services to construct and maintain water supply systems at city, town, village and household levels; provision of bottled drinking water; small-scale private water sellers including donkey carts; provision of water supplies through tankering in humanitarian contexts; sales of household water treatment products, water containers, jerry cans, soap; supply of water treatment chemicals; supply of water quality testing equipment and consumables; water quality testing services; repair of water quality testing equipment; consultancy for water safety related studies; private institutions providing training related to water safety; the media and public-private partnerships for the promotion of household-water treatment products and processes and household water hygiene.

Examples of challenges faced in relation to the private sector relevant to DWS:

In relation to registration and competence of the private sector: Some private operators start up businesses without knowledge of how to run a business or without technical experience of the area they are operating in; without adequate regulation and penalties, the quality of services provided may not be adequate to ensure water safety; a registration process for the private sector is reported to exist in the MoWRIE but it isn't fully utilised and the private sector may not be aware of the process; for water sold on the road – users can't be sure they have not been refilled; people are drilling without supervision or permission; and some private companies are "only with a bag on their shoulder".

In relation to policies, laws, standards, guidelines, enforcement, coordination etc: There is an absence of standards / specifications for materials and equipment including for water treatment chemicals – so anyone can buy them from the local market, including government, but these could result in poisonous materials being put into the drinking water; poor quality equipment – it breaks down within few years / cheap products from China etc; each person they meet tells a different story about policy and strategy and there are different laws and regulations at Federal and State levels; there is poor coordination between the Government and the private sector; there are no unified standards – consultancies use international standards. Most private sector organisations which attended the national workshop (except for one) did not note any specific law or regulation that they follow, which could indicate lack of knowledge / awareness within the private sector; there is weak enforcement against those who disobey; and there are few public-private partnerships.

In relation to money and customs processes: They do not have access to hard currency so they have to use the black market to be able to purchase items from outside of Sudan; there is limited flexibility in contracts

for fluctuations in exchange rate and the increase in real costs of the work; and sanctions have proven challenging particularly related to the high costs for American products (although as the sanctions have now been lifted this will hopefully improve). They face multiple problems with importation including: customs delays which can also lead to chemicals expiring; lack of trust (the customs sometimes have concerns that the water quality testing kits may be explosive devises rather than water quality testing equipment); the importation taxes are too high; different labs used as part of the importation process have different parameters; staff involved in importation are not qualified / knowledgeable on all areas; and delays in payments from government for contracts.

Capacity building: Some organisations have had some capacity building – such as on water quality testing. Participants from the private sector suggested that trainings could also extend to the private sector (even if paying some fees) or a request was made as to whether the Government could share their training protocols with the private sector? Training is provided in some project tenders.

Issues related to the current processes for the regulation of bottled water have been discussed in **Section 3.3.7.1.**

3.5.3 Financing

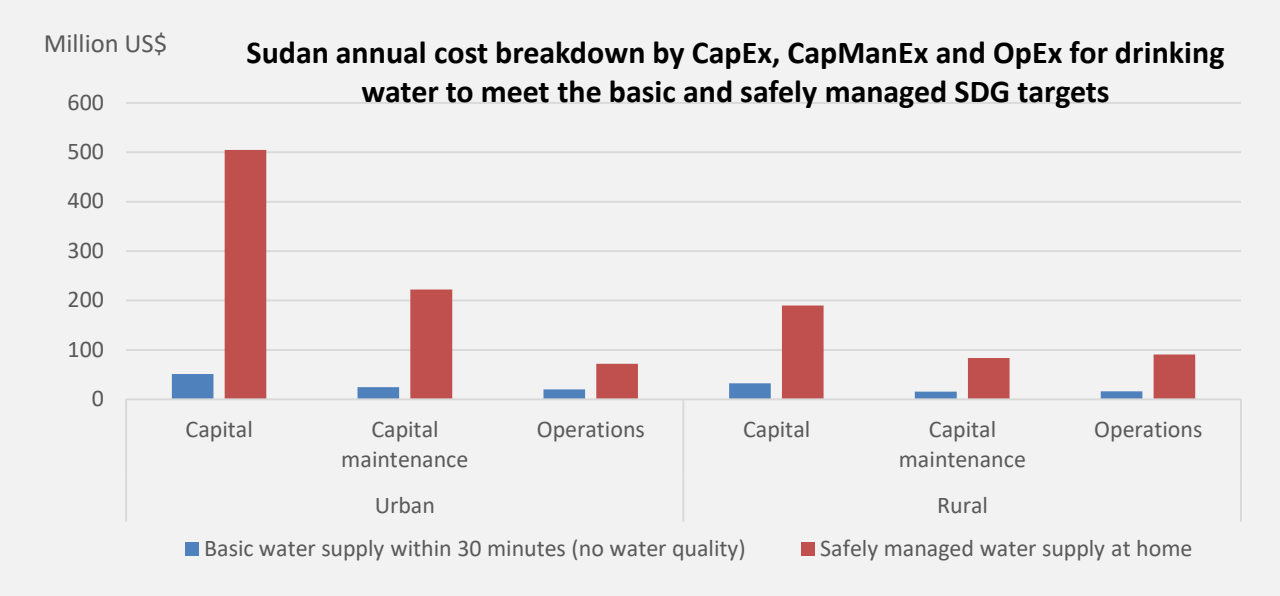
Global estimates of costs for DWS for Sudan

The following graphs in **Fig 9** and **Fig 10** - published by the World Bank (Hutton and Varughese, 2016) provide an estimate of the annual costs of meeting the SDGs for water supply – both:

- Basic drinking water (JMP 'improved water' but within 30 minutes of the home roundtrip)
- Safely managed water supply (on-plot, continuous and safe water supply)

The first graph provides a breakdown by urban and rural and also the annual capital cost (CapEx), capital maintenance costs (CapManEx) and operations costs (OpEx). The second graph provides estimates of the percentage of Gross Domestic Product (GDP) that will be required annually to meet the SDG targets for basic and safely managed drinking water as well as sanitation and hygiene.

Fig 9 - Estimates of the annual cost breakdown for meeting the SDGs for drinking water[31]



[31] Hutton, G and Varughese, M (2016) *The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation and Hygiene - Data catalogue entries for Sudan*, World Bank

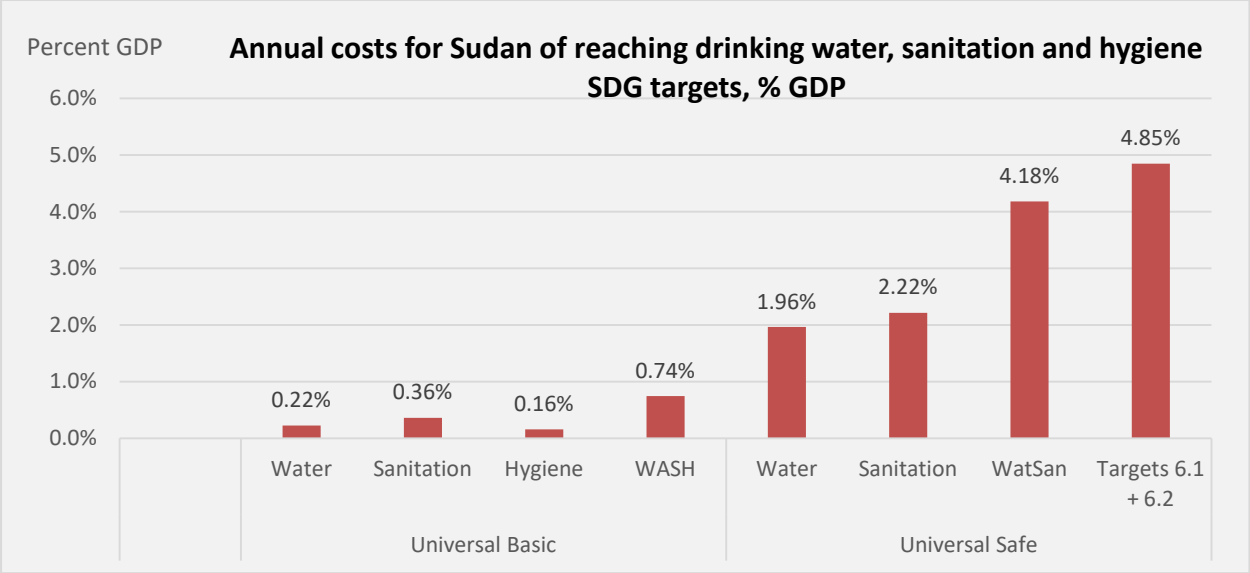
Challenges for financing:

There is a lack of budget (from Government, development partners, the private sector and others) allocated specifically to DWS more generally and also for the implementation of WSPs. The lack of finances, staff and limited logistics impacts on: inadequate volumes of chemicals; WTPs supplying much larger populations than they were designed for; old pipes are not being replaced or repaired effectively – only temporary repairs are undertaken; staff are not able to reach many water sources and supplies to check for contamination as it is difficult to get to localities, private sector suppliers and communities to provide supportive supervision. All of these impact on the safety of drinking water and the health and ultimately the development of the nation.

Tariffs and real costs:

The Key Performance Indicators report for the North Darfur Urban Water Project for the period Jan-March 2017[32], indicates that in the 4 towns under the project that the cost recovery ratio varies from 45% to 66% for three of the towns (Nyala, El-Fasher and Zalengei) to 95% for Geneina.

Fig 10 - Annual costs for Sudan to meet SDG targets for drinking water, sanitation and hygiene[33]



The Strategic Investment Programme for Port Sudan[34] notes: *"The Red Sea State Water Corporation operates at a loss. It is an unsustainable financial burden on the State budget, relying on a State grant for annual emergency works. Annual losses in 2012 & 2013 were about 7-8 million SDG (equivalent to US$1.2m). Losses would be higher if the required operating and maintenance costs were included. Revenue from water sales is unable to cover even the costs of salaries. Tariffs do not reflect the real cost of provision of services. The flat rate tariff per month does not relate to actual consumption of water which encourages wasteful practices. Tariffs and revenue would need to be 90% higher for RSSWC to break even, and probably 150% higher to cover adequate maintenance. As the size and hence asset value of the network increases with any future infrastructure provision, the maintenance cost must also increase".*

In the UW4D study in the 4 State capital towns[35], the expenditure from 2016 was split: a) salaries and allowances (42% of the total); b) Operation and maintenance (45%) and c) finance and depreciation (13%). At the moment only 9% of the O&M budget goes on maintenance and repairs of infrastructure. But the

[32] Urban Water Administration Offices (2017) *Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala*
[33] Hutton, G and Varughese, M (2016) *The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation and Hygiene - Data catalogue entries for Sudan*, World Bank
[34] NewTech Consulting Group and Mott MacDonald (2015) *Port Sudan, Water and Sanitation Strategic Investment Programme, 2016-2022,* November 2015 (Updated with Annex 5, June 2016)
[35] No author (2017) *Tariff Study – Volume IV, Key Findings, North Darfur State*

UWAs acknowledge that they do not have a clear understanding of the real costs of operation and maintenance of their water services. Preventative maintenance is not carried out, only maintenance on a reactive basis subject to available funds or ad hoc requests to Government for funds.

It is also reported that in some States the drinking water tariff does not go directly to the SWC, but is paid directly to the Ministry of Finance and National Economy. In some cases this is when the payments for water and electricity have been combined into one payment (for example in River Nile, Gezira, Sennar and Kassala). It is reported that in some States that only a small proportion of the fee is paid back to the SWC which means it has even less money to cover its staff, O&M, replacement and overhead costs. River Nile State is understood to be an exception where over 85% of the tariff is paid back to the SWC.

The charges that are made for drinking water are very low. In Khartoum this ranges from 30, 50 or 80 SDG per month, which is a very low charge and the same even if you use a large volume of water. There is also a particular risk that SWCs omit the chlorination stage of the water treatment process because the chemicals are so expensive.

Raising the tariffs will most benefit people of lower income

Provisional findings from a study of the tariffs and costs to households in four towns in North Darfur[36] has established that it is the households which are not connected to the network or those who have less regularity in service who pay significantly more for their water as they use water vendors to supplement their supply. For example from the Water Market Survey in El Fasher, peri-urban households spend SDG 245 per month for water, urban households SDG 229 and IDPs 119 per month, but the charges for connection to a pipe varies from SDG 30 to 40 per month. The Strategic Investment Programme for Port Sudan[37], also comes to the same conclusion establishing that the annual average cost for those using water vendors is equivalent to US$ 12.5 per m^3, compared with the piped network of US$ 0.67 per m^3.

Part of the challenge is that water until relatively recently was free and the politicians will not permit an increase in tariff. The provisional findings of the two analyses indicate that setting the tariffs too low, means that maintenance does not occur effectively and this tends to most disadvantage the lower income communities as they are less likely to have a piped and continual supply. There is a need to increase awareness – both political and with the citizens of Sudan.

Prioritisation of finances for DWS:

DWS has generally been given a low priority by most actors and when it is integrated into broader budgets it tends to get lost and teams working specifically on DWS in the MoH tend to be small. The main priority seems to be on the quantity of water (which is also important), but the quality of the water does not seem to have been of such a concern to those supporting water supply. One stakeholder noted that most of the Health Sector and WASH Sector's funds are used for humanitarian purposes (although the actual budgets for humanitarian and longer term contexts were not compared for confirmation) and the Health sector as a whole only gets 2% of GDP when it should be 6-12%. WHO and UNICEF provide some funds for this area, but most is targeted for specific projects / activities.

3.5.4 Planning, monitoring, research and learning

Humanitarian plans:

The following two humanitarian plans include some brief mentions of water safety.

- **Humanitarian Response Plan, 2017** – It includes several references to water safety including a focus on: water resources management; water safety; sanitary risk control/management (safe water handling; end

[36] No author (2017) *Tariff Study – Volume IV, Key Findings, North Darfur State*

[37] NewTech Consulting Group and Mott MacDonald (2015) *Port Sudan, Water and Sanitation Strategic Investment Programme, 2016-2022,* November 2015 (Updated with Annex 5, June 2016)

open defecation; hand-washing; water source protection); capacity building for operation and maintenance and sanitary risk mitigation; addressing the issue of water quality; and addressing and preventing malnutrition and communicable diseases through ensuring vulnerable people have clean drinking water.

- **South Sudan, Regional Refugee Response Plan, Jan-Dec 2017** – Two brief mentions: improving safe water access with an emphasis on water quality monitoring and maintenance; and intensified hygiene promotion at refugee sites including on safe water handling and storage.

Water safety plans:

WSPs are currently not being done. A few examples have been identified where they have been tried:

1. It is reported that UNICEF has supported WSPs in Kassala in 4 villages and in the Kordofan States;
2. During a training JICA supported a process of water point mapping in one Locality in White Nile which the White Nile SWC are calling a Water Atlas. The WN SWC notes that it intends to continue the mapping process in the other localities.
3. Water Point mapping with risk analysis has also been undertaken in White Nile State as part of the AWD response and the cases of AWD mapped against the water points. In addition the communities that have been most affected by AWD have been mapped against the type of water source. The draft map indicates that communities that are along the White Nile with less access to boreholes or *hafirs* have been those most affected by the AWD.
4. The MoH and MoWRIE have prepared a document called a 'Water Safety Plan 2017'. This plan focuses on how to ensure that all water sources are chlorinated across Sudan in response to the AWD outbreak. It is not in reality a WSP identifying the hazards, hazardous events, risks and control mechanisms as per generally accepted practice. But it includes some recommendations for control mechanisms which will impact on improving DWS.

Recent training has also been undertaken on WSPs: Supported by UNICEF – in the four Kordofan States; by REDR / WHO – in 5 Darfur States; By REDR / WHO – at Federal level with participants from across States. One of the new guidelines for WASH in emergencies also focuses specifically on WSPs. It has not yet been established if there are any components of WSPs being undertaken by the SWCs, for example any mapping of the distribution networks with plans for maintenance to reduce pollution risks except under the UW4D project, although it is understood that in some SWCs monitoring only tends to happen if a problem is reported. A number of staff from SWCs have received various forms of training on WSP development.

Sanitary inspections/ surveys:

Sanitary inspection formats have been integrated into the FMoH Manual on DWQ and Safety, 2016 and they are also included in the new WASH in emergencies guidelines on water source selection. It is not clear how widely they are being used or if the findings are being responded to. An example of a Water Quality and Safety report by the State MoH Environmental Health Section in South Darfur highlights the percentage of sources contaminated (but does not give details of this) and sanitary inspection scores (low, medium and high risk). The same reports also indicate how many of the wells have been chlorinated and whether training on chlorination has been given.

Documentation and reporting:

Water quality analysis is being undertaken to some degree at different levels and by different institutions. Key observations include: that there are a range of different forms being used for the recording of DWS related issues – which is positive, although it was not clear that they have been standardised across States and Localities. In some locations records are not kept on site – for example in Zamzam IDP camp. The MoH representatives have personal notebooks and fill in sheets at State level and the WES team reports some data to the State level. Having log books on site would be positive to keep a track on the checks over time and also how particular problems have been responded to.

An example of good practice is the Key Performance Indicator (KPI) quarterly reports are being produced under the UW4D project for the 4 State capitals. These encourage tracking of progress against a set of key indicators, which include KPIs related to: KPI-1: Water Production; KPI-2: Energy utilisation; KPI-3: Water availability; KPI-4: Leakage management; KPI-5: Customer database; KPI-6: Customer complaints management; KPI-7: Nonrevenue water; KPI-8: Revenue collection; KPI-9: Unit operational cost; KPI-10: Cost recovery. Adding a KPI for DWS would also be positive.

Certificates to confirm that water is acceptable for drinking (including in relation to bottled water) have been viewed as issued by a SWC and also the National Public Health laboratory. The FMoH is collecting data which is being fed up from locality to State to Federal. This includes water quality data and availability of equipment. The MoWRIE collects data from State level mainly on water related activities such as construction or rehabilitation and water treatment chemical supplies. Reports from the Khartoum State MoH to the Khartoum State SWC were also seen and both parties confirmed that these results are provided identifying issues when they arise. Log books are being used in laboratories attached to WTPs and the White Nile laboratory also had WQ data in a computer. A few errors were seen on sheets (use of Total coliform instead of *E.coli*; mg/l next to pH). The Alagaya refugee camp WTP used record sheets for both water quality results, fuel used and also maintenance checks.

In two locations records were seen of on-going monitoring being undertaken along the water supply chain to the household, but this does not seem to be a common occurrence in all locations. One positive example of this happening was in relation to the supplies in the White Nile refugee camps – with data shared by WHO; the other was MoH record keeping sheets in North Darfur related to the IDP camps. These sheets provided evidence of checking free residual chlorine (that was zero) as well as the hygiene of the toilets and the condition of the jerry cans. One attempt was also seen of mapping water quality with AWD cases, again in the White Nile by WHO. No pattern was apparent in this case, but this is still a worthwhile exercise if the data is available as it could potentially be used to help target priority actions. Some data is also being collected for AWD activities, including some comments on the distribution of chlorine tablets.

With record keeping and recording water quality data there is always a risk that the person reporting may just write what they know is an acceptable level – care will be needed in training and supervision to raise awareness that this is not acceptable and that accuracy to the real situation is what is required.

<u>Databases:</u>

There seems to be a big challenge from the range of databases and organisations holding and supporting databases and M&E systems that cover some elements of DWQ. There is a significant risk of duplication and overlap between the different databases. For example the same water sources may be included in the databases established by the MoWRIE/DWSU, the MoWRIE/GWD, the FMoH and SWCs with support from: UNEP, UNICEF and WHO and those held by the SWCs. The databases used by the MoWRIE DWST lab and the GWD laboratory at national level (which is ACCESS based) are not linked to the main GWD water sources database. The reason given for this is that there is a need for GPS data for any water quality data to be entered into the main GWD database. There is a need for all of these organisations to sit together to look at the content of the databases each are supporting, their purposes and users, and to discuss and agree if there is a need to consolidate any of the databases (such as to have consolidated databases at State level), or if they should remain separate. Consolidation would pose significant challenges as it would require close collaboration between the Ministries as well as the Development Partners and an agreement on who would be responsible for the funding, design and management of the database. Collaboration takes time, the various funding channels and mechanisms may be challenging to align and each Ministry and State level institution will have its own reasons for wanting to manage the database as they may use the data for different purposes and have different data collection systems. Therefore a decision may be made to keep them separate and overlapping.

In terms of the existing databases, the MoWRIE/GWD database has the most comprehensive range of water quality parameters indicated. The FMoH spreadsheet based database that was established with support of WHO when a water source and water quality mapping was undertaken in 7 States in 2014, seems the most

useful for DWS as it is in a simple spreadsheet format and includes a column for a sanitary survey score and priorities for action as well as key details of the water points and water quality. This mapping has also been supported by WHO in East Darfur in 6 of 9 Localities in 2016/17. The Water Atlas as described in White Nile as having been prepared in one Locality has not yet been viewed, but is understood to include maintenance status. The MoWRIE/DWSU/WES database that is currently not functional, but where there are plans for updating, has some information on water quality and on the water point but it was mainly used on a project basis. Some questions have been raised about the accuracy of the data included on some of the databases relating to specific water sources.

National and targeted surveys:

Some data related to the type of water source and the type of HWTS used by households who use unimproved sources is already included in the last MICS, but there is an intention to strengthen this in the next MICS. Also the Federal Ministry of Education (FMoE)/ FMoH/ UNICEF are planning to support a mapping of school WASH in 2017, which will also include water safety.

Research and learning:

JICA has been supporting the establishment of websites for the DWSU, DWST and SWCs which will serve as an opportunity to share information on good practices as well as enable the citizens to access information on their water services.

There has been some research by the University of Gezira on water quality along the water source chain from the Blue Nile to the household, undertaken in collaboration with the Gezira State and universities in Kenya and South Africa; and the University of Gezira has also undertaken research into WSPs in Darfur.

University students across a range of universities in Sudan are undertaking research projects into DWS related issues. Examples from the University of Khartoum include those focussing on: Evaluating efficiency of treatment units and WTPs; assessment of drinking water quality in hospitals; water from wells that are connected to public water distribution system; bacteriological quality of drinking water; the quality of water of swimming pools; sufficiency and storage of water in schools; and quality of vendor-provided water. But apart from examples of student projects, there is generally only a limited amount of research, surveys and learning related to water safety.

3.5.5 Capacities and capacity building

Human resources for DWS:

Challenges faced in relation to human resources for water safety: The teams working specifically on water safety in the MoH and at localities tend to be small, for example: FMoH - there are three staff, in Khartoum State - there is one, in Khartoum Locality - there are two, in Kassala Rural Locality - there is one.

The limited number of staff also limits the time available to undertake water safety related activities, which are also severely limited by lack of allocation of budget and vehicles. Salaries also tend to be low contributing to low motivation. The low status of the Environmental Health profession generally and limited opportunities for advancement also reduces the number of people who choose to work in or stay in the profession; and there is also a high turnover of staff trained in WQ analysis at State and Locality level. This leads to gaps in capacities for people who take over their posts without the associated training. In the universities there is a high turnover of professors in EH who are attracted to work in the Gulf States where there are much better working conditions. Likewise skilled and trained personnel working at SWC level also go to Saudi Arabia and other Gulf State countries to work. In the River Nile State, it is reported that the SWC has been able to increase salaries from the water tariff, which may help to retain trained staff.

Logistics:

A lack of access to logistics (vehicles and fuel) is one of biggest issues for maintenance, monitoring and surveillance. Laboratory teams reported to not be able to respond to complaints and routine monitoring is not undertaken. Some reported to sometimes taking public transport to try and reach locations to respond

to complaints. MoH staff responsible for water safety at State and Locality level reported not being able to get to many water points due to limited access to vehicles and a team managing a WTP for a refugee camp reported having difficulty getting to the surface water inlet to be able to clear away materials blocking the inlet or for repairs and also to get between camps. No water safety teams were met who had dedicated vehicles and those that have access generally only have shared access to one vehicle shared with the wider EH team, which in some cases in also in a bad condition.

Analytical capacities – laboratories / field equipment:

A range of Government of Sudan Ministries, State level government, Locality, universities and training institutions and the private sector operate laboratories or have field equipment for assessing drinking water quality (DWQ).

Examples of laboratories and teams with DWQ equipment:

- **Government laboratories at Federal level:** The National Public Health Laboratory of the FMoH (previously known as STAC) – which is the main reference laboratory for the whole of Sudan; The MoWRIE, Groundwater and Wadi's Directorate; National Environmental Research Council (NERC); Sudan Standards and Metrology Organisation (SSMO) – National; Sudanese Armed Forces; Ministry of Oil and Petroleum; and the Ministry of Minerals. There is also a Federal laboratory for the State Electricity companies.
- **Universities and training institutions:** DWST – National and in some States (equipped by JICA); Allied Health Sciences – National and in all States (may not have own labs); University of Khartoum, Gezira, Bahari and AAU EH Departments (as examples); College of Water Resources, Sudan, Department of Water Resources
- **State level:** EH Dept., State MoH; State Water Corporation – including Central Lab and labs at WTPs; State SSMO
- **Locality level:** Water Safety Unit, Health Affairs Dept., Locality Government
- **Private sector:** It is also reported that a number of private sector organisations also have laboratories with DWQ capacities

Capacities of the laboratories:

The capacities of the laboratories visited varied significantly. Examples of the variations include:

- **SSMO laboratory** - This laboratory is accredited by the International Standards Organisation (ISO) through undertaking international proficiency tests. Their main laboratory is in Khartoum but that also have a large branch in the Red Sea State. Their laboratory covers food and water, but there is also a laboratory for paints (but which it is understood does not currently test for waterproof materials / paints for drinking water tanks and there are no standards in Sudan for the same). The SSMO sets the standards for DWQ (see **Section 3.5.1**) and also approves other laboratories in Sudan.
- **Laboratories with greatest capacity and ability to test complicated pollutants** - From the laboratories visited those with the widest range of equipment and ability to undertaking a wider range of tests include the FMoH National Public Health Laboratory (NPHL) and the DWST national training laboratory; but even the NPHL has gaps in the functionality of its equipment and the laboratory facilities are quite old. The NPHL and the SSMO laboratory have the capacity to test for pesticides and insecticides; but the NPHL would communicate with the following laboratories if other specific contaminants are found: The Ministry of Oil and Gas for suspected oil related contaminants; The Military for suspected radiological contaminants; The Ministry of Minerals for other contaminants, for example related to mining processes. The MoWRIE/GWD is also starting to do isotopic analysis with support of the International Atomic Agency, but the equipment is broken down (due to power fluctuations) and needs spare parts and some work on the software. This needs support from outside of Sudan. There is a plan to combine

the MoWRIE GWD, DWST and Electricity laboratories into one laboratory. The Khartoum SWC central laboratory at Mogran WTP is currently testing for algae using physical observational methods.

It is understood that no laboratories in Sudan have the capacity to test Volatile Organic Compounds (VOCs), which are relevant to assessing the toxicity of paints. Also it is not clear that any water related laboratory has the capacity to test for protozoa in water, which is required as one of the Sudan DWQ standards. Medical laboratories can test protozoa, but these are likely to be from stool samples rather than water.

- **The SWC central laboratories** – Those visited were based in one of the State capital's WTPs. The capacity of the laboratories varies - for example: The SWC Central laboratory in Kassala has been set up in a meeting room at a relatively new WTP (2014 supported by JICA) and does not have its own water supply or sinks. But the laboratory is staffed by highly committed and competent staff who are clearly looking after the equipment that they have access to and utilising the equipment and space they have to provide an effective DWQ service. The central laboratory in White Nile, at the Kosti WTP, has a formal laboratory and quite a large number of laboratory staff, but less access to functional equipment. A number of items of equipment broke down several years ago and have not been repaired. The laboratory is only able to test for chlorine residual and pH using a pooltester as it has no functional photometers.
- **WTP laboratories** - Some have laboratories, but most have only basic equipment (such as for measuring turbidity and chorine residuals) or no equipment. Where the jar test is done (such as in Burri WTP in Khartoum State) it has been shown to establish variations in optimal PAC dosage from 1 to 50 mg/l (the latter in the Autumn). This is quite a large range and includes potential losses from inappropriate dosages where the jar test is not done.
- **MoH laboratories at State level** – Some of these laboratories have more significant problems. For example: The MoH DWQ laboratory in Khartoum could only undertake microbiological testing of different forms at the time of the visit, all of the equipment that it had to measure physical and chemical parameters for DWQ was broken and seemed to have been for some years. It was later reported that some of it was under maintenance and is now repaired. They also have one piece of expensive equipment, a High Performance Liquid Chromatograph (HPLC), but this has not been used since it was obtained in 2011. It is still wrapped in plastic, does not have consumables and it is reported that as the consumables are so expensive they are considering to instead use it for blood testing. The MoH DWQ laboratory in Kassala has a formal laboratory and some field based equipment, but currently has no laboratory staff. It also has a large box of consumables for a range of parameters that can be measured with a Palintest Photometer, but does not appear to have a Palintest Photometer. The WQ team of MoH in White Nile have a range of DWQ field equipment, but no laboratory, so the equipment is being kept in a metal cabinet in the team's office and some consumables which have become expired. The staff are clearly highly committed, but are also self-trained in the use of the equipment and are training others.
- **Locality level** - In Khartoum State Locality, there are two staff in the Water Safety team and they have two Photometers which they use for chlorine residual, but only one turbidity meter. For microbiological testing, bottles of media are collected from the MoH Central lab and samples sent to this lab for testing. In Kassala Rural Locality the Health Affairs Department has one staff member working on Water Safety. He took over from someone who had previously been trained on DWQ analysis including microbiological testing, but who had left the post. The team have an older design Wagtech Potatest and associated items but they are old and not kept in a good condition. Testing is currently undertaken using a Pooltester only, mainly for chlorine residual.
- **WTP supplying refugee camps in White Nile** – This is now being managed by the SWC and has a Wagtech Potatest and a Palintest Photometer. The Potatest does not appear to be used for microbiological testing and the turbidity tube is damaged. The MoH are undertaking monitoring of the water supply.
- **Training institutions** – From the three universities that were met, the University of Khartoum, Bahari University and AAU – only Khartoum University has its own departmental laboratory, although AAH can

access a laboratory shared across multiple departments and Bahari has some items of field equipment. The University of Khartoum has a good quality laboratory and equipment that is clearly very well looked after but they only have limited numbers of items, for example only two turbidity meters. This means that they can only usually provide demonstrations for the students (in groups of 40). For Bahari, AAU and the Academy of Health Sciences – they mostly rely on sending their students to other laboratories run by the MoH, SWC at WTPs, the SSMO and NERC. But some of these laboratories also have limitations in equipment and consumables, which will also limit the student's learning experience. There are a range of other universities that cover DWS across Sudan, which may or may not have laboratory capacities. For example in Gezira, the Blue Nile Institute for Communicable Diseases; and in Northern State the University of Dongola. It is also reported that some of the SWC DWSTs not visited also have laboratories.

- **Microbiological testing** - A variety of tests are undertaken for microbiological analysis, including:
    - The multiple tube fermentation (of most probable number, MPN) technique + confirmatory tests (using MacConkeys, Brilliant Green and Lactose broths).
    - The membrane filtration (MF) method (using Membrane Laurel Sulphate Broth, MLSB) – but this was found to be less common and even where the Wagtech Potatest kits existed, only one seen across institutions appeared to currently be in use. The cost of the consumables appeared to be an issue in some of the more established laboratories.
    - The only location where H_2S bottles were observed was the White Nile MoH, who just had a few bottles. In Kassala Locality they noted that they were given some but they were out of date / not functional as they went black as soon as water was put in them. However this may have been because of the presence of naturally occurring H_2S in groundwater sources, which will lead to the immediate change in colour to black.

Challenges for laboratories and staff with field kits

Examples of the challenges for laboratories and staff with field kits include: There are a wide range of capacities of laboratories and equipment at State level and below; Some of the laboratories and equipment are old – there is a need for updating; Some state MoH have no laboratory and some WTPs have very limited if any equipment; University and training institutions do not have adequate numbers of equipment for the number of trainees, whereas there is a range of broken equipment across laboratories that it may be possible to repair and use; The MoWRIE GWD laboratory has no administrative link to the labs at State level and can only provide administrative support; There is a range of broken equipment not repaired – sometimes repair has been asked for repeatedly for years; There is a deficiency in maintenance skills for both field and laboratory equipment; Staff need training on new techniques – training tends to only be available when it is linked to a specific project; Some consumables have expired and there can be a long procurement time and cost for consumables and calibration fluids (which only last for a few years) – particularly those that come from outside of Sudan (for example HACH and MF consumables); Some consumables have expired or do not function as expected (even new ones coming in the Pooltester kits) – which can lead to inaccurate results, such as in relation to chlorine residuals; Vehicles not available to be able to go out for sampling and to respond to complaints – some are relying on partner vehicles; Gaps for the identification of algae – although algae and the risk of blue-green algae is a problem in a number of locations taking water from the Blue Nile; Turnover of staff leaving replacement staff without appropriate training; Need to check on health and safety, including hand-washing in laboratories.

A few methodological gaps need revisiting – for example ethanol is sometimes being used instead of methanol for the disinfection of the membrane filtration equipment; there appears to be some use of Total Coliform as a faecal indicator instead of *E.coli* or Thermotolerant coliform; there is also concern globally over the use of H_2S kits for the identification of *E.coli*, despite the claims of the producers, as they can give false positives and hence water sources rejected when they only have naturally occurring coliform. Hence if H_2S kits are used there is a need to follow up any positive results using the MPN or MF methods to confirm the faecal nature of the contamination.

Capacity building for DWS:

A number of training opportunities exist in Sudan that have relevance to DWS. Observations include:

1. The DWSTs seem to be the only training institution at present with a specific course on operation and maintenance and pipe networks and design, areas that are major gaps in relation to ensuring water safety in Sudan.
2. There has been an increase in focus on sanitary investigations and WSPs in trainings, with examples of trainings conducted recently covering both by the FMoH, WHO/RedR, and UNICEF/MoWRIE. The use of videos (UNICEF supported training in Kordofan) to highlight particular hazards and the field work integrated into the WSP trainings with discussion and feedback (supported by UNICEF and REDR/WHO) are both positive developments. The FMoH has trained 270 PH Officers in the use of the Manual for Drinking Water Quality and Safety in 2016, which includes sanitary investigations/ surveys.
3. Much of the materials are still in English, which may reduce their value, as many people working at State and Locality level may not have strong enough English to make the most of the materials.
4. There are a range of departments at universities and the network of Academy of Health Sciences institutions that include DWS related topics in their courses. But large student numbers and lack of access to water quality equipment and laboratory access, limits the opportunities for student learning. Also projects tend to be more descriptive rather than interventional, which the universities feel would be more beneficial for building the skills of the students.
5. The FMoH Continuous Professional Development Directorate (CPDD) is the mandated institution to train MoH staff. It provides a 5 day training on DWS for MoH and Locality employees focussing on monitoring, surveillance, water quality testing, community engagement, water treatment. They also have courses related to hygiene promotion, environmental health impact, food safety (which may have some relevance for bottled water and ice) and pesticides and insecticides (which may have some content relevant to pollution of drinking water).
6. It is also reported that a number of international NGOs have provided training on water quality analysis.
7. The REDR/WHO supported training that was held in Khartoum on 'Water quality and infrastructure' was very practical and focussed on the likely issues that are likely to be seen at sub-national and community levels. The DWSTs tend to provide quite detailed water quality training, suitable particularly for staff that are likely to have a laboratory role. The REDR/WHO training in Darfur focuses on State and Locality level staff.
8. Whilst there is some good training being provided, it is positive for all institutions to continually reflect on their training materials to ensure that the most relevant topics, parameters and equipment that are likely to be used by the specific groups of trainees are the main focus of the content. This is to ensure the greatest benefit from the trainings, rather than risking being too theoretical on subjects that the trainees may not otherwise use.

For more information on the range of different courses available see the contextual analysis report.

3.6 Trends, progress and bottlenecks to scaling up access to SDW in Sudan

3.6.1 Access to drinking water services

The following graphs show JMP 2015 estimates of access to different levels of access to drinking water services as defined by the SDG drinking water ladder and also how overall access has progressed over time. Note that this figure indicates that at present the JMP has estimated that there is no access to safely managed drinking water supplies in Sudan. This is because the data is not available on the quality of drinking water supplies and hence this estimate cannot be made effectively at this time.

Fig 11 - Estimates for the drinking water ladder for Sudan, 2015

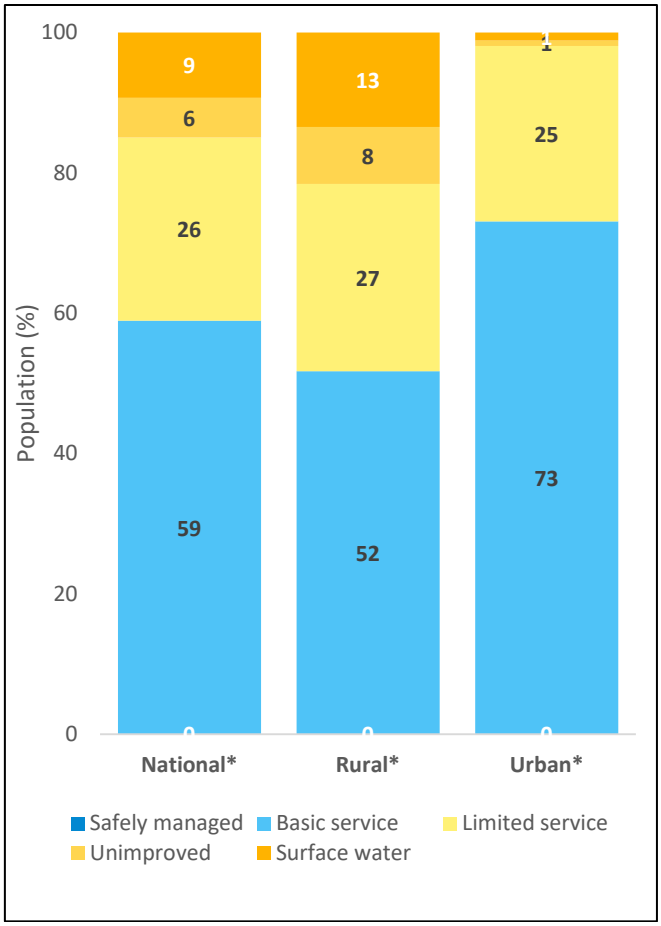
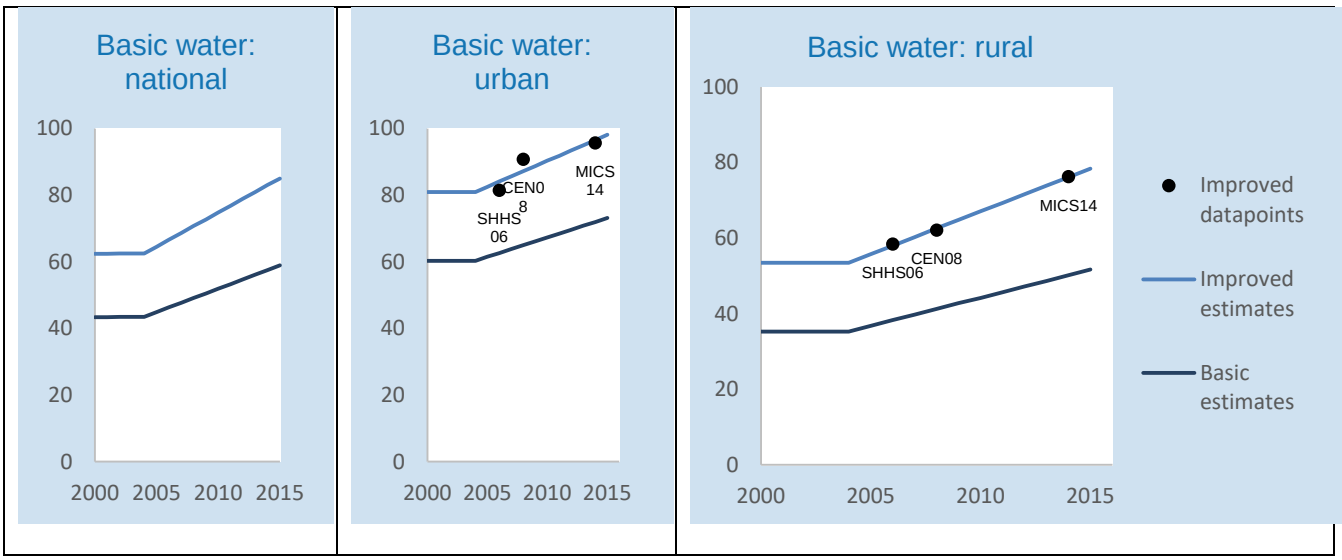


Fig 12 - Trends of access to a basic service (as per the new JMP drinking water ladder definition) over time



3.6.2 Strengths in ensuring DWS in Sudan

The current strengths in Sudan in relation to ensuring DWS in Sudan include:

- The existence of dedicated staff at all levels with responsibilities for the supply of safe water or surveillance; some very committed working with difficult limitations such as limited equipment and logistics; and a range of training available for different staff in different roles and levels.
- There is some mention of DWS in laws, regulations and guidelines; the MoH and some Localities are undertaking monitoring activities and feeding back to the SWC on performance of WTPs and there appears to be good coordination between some State MoHs and SWCs. Some documentation of water quality testing exists and is being reported to varying levels – for example through the MoH system. Some enforcement/ activation of laws is occurring related to approval for use of boreholes.
- There are a range of water treatment plants (WTPs) still operating, some for many years (even near 100); a range of laboratories and water quality equipment is available; and there is also evidence that there is chlorination being undertaken related to the current AWD situation.
- Several databases exist and there have been various attempts to map water sources and water safety related issues (for example the WHO supported water source WQ database had sanitary survey included); there are reported to have been a few WSP trials; and there has been training on WSPs in Kassala and Kordofan (supported by UNICEF) and in Darfur (supported by WHO and REDR).

However, the above are not without limitation. See **Section 3.6.3** for an overview of the current bottlenecks.

3.6.3 Bottlenecks for DWS in Sudan

Figure 13 - provides an overview of the bottlenecks for ensuring SDW in Sudan.

3.6.4 Theory of Change for scaling up access to SDW in Sudan

Figure 14 – highlights the Theory of Change for scaling up access to SDW in Sudan.

Fig 13 - Bottlenecks for scaling up access to SDW across Sudan

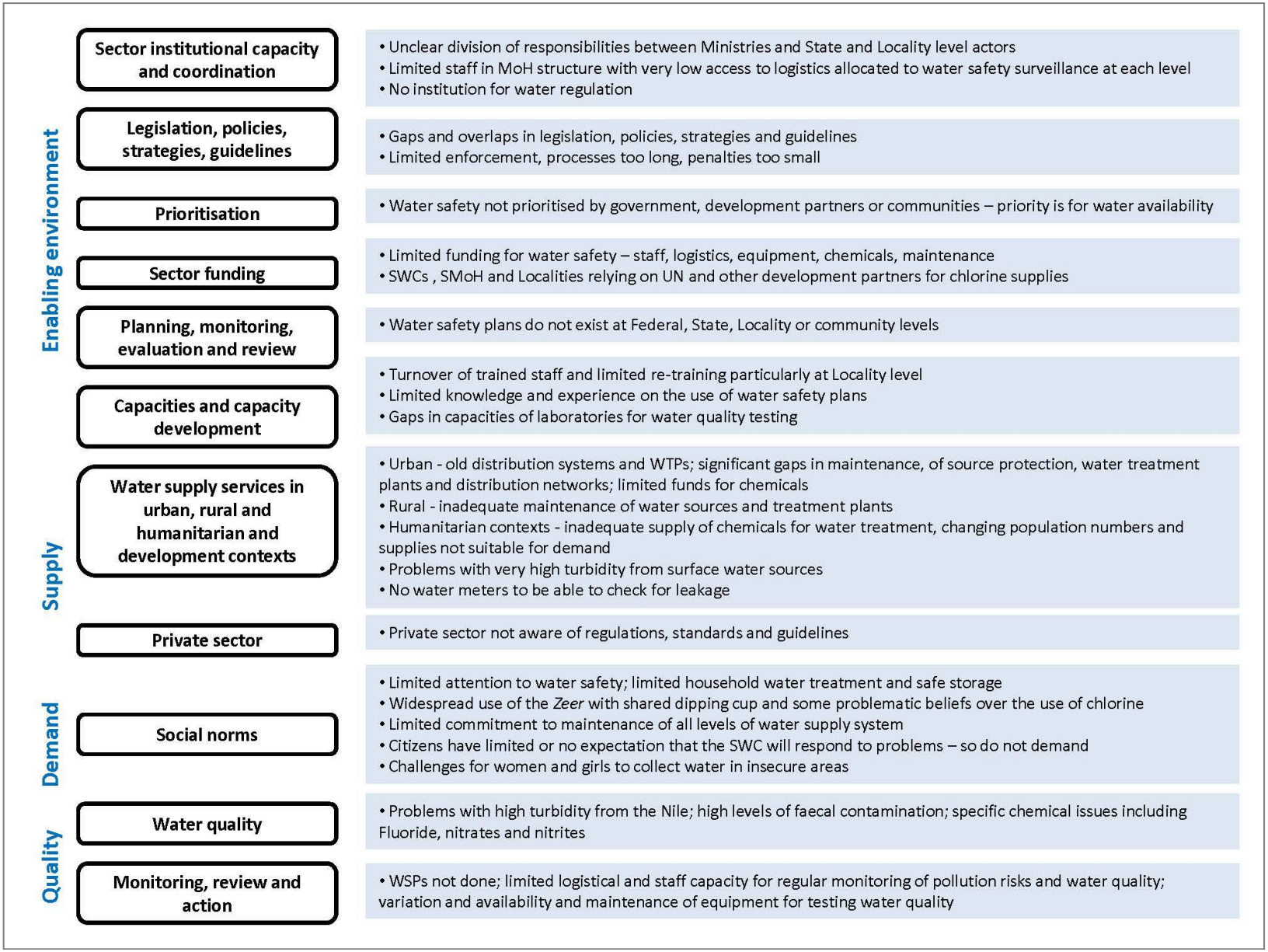
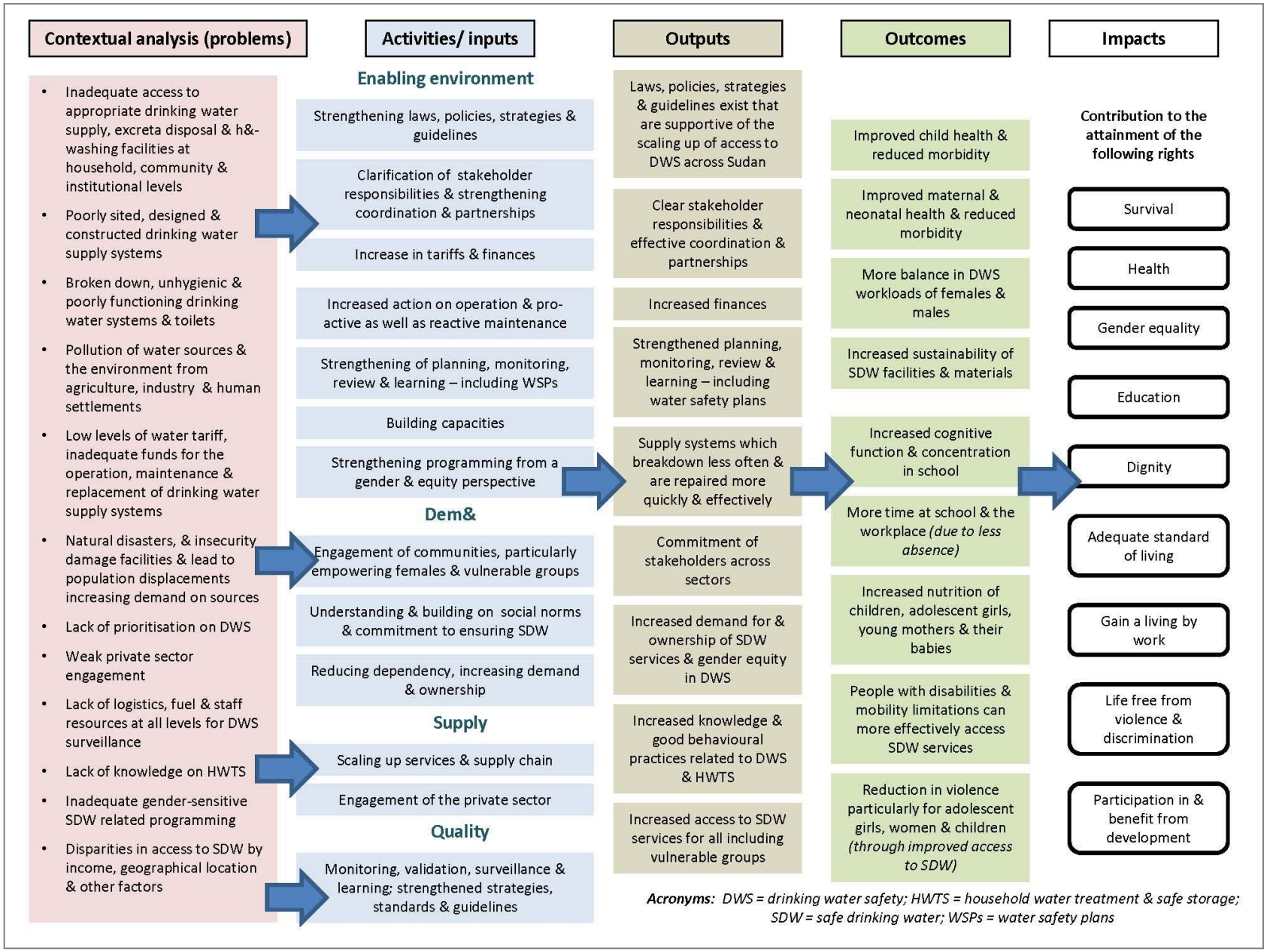


Fig 14 - Theory of Change for scaling up access to SDW across Sudan



4. Vision, purpose, principles of the SDWSSF

4.1 Vision

All people in Sudan have sustainable access to and use safe drinking water (SDW), contributing to the upholding of a range of human rights and the longer term prosperity and development of Sudan.

4.2 Purpose

The SDWSSF will contribute to scaling up access to SDW across Sudan in development, humanitarian and transitional contexts through:

1. Providing clear strategic direction, leading to increased harmonisation of approaches by all stakeholders across sectors, including government, non-governmental organisations and the private sector.
2. Increasing understanding of the cross-sectoral responsibilities and the contributions related to the supply, monitoring and sustainability of SDW to upholding a range of rights for the people of Sudan, including but not limited to: education, health, nutrition, dignity, gender equality and economic development.
3. Encouraging increased collaboration, partnerships and engagement across sectors, resulting in increased commitment, resources, learning and strengthened capacities of all stakeholders.

4.3 Principles

The scaling up of access to SDW in Sudan will be undertaken with the following principles:

Principle 1 - Community engagement and equity - *Community engagement and understanding the norms, skills, priorities and needs of communities, particularly women and girls and those of vulnerable or marginalised groups, will underpin efforts to develop solutions*

The efforts to scale up access to SDW in Sudan will consider the motivations, cultural norms, skills, priorities and needs of the girls, boys, women and men of Sudan; encouraging their leadership, participation and innovation, and increasing demand for SDW services, as well as sustained practice of positive hygiene behaviours that contribute to ensuring SDW.

Particular efforts will be made to ensure that the skills, needs and priorities of women and girls are considered, as well as those of men and boys, when designing interventions and services and engaging with children to build their capacities and knowledge on ensuring SDW from a young age. Particular efforts will also be made in identifying, involving and prioritising the needs of the poorest and those in most vulnerable or marginalised situations, including those affected by disasters, conflict and other emergencies.

Principle 2 - Leadership, coordination and partnerships - *Strong, clear and accountable leadership, coordination, partnerships and teamwork will underpin all efforts*

The three lead Ministries for SDW in Sudan at Federal level are the: MoENRPD - lead for environmental protection of water resources; MoWRIE - lead for the control of water resources and supply of SDW; and the FMoH - lead for surveillance of safe drinking water and enforcement and sanitation and hygiene promotion. The overall coordinator of the WASH sector is the MoWRIE/DWSU. Their leadership of these different areas are to be implemented collaboratively and in a spirit of team work and shared responsibility, working towards the same goal, across sectors and Ministries. Likewise at State level the leads are the State Water Corporations for the supply of SDW and the MoH for the surveillance and control of SDW. The Localities have the responsibility for ensuring access to SDW in their areas of responsibility as well as surveillance and control of SDW and work in partnership with communities and the private sector who are responsible for managing water supplies at community level. Collaboration will make the most of the varied skills,

experiences and opportunities that come from each sector, particularly across the sectors and institutions with responsibilities for health, water, education and environmental protection, finance and social welfare; as well as with the Administrative Units (Municipal) and Localities.

Partnerships will be established and nurtured between the Government of Sudan at all levels, across sectors and organisations, including community based organisations, non-governmental organisations, research institutions, the private sector and bilateral and multi-lateral organisations, making the most of the skills, experiences, knowledge and resources of each.

Principle 3 - Capacity development - *Developing capacities at individual, institutional and enabling environment levels is recognised as a key step in the process of scaling up for sustained solutions*

Efforts will be made to build capacities at all levels, from community, Locality and State to Federal levels; building capacities of individuals and institutions and strengthening the enabling environment. Capacity building will include, but not be limited to: legal, policy, regulatory and enforcement/ activation of laws capacities; technical skills and cross-cutting issues such as gender, equity and vulnerability; increasing transparency and accountability and strengthening management skills, as well as ensuring that the institutions with responsibilities for SDW have the resources, equipment and technical skills to be able to effectively carry out their responsibilities at all levels.

Principle 4 - Sustainability - *Sustainability of facilities and behaviours will be integral to the design of solutions*

All efforts on SDW will consider the short, medium and longer term sustainability of facilities, services and behaviours. Sustainability will be considered from the financial, technical, environmental and social perspectives and the impact of climate change. Interventions in the early stages of humanitarian responses will consider the impacts of approaches on later solutions for longer term actions and communication will be made with communities about the likely change in approaches and level of support over time.

Principle 5 - Monitoring, evaluation and learning - *Innovation will be encouraged and the quality and effectiveness of interventions will be improved through continual monitoring, evaluation and the sharing of learning at all levels and fed back into designs for improved solutions*

Monitoring, evaluation and information management related to SDW interventions and their results will be strengthened, providing both quantitative and qualitative feedback and contributing to learning and the continuous improvement of services and approaches. Innovation and the testing of new approaches will be encouraged as well as the sharing of experiences and learning. The most effective use will be made of partnerships between higher educational institutions and operational organisations and institutions for mutual benefit of the quality of interventions, as well as for continuing capacity building of future professionals working in the area of SDW.

5. Strategies – Control measures for DWS in Sudan

5.1 Supply – Protection, selection, siting, design of system and construction

Strategic objectives:

1. To improve the protection of water resources
2. To select, site, design and construct systems that maximise the safety and sustainability of drinking water supplies for the population of Sudan, including populations in refugee and IDP contexts

Strategies:

1. Identify the stakeholders with a role in protecting, selecting, siting, designing, constructing, managing and operating and maintaining the drinking water system and who will be the owner of the system including the community who will benefit from the supply, and involve them in all stages of the process.
2. Strengthen the collaboration across sectors and stakeholders in environmental protection of the water resources and strengthen the requirement for social and environmental impact assessments for development in the area to clearly consider the impact on water resources.
3. Strengthen the standard processes for selection of water sources and the design and construction of the source abstraction, treatment and supply system to maximise the safety and sustainability of the drinking water supply. The tables in **Annex II** - provide an overview of specific practical strategies along the drinking water supply chain.
4. Pay greater attention to establishing appropriate conditions for effective chlorination (reducing turbidity, storage of chlorine) and increasing the dosages to ensure that 0.2 mg/l free chlorine residual can be found in stored water at household level in the most distant ends of the network after 24 hours. Also to undertake research in Sudan to refine the appropriate dosages and residuals in different contamination and climatic temperatures.
5. Establish a strategy to respond to changes in population in refugee and IDP contexts to ensure sustainable DWS of both adequate quantity and water safety.
6. Undertake a specific targeted study[38] involving a international expert on algae[39] who can build on existing knowledge and experience of the Khartoum SWC[40] and work with them and the National Public Health Laboratory and other SWCs to identify: a) What problem exists; b) In which areas of Sudan does it exist; c) For how many months of the year; d) Is it a significant problem that poses risk to health or is it a minor problem that is already being covered by existing water treatment processes; e) What are the most appropriate solutions?

See also **Section 7.5** on building capacities related to this strategic objective.

5.2 Supply - Management and operation and maintenance

Strategic objectives:

1. To strengthen management processes and commitment and action on operation and pro-active maintenance that will underpin the availability of sustainable SDW for the population of Sudan

[38] This will then help to determine if any further action would be needed, or can be used to allay the public fears if there is a larger algae bloom problem again in the future. If the problem is mainly only due to sugar factory wastes then a solution may be to ensure these wastes are treated and do not get into the Nile so the blooms do not happen.

[39] The international expert should be selected to not have a risk of bias towards over-emphasising the problems, for example because they are selling a product

[40] Fathelbari, M.O (2014) *Algal Removal Strategies and Treatment Options in Drinking Water Bodies (River Nile), Khartoum State – Sudan, July 2014*, Final Paper, 37th International Postgraduate Course on Environmental Management for Developing and Emerging Countries, Technical University of Dresden

Strategies:

1. Clarify good practices for management that effective operation and pro-active maintenance of all facilities and equipment as part of the water supply chain. **Table 9** in **Annex II** - provides an overview of specific practical strategies related to O&M.
2. Establish and maintain functional water quality analysis facilities at each WTP that have the capacity to test the source, along stages of the treatment process and the water leaving the WTP and to test the optimal dosages for water treatment chemicals.
3. Each water supplier should be required to establish the real costs of operation and preventative and responsive maintenance for their services and be required to ring fence this amount in their annual budgets to be dedicated for operation and preventative maintenance.
4. Increase the use of water meters to better understand leakage.
5. Introduce the standard reports of KPIs for all SWCs in Sudan to include one KPI related to DWS.
6. Clarify who is responsible for what elements of maintenance and specify these in agreements with communities and private householders (for example that the SWC will be responsible for the main supply pipes to water yards and the main storage tanks).
7. Improve health and safety requirements and the personal protective equipment (PPE) for water sector operatives when handling chemicals, in particular chlorine and require that all sector operatives are provided with and wear the required minimum PPE.
8. Improve the system and management of the discharge of sludge from WTPs to minimise impact on the environment.

See also **Section 7.5** on building capacities related to this strategic objective.

5.3 Demand - Community engagement, hygiene promotion and enforcement/ activation of laws

Strategic objectives:

1. To strengthen hygiene promotion with, and community engagement of, the population of Sudan to facilitate actions to improve sustained access to SDW at household level
2. To increase the effectiveness of the process of enforcement/ activation of laws to act as a motivator for drinking water suppliers to improve the consistency of SDW in Sudan

Strategies:

Community engagement and HP:

1. Establish channels and methodologies to undertake/ strengthen hygiene promotion, and increase engagement with the population of Sudan (women, men, girls, boys and people from particular vulnerable or disadvantaged groups) increasing public awareness on:
    a. Strengthening ownership / feelings of ownership of the water supply facilities
    b. Reporting failures and problems and demanding their rights and action on maintenance by the SWCs
    c. Protecting, managing, operating and maintaining community level water supplies
    d. How to organise communities for hygiene promotion and engagement to implement and monitor WSPs
    e. Good practices in the collection, handling, household treatment and safe storage of drinking water

f. Reasons for not using surface water during the rainy season instead of SDW

g. Good practices in the design, management and operation and maintenance of household roof water storage systems and piped supplies

h. How to ensure that the most vulnerable and disadvantaged are involved in DWS processes and benefit from them.

2. For schools (including *Khalwas* / religious schools), health facilities and other public institutions and places:

    a. Establish the role of Teachers, Parent and Teacher Associations and Health Facility Management Teams in the management of DWS in schools and health facilities and provide capacity building

    b. Focus on the issues in strategy 1 above and particular risk areas, such as ensuring soap is available for handwashing, not sharing cups and having taps on *Zeers* or other storage containers and preparing WSPs

    c. Particular attention on educating school children on the critical importance of pro-active maintenance to sustain drinking water supplies and other services

3. Monitor the effectiveness of the hygiene promotion, communication channels and methodologies on positive behaviours relating to access to SDW

4. Establish / strengthen mechanisms for the reporting of faults and complaints to water suppliers by the general public and the system for monitoring action

5. Ensure that all professionals and institutions working on DWS in Sudan follow *"don't ask people to do what you are not doing",* and are positive role models for the wider community (for example have soap for hand-washing, have clean and well-drained water points in their offices, do not use shared cups for drinking water)

6. Ensure there is a mix of people in teams which engage with communities on DWS related issues, including women, men and people from minority or marginalised groups.

<u>Enforcement:</u>

7. Strengthen the systems for monitoring and enforcing regulations related to bottled / packaged water and ice producers and suppliers, including small ice sellers

8. Revise the existing community empowerment guideline (in Arabic and English) to include WSPs and strengthen all HP materials to have a component of DWS and specific information on what SDW is.

9. Improve the effectiveness of the process of enforcement/ activation of laws. Actions:

    a. Clarify which institutions are responsible for enforcement/ activation of laws

    b. Increase collaboration between the institutions responsible for enforcement across the agriculture, environmental and water sectors and with the Localities

    c. Establish which institutions are responsible for and what are the processes to enforce government institutions who are involved in the process of supplying drinking water

    d. Clarify the processes of enforcement/ activation of laws for different misdemeanours and types and level of penalty

    e. Streamline processes for being able to apply penalties to make them more efficient and effective as motivators for positive behaviours in relation to supply of water

    f. Consider the needs and situations or particularly vulnerable and disadvantaged groups when considering enforcement and alternative strategies to assist them to access and use SDW

    g. Increase attention on industrial pollution and toxic wastes in urban contexts

See also **Section 7.5** on building capacities related to this strategic objective.

5.4 Quality - Operational monitoring, verification of effectiveness, surveillance, documentation and citizen feedback

Strategic objectives:

1. To strengthen commitment to monitoring, evaluation, surveillance and documentation
2. To increase regular practice and quality of monitoring, evaluation, surveillance and documentation

Strategies:

1. Strengthen the commitment of drinking water sector and Environmental Health professionals to undertaking the processes of:
    a. Operational monitoring
    b. Verification of the effectiveness of treatment and supply systems
    c. Surveillance of pollution risks related to drinking water supply
    d. Documentation and reporting of risks – including permanent log books / records on site for monitoring and strong emphasis on honest recording of actual results (not what is expected as good practice)
    e. Undertake responses to remove the risks and implement mitigating / remedial action
2. Install a system of publicly accessible records of complaints / reports on problems with water services and a record of what has been done about them
3. Increase regular practice and quality of the above, including with supportive supervision and feedback
4. Increase checking of the effectiveness of tablets for DWQ monitoring field kits to ensure accurate results
5. Increase engagement of communities in monitoring and reporting.
6. DWS in schools, health facilities and other public institutions should be included in the general surveillance system, in the monitoring of water resources, be part of health facilities and school inspections and be included in specific trainings for staff (teachers including MoE and religious teachers; and health facility managers and staff).

See also **Section 7.4** for strategies related to establishing/strengthening existing databases and **Section 7.5** on building capacities related to this strategic objective.

See the tables in **Annex II** – for specific practical strategies along the water supply chain.

6. Strategies – Cross-cutting issues for DWS in Sudan

6.1 Gender, equity and vulnerability

Strategic objectives:

1. Ensure that SDW supplies respond effectively to the needs of all people in Sudan, particularly women and girls, people with disabilities or mobility limitations and those who may be disadvantaged or in marginalised or particularly vulnerable situations.

Strategies:

1. Develop practical strategies and guidance to be able to practically consider gender, equity and vulnerability in their work and support women's increased involvement in the sector and in management and implementation, including through men and boys' support for this change.
2. Investigate how to better use the skills and knowledge of women's organisations and youth organisations to support increased engagement of women and girls and people from vulnerable, marginalised or otherwise disadvantaged groups, as well as men and boys in SDW.
3. Particular guidance to be provided on technical options for improving accessibility of SDW facilities for people with disabilities and people with mobility limitations and integrate it into legislation and policy.
4. Consider how the WASH sector can better engage with Ministry of Welfare and Social Security (MoWSS) to help it build its capacity in responding to gender, equity and vulnerability related issues.
5. Increase the collection of disaggregated data related to SDW outcomes and programmes and analysis to develop strategies in response.
6. Ensure teams include people from various genders and backgrounds, including women, men and people from marginalised or minority groups.

See also **Section 7.5** on building capacities related to this strategic objective.

6.2 Sustainability, seasonality, environment, climate change and Disaster Risk Reduction

Strategic objectives:

1. To increase the sustainability and safety of drinking water systems, including from the effects of climate change across the seasons, and improving SDW related behaviours
2. To protect the environment through effective design, siting and management of drinking water systems
3. To strengthen DRR to improve sustained access to SDW during times of humanitarian crisis

Strategies:

1. Priority to be placed on increasing awareness and commitment on the critical importance of operation and pro-active maintenance and sustainability of drinking water systems in maintaining access to SDW and the implications of not undertaking pro-active maintenance.
2. Strengthen monitoring of the quality and capacity of groundwater aquifers and use of groundwater supplies over time, including water levels and associated quality changes.
3. Strengthen /establish a sense of ownership of the water source and water supply system and ensure that the management body is able to finance the required costs for O&M to help strengthen sustainability.
4. Create positive social norms at community and household levels using participatory demand-based approaches to promote demand for protecting, operating and maintaining community based and household water supplies and for HWTS.

5. Strengthen DRR (including early warning and emergency preparedness systems) and capacity for SDW with particular attention on preparations for outbreak prediction, prevention and control, increasing attention to monitoring and surveillance linked to the rainy season.
6. Build on existing learning on modifications needed to existing systems to respond to climate change.[41]

Also see **Section 7.1** – for strategies related to the legal and policy framework.

[41] The following reference has useful practical guidance on pages 35-42: WHO (2017) *Climate-resistant Water Safety Plans*: Managing health risks associated with climate variability and change

7. Strategies – Building blocks for DWS in Sudan

7.1 Legal and policy framework

Strategic objectives:

1. To update and strengthen the overall coherence of the legal and policy framework for SDW in Sudan

Strategies:

1. Review, finalise and endorse the legal and policy framework in relation to SDW in Sudan – including one overarching Code for DWS in Sudan, which will link all legislation and specify all institutions roles and legal responsibilities in Sudan.
2. Ensure the Water Sector Legal Reform process effectively considers SDW, including the establishment of an independent drinking water regulation institution / structure[42].
3. Review the consistency of Federal, State and Locality level legal and policy frameworks relating to SDW.
4. Update the Regulations of SDW Control, 2014, to respond to gaps and make clarifications.
5. Make laws and policies understandable for the general public – through simplified formats widely disseminated.
6. Strengthen the systems for enforcement/ activation of the laws related to SDW where actions do not comply with Federal, State and Locality drinking water regulations and by-laws.
7. Establish a cross-ministry oversight body for the supervision and enforcement/ activation of laws of packaged/ bottled water and ice production and supply businesses in Sudan.
8. Strengthen regulation and enforcement processes related to the provision of drinking water through private sector operators.
9. Review, update or add to the guidance available related to SDW in Sudan and standardisation of protocols.
10. Key laboratory specialists such as from the National Public Health Laboratory, the SSMO, the MoWRIE GWD lab, etc should form a committee to discuss the need for establishing specifications and a certification process for paints and waterproofing materials (and possibly other equipment) for use in drinking water facilities; and then the committee to make a proposal / plan as to the mechanism to be established for this and which laboratory should be strengthened to be able to undertake the testing and certification process.

7.2 Stakeholder responsibilities

Strategic objectives:

1. To clarify the institutional responsibilities for SDW across Ministries and between all stakeholders and strengthen inter-sectoral coordination
2. To maximise the potential of the private sector of different types and sizes in the supply of SDW in Sudan
3. To create an enabling environment and strengthen regulation of the private sector involved in the provision of SDW in Sudan

[42] *The establishment of an independent regulatory body for the regulation of the drinking water sector is understood as good practice. It usually has responsibilities such as regulate tariffs; take and respond to complaints; certify against regulations; monitor drinking water corporations. The SSMO undertakes the role of setting standards and some enforcement activities and the FMoH has a surveillance role related to DWS but does not currently appear to take a strong enforcement role in its role as the Competent Health Authority, particularly in relation to governmental bodies such as the SWCs.*

Strategies:

General:

1. Strengthen inter-sectoral coordination processes to provide oversight and bring together efforts of all stakeholders on SDW.
2. To review the legal status and responsibilities of each key institutional actor in relation to SDW in Sudan and update legislation to respond to any gaps and to reduce points of overlap.
3. Clarify legal and practical responsibilities for enforcement/ activation of laws – lead and supporting institutions; specifically to clarify the role of the MoWRIE and SWCs in certifying drinking water is suitable for drinking.

Private sector:

4. To undertake a study on the private sector opportunities to engage with SDW in Sudan, identifying the major constraints and developing an action plan to respond.
5. Strengthen / clarify the specifications to be used for products used in drinking water (whether national or international specifications/ standards) and raise awareness within the private sector of these specifications as well as existing laws, regulations, policies and guidelines.
6. Simplify the customs procedures to reduce the time of clearance and to reduce import taxes on DWS related products.
7. Undertake discussions on how to increase access to foreign currency for the private sector working on DWS, improve requirements for contracts to include contingency for inflation and speed up payments from government contracts.
8. Pay particular attention to clarifying the responsibilities of packaged/ bottled water and ice producers and sellers, including small ice sellers, and raise awareness on, and monitor and regulate the same.
9. Promote opportunities available for the private sector in SDW, for example in the promotion and sale of HWTS products to attract new businesses.

See also **Section 5.3** on enforcement and also **Section 7.5** on building capacities related to this strategic objective.

7.3 Financing, advocacy and political commitment

Strategic objectives:

1. To significantly increase the political commitment for DWS in Sudan including increase in investment and financial allocations for the provision of SDW in Sudan
2. To increase commitment and action to ensure adequate finances are available for operation and maintenance of drinking water systems
3. To identify and propose new financial resources for SDW in Sudan, with the participation of and from communities, from across sectors, the private sector, from micro-finance and through cross-subsidies

Strategies:

1. Increase regular engagement with the Ministry of Finance and National Economy (MoFNE), raising their awareness of the importance of SDW to the overall health of the population of Sudan and broader development of Sudan.
2. Establish a minimum percentage of national income (GDP) that should be spent on water supply and key elements of DWS.

3. Establish clear priorities for the expenditure of the budget considering the current capacities and capacity building needs to execute the necessary actions.
4. Politicians to be informed of the cost of the AWD response and how this would compare to improving DWS over the longer term.
5. Undertake advocacy at Federal, State and Locality levels to increase understanding on the importance of SDW, not only in emergency situations but also for the current and longer term context and for increases in regular budgets for SDW. Include advocacy through the Governor's Office of the Ministry of Local Government, the Commissioner's Office at Locality level and at Presidential level through the Public Heath National Coordination Council. Make the most of the opportunity of the establishment of the National Committee on Water Safety to keep attention on the importance of SDW.
6. Increase drinking water tariffs to enable effective O&M, to sustain the SWCs and to encourage the retention of staff. Where the tariff is being taken by the Ministry of Finance, to ensure that the SWC receives a large proportion of the tariff for its operations.
7. Scaling up household and community contributions to SDW through encouraging positive social norms in relation to safe HWTS and increased understanding of poor O&M of community level supplies on SDW.
8. Increase government commitment to funding water treatment chemicals for urban and rural drinking water supplies in longer term, transitional and humanitarian contexts and reduce reliance on supply by UN agencies and other development partners.
9. Encourage increased financing through different sectors, such as the Education Sector in relation to schools and other educational institutions, the Health sector for health related institutions.
10. Investigate whether micro-finance, savings clubs and other micro-finance opportunities may be useful and appropriate tools for raising finance for SMEs or households for HWTS options.
11. Investigate new financing opportunities from the private sector from direct investment, from Corporate Social Responsibility, from marketing campaigns as part of their product promotion or as part of public-private partnerships.

7.4 Planning, monitoring, research and learning

Strategic objectives:

1. To increase the implementation and monitoring of WSPs at all levels including the consideration of gender and equity at each stage.
2. To reduce overlap in monitoring systems between institutions to result in simple streamlined and efficient gender-sensitive monitoring systems for collecting information on SDW that can be used at all levels and sustained over time.
3. To increase opportunities for experience sharing and learning opportunities for professionals working on SDW at all levels.

Strategies:

1. Develop a participatory plan to implement WSPs at all levels and to increase the number of WSPs implemented at State, Locality, water supply networked system and community point source levels.
2. All SWCs to be required to prepare WSPs for the urban drinking WTPs and piped networks as well as point sources that they manage and operate, including considering the impact of sewage networks and waste.
3. Design WSP processes to pro-actively consider the perspective and skills and involve all groups in the community including women, men, children and people who may be considered vulnerable,

marginalised or disadvantaged (such as the poorest members of the community, older people, people with disabilities and people who may be minorities)

4. Establish systems to verify the implementation and effectiveness of WSPs and to establish remedial actions.
5. Coordination to be undertaken between all ministries and development partners involved in supporting the establishment or strengthening of M&E or MIS systems that are of relevance to SDW in Sudan to:
    a. Where possible reduce overlap in planning, monitoring and database systems related to water sources and drinking water, whilst also considering their purpose and the users to ensure that they are accessible and used
    b. Clarify how different institutions can access and input data into the agreed database(s)
    c. To integrate the results of sanitary inspections/surveys and the existence of WSPs for each water source and drinking water system
    d. To enable sustainability of the system / database(s) and use over time
6. Strengthen the collection of standardised SDW related data in all national surveys
7. Increase operational research on SDW related issues, including on:
    a. How to respond to issues such as turbidity
    b. How to reduce specific contaminants such as algae, nitrates, fluorides and toxic wastes
8. To increase opportunities for the collation of learning and reflection and learning on SDW related issues at all levels and across sectors (Water, Health, Education, Environment) with particular focus on State, Locality and water supply system levels.
9. Increase opportunities for the sharing of experience and the results of research and learning between professionals working on SDW at all levels and also opportunities for sharing of good practices between communities.

See also **Section 7.5** on building capacities related to this strategic objective.

7.5 Capacities and capacity building

Strategic objectives:

1. To build the capacity of the professionals of the future to work in SDW at all levels using an array of capacity building approaches to train, coach and mentor, through the provision of resources and equipment and through the development of systems which will enable the capacities to be utilised
2. To strengthen the capacities of the existing training and educational institutions which train sector professionals on DWS
3. To utilise the knowledge and skills of the higher education institutions to undertake applied research, assessments and evaluations related to SDW, whilst also updating the knowledge of the lecturers

Strategies:

Higher education institutions:

1. To increase coordination and engagement between universities, colleges and other training institutions and operational institutions and agencies to:
    a. Increase opportunities for students to experience SDW supply systems in the workplace and community
    b. Increase the number of lectures from operational professionals to training institutions / students

c. Increase opportunities for staff and post-graduate students to contribute to operational research

Laboratories and field testing equipment:

2. To undertake a more detailed review/ survey of the water quality testing capacities across institutions and levels (laboratory and field based) and a market survey to:
    a. Identify existing capacities, strengths and gaps across institutions and levels
    b. Consider if there could be ways to increase efficiency of laboratories through collaboration or sharing resources, including broken equipment in need of repair and equipment that is not being used
    c. Consider if establishing regional laboratories with higher capacity to test a range of more complex parameters may be effective (whilst also considering the implications of the long distances that would be required to travel to utilise the laboratories and the costs involved)
    d. Evaluate the mechanisms for repair of water quality testing equipment across institutions and make recommendations for strengthening capacities of mechanics
    e. Establish the current market situation in relation to accessibility to consumables required for the range of water quality test equipment being used in Sudan

Sector professionals:

3. To particularly strengthen capacities of professionals in the following areas:
    a. In the selection, design and construction of drinking water systems to consider implications for the safety of drinking water supplies.
    b. To build capacities of professionals working at Administrative Unit, Locality and State levels (across institutions and sectors) to prepare and monitor WSPs and undertake remedial actions
    c. Management and pro-active O&M related to all stages of the water supply chain – with particular attention on commitment to pro-active maintenance
    d. Optimisation of the efficiency of water treatment through jar testing and dosing using the range of water treatment chemicals used in Sudan – with particular attention on coagulation and chlorination
    e. Operational monitoring; Verification of the effectiveness of treatment and supply systems; Surveillance of pollution risks related to drinking water supply; Documentation and reporting of risks; and responses to remove the risks and implement mitigating / remedial action
    f. Significantly increase access to logistics and budgets for the water safety teams to undertake regular monitoring and surveillance of drinking water sources and systems
    g. Support the capacity building of the institutions and professionals responsible for enforcement/ activation of laws to have adequate transport, funds, access to water quality testing equipment or laboratory facilities and knowledge on the processes for the enforcement/ activation of laws
    h. Where possible increase salaries / incentives to encourage qualified staff to remain in their roles in Sudan – especially in remote locations
    i. Establish periodic capacity building related to SDW including to respond to the turnover of staff
    j. Household water treatment and safe storage – a menu of options
    k. Testing and treatment of algae (see **Section 5.1** for other details)
    l. The testing of pesticides and insecticides in more locations across Sudan

m. How to practically consider gender, equity, disadvantage in their work and support women's increased involvement in the sector, including through men and boys' support for this change and also how to involve all groups in the community including women, men, children and people who may be considered vulnerable, marginalised or disadvantaged (such as the poorest members of the community, older people, people with disabilities or minorities)[43].

Communities:

4. To particularly strengthen the capacities of communities in the following areas:
    a. To understand their rights under the Laws, Acts and standards and how to demand their rights
    b. To prepare and monitor WSPs and undertake remedial actions
    c. How to undertake monitoring of DWS at community, household and institutional levels, and remedial actions in response
    d. Household water treatment and safe storage – a menu of options
    e. How to involve all groups in the community in DWS related processes and ensure benefits for all - including women, men, children and people who may be considered vulnerable, marginalised or disadvantaged (such as the poorest members of the community, older people, people with disabilities and people who may be marginalised or minorities)

Private sector:

5. Provide capacity building in specific priority areas for the private sector such as:
    a. National policies, strategies and guidelines as well as opportunities for capacity building in HWTS or marketing skills, considering the needs of small to larger private sector actors.
    b. Pay particular attention to building capacity of packaged/ bottled water and ice producers and small ice suppliers to know their responsibilities.
    c. Other areas to consider: O&M of desalination plants; standards and specifications for equipment and chemicals; DWQ testing; water treatment; water management; establish a water manual; sustainability; and customer service staff about chemicals and equipment.

See the tables in **Annex II** – for a more detailed list of priority areas for capacity building including along with the water supply chain.

[43] Useful reference: WHO (2017, draft) *Equity in Water Safety Planning, A guide to integrating equity considerations into the water safety plan process,* Draft version, 27 September 2017

Annexes

Annex I - Stakeholder responsibilities

The stakeholders have been split into the following groupings based on the **Fig 3** in **Section 1:**

- Responsibility category – Environmental protection of water resources
- Responsibility category – Control of water resources and supply of safe drinking water
- Responsibility category – Surveillance of safe drinking water and sanitation and hygiene promotion
- Localities, Administrative Units and communities
- Supporting stakeholders

The Localities, Administrative Units and communities have been separated out as they have responsibilities across all three categories.

Table 3 - Responsibility Category – Environmental protection of water resources

	Responsibilities
The 'competent authorities' in relation to the protection of the environment including water resources	*16 - Each of the agencies listed below **are competent authorities** to protect the environment and seek to achieve the objectives set forth in article 4 and the agencies are:* *a) The Council in accordance with functions and the power conferred upon it under the provisions of this law.* *b) The ministries and federal agencies and institutions concerned health and environment protection in all fields of health and agricultural, industrial and housing, economic, cultural, social and other in accordance with the powers granted to them under the law in force* *c) The Council, ministries and organs of state and bodies competent to protect and upgrade the environment* *d) Societies and national and foreign institutions interested in upgrading and environmental protection authorized to work in the country as the environmental protection work of the people requires enable the community to play its role in organizing gross-roots effort at the federal and state level.* *e) The civil administration* *The duties of the competent authority in observance of environmental policies:* *18 - The competent authority shall observe and follow the following policies and guidelines for the protection and promotion of the environment in country:* *a) The development and adoptions of quality standards which lead to the protection of the environment and prevent its degradation and follow-up the commitment.* *b) Maintaining the different sources of water and protect it from pollution and rationalize the use of water.*
Supreme National Council for Environment and Natural Resources	• **Established under the Environmental Conservation [Protection] Act, 2001** • The most important of its functions is the preservation of different water resources, the right to develop an inventory, the protection of natural resources from pollution and that it can require environmental impact studies. • It has to work in conjunction with the Council for Water Resources to protect water resources from pollution.

Ministry of the Environment, Natural Resources and Physical Development	• **Lead Ministry for the environmental protection of water resources** • Preservation of water resources and their protection from pollution. • Prepares policies, strategies and plans of relevance to the protection of water resources. • Requires checks and approves environmental impact studies for physical development. • Undertakes research related to the environment and water resources. Enforcement roles: • Enforces in response to environmental pollution related incidents/ abuses.
Ministry of Agriculture	• Establishes controls on the use of pesticides, insecticides and fertilisers. • Prepares policies, strategies and plans of relevance to the protection of water resources. Enforcement roles: • Enforces in relation to agricultural incidents/ abuses [assumed - by taking away agricultural permits or issuing fines]
Ministry of Petroleum	• Establishes controls on the production and use of petroleum products. • Prepares policies, strategies and plans of relevance to the production and use of petroleum products including considerations related to the impact of petroleum on the environment and water resources. Enforcement roles: • Enforces in relation to petroleum related incidents/ abuses [assumed - by taking away petroleum related permits or issuing fines]
Ministry of Mines	• Establishes controls on the mining industry. • Prepares policies, strategies and plans of relevance to mining, including considerations related to the impact of mining on the environment and water resources. Enforcement roles: • Enforces in relation to petroleum related incidents/ abuses or fines [assumed - by taking away mining related permits or issuing fines]
Ministry of Industry	• Establishes controls on industry. • Prepares policies, strategies and plans of relevance to industry, including considerations related to the impact of industry on the environment and water resources. Enforcement roles: • Enforces in relation to industry related incidents/ abuses or fines if industry is not abiding by agreements related to the protection of the environment related to their waste products [assumed - by taking away industry related permits or issuing fines]
Ministry of Animal Resources & Fisheries	• Establishes controls on the management of animal resources and fisheries. • Prepares policies, strategies and plans of relevance to animal resources and fisheries, including considerations related to the impact of industry on the environment and water resources. Enforcement roles: • Enforces in relation to animal or fisheries related incidents/ abuses or fines [assumed - by taking away related permits or issuing fines]
MoWRIE	See the table below
MoH	See the table below
Localities	See the table below

Administrative Units	See the table below
Communities and community level institutions	See the table below

Table 4 - Responsibility Category – Control of water resources and supply of safe drinking water

	Responsibilities
National Council for Water Resources	• **Established by the Water Resources Code, 1995** • Has powers to define the general policy for water resources • Overall supervision for the withdrawal and use of water resources • Protecting streams and water from pollution • Laying the foundations for the establishment of drinking water systems • Regulating deep and shallow wells • Expected to coordinate with the Supreme Council for Environment and Natural Resources and the competent authorities
MoWRIE	• **Lead Ministry for the control of water resources and supply of SDW** DWSU: • Coordination for WASH sector (humanitarian and development) • Development of Federal policy, strategy and plan formulation related to WASH • Development of guidelines related to all elements of WASH • Monitoring, evaluation, research, documentation, dissemination and learning • Management of foreign funds through to the States GWD including laboratory: • Management of water resources • Water resources research • Management of groundwater database • Predictions of how aquifers will perform • Monitoring surface and groundwater – monitoring and production wells • Management of water monitoring stations • Testing of groundwater quality and issuing certificates of the results Enforcement role: • Enforces by the ability to take away permits for groundwater abstraction – under the **Water Resources Code, 1995** - Issuing permits for groundwater and surface water extraction, and monitoring and inspections related to its use. *"The Ministry may delegate any of its powers to anybody within any of the States". "The competent court must order, at the request of the Minister, in case of trans boundary waters, or the Governor of the concerned state, in case of non-cross, at any of the stages of the proceedings, the stopping or removing any action in contravention of the provisions of Article 13"* [related to the control of flow and use of water].

	Issues or revokes licences under the **Groundwater Extraction Regulations, 2014:** • The competent authority is the MoWRIE • *"The competent authority may grant a license to participate in the exploitation of water as it deems appropriate".* • *"The representative of the competent authority may enter the licensee's sites to verify that he has fully implemented the licensing requirements, including sampling and conducting the necessary tests".* • *"The competent authority may, in case the licensee commits any violation of the provisions of these regulations, punished" with revoking of the licence.* • *"The competent authority may repeal the license to use groundwater immediately in any of the following cases: a) Pollution occurs in the well; b) Excessive withdrawal of water in the sense that exceeds the quantities allowed to be withdrawn; and c) If the withdrawal cause unavoidable damage"* <u>The EH Act, 2009:</u> Clause 8 says: *"Must for anyone working in the field or drinking water in the various levels of government to abide by the conditions and regulations of the following: (A) To confirm the validity of drinking water and pollution-free networks in accordance with the approved specifications".* But it is not clear if this refers to the supply of drinking water from their own system or they can approve the use of water for drinking? The Regulations for DWQ and Control, 2014, specify that the establishment of any project of drinking water should receive a license from the *'competent health authority'.* **<u>Important notes on authorities to approve and enforce in relation to drinking water:</u>** **1. No laws/regulations have been seen which specifically give the MoWRIE or the SWCs the authority to approve water for drinking water use. It may be included in general terms of approval for all water resources uses or possibly under the EH Act 2009, but it isn't fully clear.** **2. No laws/regulations have been identified where the MoWRIE or SWCs have the authority to enforce in relation to bottled water factories.** <u>DWST including laboratories:</u> • Capacity building / training on DWS related subjects to water sector professionals and other stakeholders • Private water quality testing

Ministry of Urban Planning and Infrastructure (or equivalent) and / or State Water Corporations	<u>SWC:</u>
	• Development of state level policies, strategies and plans related to water supply
	• Responsible for water abstraction, treatment, storage and transfer up to point of supply:
	  ○ Planning, design and construction of water supply infrastructure from abstraction to point of supply
	  ○ Supervise and design community systems and handover to communities to manage
	  ○ Operation and maintenance:
	  ▪ Pro-active and remedial action for maintenance
	  ▪ Maintain key spares and equipment supplies to enable on-going and efficient maintenance
	• Planning, water quality assessment:

	○ WQ testing of the water source, the effectiveness of the treatment processes and effluent to point of supply on a regular basis ○ Prepare WSPs, undertake sanitary surveys of water systems and points, monitor over time and take remedial actions ○ Monitor and report on progress over time against key performance indicators • Engagement with citizens / communities: ○ Communicate with the general public about the service provided and maintain a complaints line and procedure ○ Respond to complaints with remedial action and feedback to the consumers ○ Provision of capacity building to operators and community committees / members for sustaining SDW supplies • Engagement with the private sector to support the provision of SDW • Finances: ○ Setting, collection and management of tariffs for DWS ○ Procurement of and management of funds WES: • Responsibilities as noted for the SWC above – but for humanitarian contexts on a project basis • Manage water supplies and monitoring of WASH package for refugee and IDP camps[44] Enforcement role: • Delegated powers from the Ministry as noted above [presumed]
Private sector organisations	Roles of the private sector: • Provision of water supply equipment – such as pumps, pipes, taps, water storage tanks, water treatment plants, paints/sealants and associated equipment and materials • Construction personnel – providing services to construct and maintain water supply systems at city, town, village and household levels • Provision of bottled drinking water and ice • Small-scale private water sellers including donkey carts • Small scale ice sellers • Provision of water supplies through tankering in humanitarian contexts • Sales of household water treatment products, water containers, jerry cans, soap • Supply of water treatment chemicals • Supply of water quality testing equipment and consumables • Water quality testing services • Repair of water quality testing equipment • Consultancy for water safety related studies • Provision of training related to DWS / knowledge dissemination • The media and public-private partnerships for the promotion of household-water treatment products and processes and household water hygiene Responsibilities of the private sector: • To abide by the legislation, standards, specifications and guidelines of Sudan and the various States (or international standards where Sudanese standards / specifications do not exist) while undertaking their roles

[44] In humanitarian contexts for WASH programmes supported by UNICEF, the WES team are responsible for water supply and the MoH for sanitation and hygiene including water surveillance.

Ministry of Education	• Contribute to the development of policies, strategies and guidelines relating to SDW in schools • Ensure the availability of SDW for all pupils and staff • Ensure good food handling and hygiene including the use of SDW in food preparation • Ensure the availability of accessible, gender-appropriate hygienic latrines and hand-washing facilities with soap and water for all pupils and staff • Inclusion of guidance SDW in the curriculum • Inclusion of SDW in the school inspectors standard inspection routines • Support all schools to prepare and monitor WSPs • Provide capacity building for staff on SDW • Monitor the situation of SDW availability and maintenance in schools
Ministry of Health	See the table below
Localities	See the table below
Administrative Units	See the table below
Communities and community level institutions	See the table below

Table 5 - Responsibility Category – Surveillance of safe drinking water and enforcement & sanitation and hygiene promotion

	Responsibilities
National Council for Environmental Health	• **Established under the Environmental Health Law, 2009** • To propose public policies and national plans and programmes in the field of environmental health • The classification of health material produced from hazardous substances by gravity and lay the foundations and health controls for the import of those substances in coordination with the relevant authorities • Establishment of principles and guidelines for site inspections in case of suspicion of the commission of any offense in the field of health and health waste and hazardous waste in coordination with the relevant authorities
FMoH	• **Lead Ministry for surveillance, enforcement and sanitation and hygiene promotion** <u>Environmental Health Department / Water Safety Unit:</u> • Lead for federal policy and strategy formulation related to DWS, sanitation and hygiene promotion[45] • Lead for formulation of guidelines related to DWS, sanitation and hygiene promotion • Member of the SSMO Technical Committee on DWS • Water surveillance monitoring through collation and analysis of water quality data and information on actions from States and Localities covering: o Monitoring of WTP effluents and in distribution systems o Monitoring of non networked systems

[45] Overall coordination of the WASH sector is by the MoWRIE/DWSU – see their section in Table 4

	o Responding to complaints, testing and reporting results to SWCs to demand action o Refugee and IDP camps o Areas with major agricultural activities and mining, petroleum and other industries • Control of goods – imports of materials, chemicals, equipment related to drinking water [it is not clear how this responsibility splits with the SSMO] • Capacity building of State and Locality stakeholders in responsibilities related to DWS, environmental health, sanitation and hygiene • Provision of financial support and logistics to MoH and Health Affairs Departments in Localities • Monitoring, evaluation, documentation, dissemination and learning <u>DWS in health facilities</u>: • Ensure the availability of SDW for all staff, patients and visitors • Ensure good food handling and hygiene including the use of SDW in food preparation • Ensure the availability of accessible and gender-appropriate hygienic latrines and hand-washing facilities with soap and water for staff, patients and visitors • Inclusion of guidance SDW in hygiene promotion materials used at the health facility • Inclusion of SDW in the health inspectors standard inspection routines • Support all health facilities to prepare and monitor WSPs • Provide capacity building for staff on SDW • Monitor the situation of SDW availability and maintenance in health facilities <u>Enforcement role:</u> • Enforces in its role as mandated under the **Environmental Health Act, 2009** *"The Minister may, upon the recommendation of management; in consultation with the relevant authorities to stop any national institution produces hazardous [or?] medical waste or shut down its activity when it is proved that this institution represents a health hazard to citizens"* • Under the **Drinking Water Safety Control Regulations 2014**: o *"Inspector: means the public health officer who is delegated from the environmental health department at different governmental level". "The inspector may enter and carry out an inspection to any place work in preparation, selling, manufacturing, packaging or storage of drinking water".* o *"The competent health authority may forfeit the drinking water of water vendors and used [?] by a committee from the competent health authority and administration at the locality according to the public interest".* o *"The well owner shall comply with the orders that issued by competent health authority in case of indicator of water pollution".* o *"The competent health authority shall agree on location and area for factories for bottled water production".* o *"The competent health authority should stop any worker if there is a reasonable possibility to be as a risk to the public health".* o *In relation to bottled water factories: "The competent health authority should agree on drilling of water or sewage well".* <u>FMoH National Public Health Laboratory:</u> • Water quality testing • Certification for water suitable as drinking water • Water quality assessments for bottled water factories as part of enforcement role • Technical support and advice to other laboratories

	Emergency Humanitarian Affairs Directorate: • Provision of epidemiological data to establish DWS related diseases and outbreak patterns • Ensuring DWS in humanitarian contexts • Provision of financial resources and logistics for DWS in humanitarian situations CPDD: • Capacity development of MoH and Locality professionals on DWS related issues
Sudanese Standards and Metrology Organisation (SSMO)	• Established under the SSMO Act • Facilitation of a Technical Committee on drinking water • Establishment of national standards for drinking water quality • Establishment of standards for equipment and chemicals for use for drinking water systems and supply • Control of imports of equipment and materials related to drinking water • Undertake studies and research • Reference laboratory for consultation and enforcement • Monitoring of bottled water factories and enforcement[46]
State Ministry of Health	• State policy and strategy formulation related to DWS • Surveillance of drinking water sources and supplies: o Monitoring of WTP effluents and in distribution systems o Monitoring of non networked systems o Responding to complaints, testing and reporting results to SWCs to demand action o Refugee and IDP camps o Areas with major agricultural activities and mining, petroleum and other industries • Community engagement and hygiene and sanitation promotion: o Facilitate community engagement in DWS o Share information with communities re DWS o Engage with the media for mass communication • Provide capacity building for Locality staff, hygiene promoters, sanitary inspectors, teachers and other stakeholders on DWS related subjects • Provision of resources: o Distribute DWQ WQ testing equipment and chemicals to Localities o Distributing household water treatment chemicals and household water treatment units during emergencies • Reporting: o Collating DWS data from Localities and from their own surveillances and reporting to FMoH Enforcement role: • As noted for the FMoH above
Localities	See the table below
Administrative Units	See the table below
Communities and community	See the table below

[46] As stated by the SSMO, the Act has not been seen for confirmation of wording

level institutions	

Table 6 - Localities, Administrative Units and communities

	Responsibilities

Localities	Health Affairs Department:[47]
	• Undertake drinking water surveillance
	  ○ Monitor water quality from treatment works and points in the distribution system
	  ○ Monitor point water sources
	  ○ Monitor at household level – including water storage, quality, hygiene and sanitation
	  ○ Maintain DWQ testing equipment and purchase consumables
	• Respond to complaints and undertake investigation and report to SWC
	• Hygiene promotion on:
	  ○ Protecting the source
	  ○ How to monitor the distribution network
	  ○ How to undertake HWTS
	  ○ Cleaning and maintenance of containers for DW
	• Monitoring places where people prepare, drink, sell and show food and monitor the employees and ensure they have a license.
	DWSU:
	• The establishment and protection of drinking water facilities and sewerage [or drainage?] in rural areas.
	• Emergency water treatment:
	  ○ Provision of chlorine for disinfection at household and point source levels
	  ○ Supervision of disinfection
	  ○ Distribution of HWTS units
	• Manage, operate and maintain some water yards
	• Overall guidance and monitoring
	Enforcement:
	• The Health Affairs Department at Locality level can undertake monitoring and enforcement/ activation of laws under the Environmental Health Act, 2009. This therefore includes monitoring or enforcement including in relation to:
	  ○ Private operators of water supplies
	  ○ SWC networks or supplies
	  ○ WES supported drinking water supplies in humanitarian contexts
	  ○ Bottled water suppliers
	• In addition the Locality can establish its own 'Local Orders' under the Local Government Law, 2016, which will specify other possible powers.
	• *The Local Government Act, 2016 notes that:*
	  ○ *29 – The Local Council may issue local orders which have the force of law.*
	  ○ *30 (2) Any local order approved by the Local Council shall include a penalty for*

[47] Which is linked to the MoH at State and Federal level

	the gradual violation of the administrative warning to the fine to imprisonment and may include heavier penalties in the case of continuous violations. • *The Local Government Law, 2003 (temporary) notes:* Introductory section: The State Council is the only the one that has rights to stop orders of Local Government and be responsible to the laws of State Government – these are who have the power to issue the rules and articles that organise this law ○ Chapter 5 – Local Ordinance – gives permission for the Local Council to issue punishments and jail for any clauses that are not followed and to double the punishment if people do not respond when initially instructed to. ○ Schedules for the power of the Local Government: ○ *Part 3 – Engineering matters:* ▪ *1) They have the power to build and protect drinking water and sewerage systems in rural areas* ○ *Part 4 – Health and hygiene:* ▪ *1) Plan, prepare and implement projects to develop environmental health* ▪ *2) Be responsible for the monitoring of drinking water and be sure / validate and guarantee the resource is not polluted* ▪ *4) Do general cleaning works and get rid of all of rubbish and all faeces from men and animals and industrial and agricultural waste to avoid environmental pollution* ▪ *5) Build general public toilets and put law and organise how to use this instruction and observe this and make specifications for toilets* ▪ *6) Observe health in housing, agriculture and industry and establish system of buildings according to the rules of healthy buildings* ▪ *7) Separation of animals and people* ▪ *9) Watch and observe the places that people prepare, drink, sell, show and watch the employees and how they deal with all of these things to be sure there is a healthy licence.* ▪ *10) Display the health awareness messages between all civilians using different methods / resources* ▪ *12) Contribute against local illnesses that occur in this area according on the 13 plan and build health centres* ▪ *14) You have to report about illness and catastrophes and contribute to fight against this*
Administrative Units	• Undertake responsibilities as per Localities above as delegated by Localities • Community mobilisation for DWS • Monitor and report on broken systems and leakage
Communities and community level institutions	• Ownership of the drinking water supply systems • Ensure the participation of all members of the community in DWS related activities, including women, men, girls, boys and people from vulnerable, marginalised or disadvantaged groups and their equal benefit from SDW • Undertake water safety planning: ○ Monitor success of WSPs over time and take remedial actions where necessary ○ Prevention of pollution of the water resources and drinking water supplies ○ Undertake sanitary surveys and undertake remedial actions

	• System management and operation and maintenance (O&M) including:
	  ○ Cost recovery for O&M and fund management
	  ○ Water treatment (where appropriate)
	  ○ Preventative maintenance
	  ○ Purchase of spare parts
	  ○ Repair of minor faults
	  ○ Report to the Locality and / or SWC when major problems occur needing outside assistance
	• Construct, use, maintain and keep hygienic latrines and hand-washing facilities with soap at household level
	• Undertake household water treatment and safe storage
	• Clean drinking water containers regularly

Table 7 - Supporting stakeholders

	Responsibilities
Ministry of Finance and National Economy	• Allocation of Government of Sudan finances for DWS • Monitoring of budgets and expenditures of Ministries with responsibilities for DWS • Audits of finances and expenditures for DWS • Timely payment of contracts with the private sector related to DWS
Ministry of Welfare and Social Security (MoWSS)	• Responsible for community development, welfare, gender, violence, children, psychosocial health, displaced persons, people with disabilities and income generation/poverty reduction • Community mobilisation and hygiene promotion • Provide advice to the MoH, MoWRIE and MoE on gender, equity and vulnerability and how to effectively consider and respond to these issues • Ensure that all programmes focussing on the most vulnerable across sectors incorporate good WASH practices • Supporting poverty reduction and increase income generation
Humanitarian Aid Commission (HAC)	• Supervision of NGO activities and monitoring emergency areas

Higher education institutions	• Training / education – Certificates, Diplomas, Degree, Masters, PhD
	• Research
	• Consultancy such as:
	  ○ Assessments, monitoring, evaluations
	  ○ Technical advice
	• Contribute to the development of policies, strategies, guidelines and systems
	• Support documentation, knowledge dissemination and learning opportunities
	• Innovation and testing of new approaches and technologies

Sudanese civil society organisations (non-governmental organisations, community	<u>Roles:</u> • Support for SDW services for IDPs, refugees and responses to emergencies including disease outbreaks • Mobilisation of communities and support implementation of projects related to DWS • Capacity building of communities • Funding of projects

based organisations and faith based organisations)	Responsibilities: • To abide by the legislation, standards, specifications and guidelines of Sudan and the various States (or international standards where Sudanese standards / specifications do not exist) while undertaking their roles

UN and associated agencies, development partners, humanitarian donors	Roles:
	• Technical advisory support
	• Establishment of international partnerships / links
	• Funding:
	  ○ Development of policies, strategies, guidelines
	  ○ New water supply projects
	  ○ Water treatment chemicals for emergencies
	  ○ Capacity building
	• Provision of equipment
	Responsibilities:
	• To abide by the legislation, standards, specifications and guidelines of Sudan and the various States (or international standards where Sudanese standards / specifications do not exist) while undertaking their roles

INGOs	Roles: • Partner with Sudanese CSOs for the implementation of projects and programmes to support communities with SDW services • Technical advice on DWS related issues • Links with international stakeholders with specific DWS related expertise • Awareness raising and capacity building on DWS related issues • Support for documentation, information sharing and learning • Funding Responsibilities: • To abide by the legislation, standards, specifications and guidelines of Sudan and the various States (or international standards where Sudanese standards / specifications do not exist) while undertaking their roles

Annex II - Practical strategies for improving DWS along the water supply chain

The following tables provide supporting information on specific strategies that should be used to maximise the safety of drinking water. They include:

- **Table 8** – Practical strategies for improving DWS through siting, design and construction
- **Table 9** – Practical strategies for improving DWS through management, operation and maintenance
- **Table 10** – Practical strategies for improving DWS through monitoring, surveillance, documentation and feedback
- **Table 11** – Key areas required for capacity building to respond to current gaps in DWS

Table 8 - Practical strategies for improving DWS through water resources protection, selection, siting, design and construction

Stage		Strategies
Water source	**Water resources protection**	• Establish latrine designs for high water table areas to minimise pollution • Increase enforcement of regulations that reduce pollution risks • Undertake social and environmental impact assessments for all new developments that may have an impact on water resources • Strengthen solid waste collection especially around water sources
	Selection and siting	Select water source that have water quality that meets the Sudan DWQ standards or has parameters that are easy to treat to meet the standards
		Select water source and abstraction point to minimise pollution risks (for example keep away from latrines and septic tanks and sources of pollution such as industrial effluents or areas with high level of agricultural fertilisers)
		In addition to the two criteria above select the water source considering: • Acceptable yield? • Management, legal, security and socio-political and cultural constraints? • Ease of O&M? (O&M and logistical requirements) • Impacts of development? • Time of set-up? (technical and logistical constraints)
	Abstraction design and construction	Protect from animals and humans through fencing and control access
		Protect from run-off through siting away from drainage channels and use cut-off drainage channels above the source or raised bunds to divert run-off away from the source
		Protect floating intakes from ingress of weeds and make easy access for cleaning
		Protect boreholes and wells with sealed linings and grout below the surface
		Construct a concrete platform around a groundwater point source to protect from ingress of polluted water
		Construct a drainage channel to take water away from the groundwater source abstraction point to a soak away, garden, or animal trough
Bulk water treatment	**Selection**	Select water treatment processes to consider: • Effectiveness of the treatment processes including to variations in source water quality • Sustainability of access to adequate quantity and quality of chemicals and spare parts for treatment process tanks and equipment (availability, cost and funds to pay for them) • Acceptability to the consumers • Ease of O&M processes to maintain the treatment process units • Ability to monitor the effectiveness of the treatment processes and modify on a daily basis
	Design and construction	Design treatment processes to consider: • Ability to isolate treatment units for repair and cleaning whilst still maintaining constant supply

		• Ease of O&M processes to maintain the treatment units • Processes to monitor the effectiveness of the treatment processes and modify
		For a SSF - If constant flow cannot be guaranteed into a slow sand filter (for example because of intermittent power supply) then water should be pumped to a raw water balancing tank that can then continuously feed the filter through gravity flow. Other recommendations for design related to the position of valves and flow control can be found in the MoWRIE/DWSU manual on SSFs.
Bulk – water storage and distribution system to collection point	**Selection**	Select tank material that will not corrode or release chemicals into water / or lasts for longer periods before need replacement
		Select pipe materials to reduce corrosion and likelihood of leakage
		Select taps to consider: • To minimise leakage • Are suitable size and height for typical containers • Are suitable for use by adults and children • They are easy to maintain
	Design and construction	Storage tank(s) are designed to be adequate for required volume and adequate number to allow for cleaning and maintenance while still supplying safe water
		Design access points to storage tanks that do not allow ingress of run-off
		Design easy access to pipe valves & junctions via properly constructed valve chambers
		Design for continuous supply and positive pressures (wherever possible)
		Ensure appropriate numbers and locations of sluice or gate valves, air valves, non-return valves, scour valves and valves to deal with pressure and attitude to ensure effective operation and ease of access for cleaning and maintenance. Refer to MoWRIE/DWSU manual for more details.
		Good initial pipe design & quality pipe laying (avoiding air blocks) – design is checked before any new extensions or tapstands are added
		Clean new pipes and repaired pipes through swabbing the pipe section to remove solids, flushing and disinfection before re-filing. Refer to MoWRIE/DWSU manual for more details.
		Design collection points to cope with spilled water and direct the wastewater away from the collection point to the soakaway or other use
		If metal pipes are present in the storage or distribution system, consider adjusting the pH after treatment if the pH is below 5 to minimize corrosion
Collection of water and transfer of water to household	**Drinking water collection and transfer containers**	• Have small opening or well fitted lid or cap • Are easy to clean • Are dedicated for drinking water • Are suitable for use by adults, children, older people, people with disabilities and people with mobility limits
	Donkey carts and tankers and filling mechanism	Donkey carts and tankers are checked for potential contamination risks, donkeys have vets certificate and are accredited for use
		Modify filling spout to reduce wastage into donkey cart drums & tankers
		Design of water point with effective system for collection and drainage of spilled water, taking it away from the collection point to soakaway or other use
Household supply and water treatment and storage	**Selection of drinking water storage containers**	• Are dedicated for the purpose • Have a small opening or well fitted lid or cap • Are easy to clean • Have a tap • Have a dedicated cup for taking water if container does not have a tap
	Household water treatment and safe storage	• Is carried out where needed • Is easy to practice • Is affordable • Consumables are easily available • Is sustainable
	Personal hygiene	Hand-washing facility with soap or alternative is accessible near to drinking water storage container

	Roof water harvesting	Roof water harvesting tanks: • Have a first flush discharge device to remove contaminants at start of the rainy season • Have a well fitted lid that limits access from animals and people, except when needing cleaning • Have a tap to access the water
	Household pipework and storage	Household drinking water pipework is without leakage and any pipes for drinking water should be above those for sewage or wastewater in case of leakage. See **Annex III** for more details.
		Household water tanks should be: • Without leakage • Well sealed • With access limited only to specific household members for cleaning purposes • If painted on the inner surface this is only with non-toxic paints approved by the SSMO for drinking water

Table 9 - Practical strategies for improving DWS through management, operation and maintenance[48]

Stage	Strategies
Water source and abstraction	Procure and store key spare parts and consumables such as fuel, grease, oil, bolts, filters, to prevent downtime for procurement
	Procure and store required tools for maintenance
	Regular checks and repairs to the protection structures for the water source: • Fencing • Cut-off drains or bunds • Well head and protection cover • Concrete platform • Drainage channels • Soakage pits
	For surface water - check the inlet for any clogging by coarse materials, debris of wood, plastic, fabric or natural materials such as weeds or plants and clean the inlet. During flooding seasons this should be done on a daily basis.
	For springs – clean spring box and wash-out, repair leaks, disinfect if any person has accessed spring box.
	For shallow wells and boreholes - if well or borehole becomes flooded de-water, clean, chlorinate, de-water and refill.
	Closing of latrines nearby (see **Annex III** for distances) and blocking up latrine holes
	For more details for particular water source abstraction technologies, refer to MoWRIE/DWSU manuals (2009, Draft) and guidelines on: • HCWY with MP (p64-69) • LCWY with MP (p63-67) • BH with HP (p37-41) • HDW with MP (p45-49) • HDW with HP (p36-39) • Improved hafirs (p23-27) • Small dams (p41-43) • Spring development and rainwater harvesting (p16 and 27)
Bulk water treatment	**General**
	Regularly clean treatment tanks and associated pipes and units to remove sediment and build up of chemicals
	Procure and store adequate stocks of chemicals to cover gaps in supply
	Procure and store key spare parts, consumables and tools
	Undertake water quality testing at various points in the system (raw water, after each key treatment

[48] A number of these recommendations have been taken directly from the MoWRIE/DWSU technical manuals and guidelines

	stage and effluent) to establish dosing and efficiency of system – turbidity, PH, Total Coliform, free chlorine residual, jar test for coagulant dosage. Also undertake periodic tests for full range of chemical parameters. Keep records of flow rates, dosages and WQ results. For more details – see MoWRIE/DWSU manual on WTPs (p47-48)
	Sedimentation tanks and roughing pre-filters
	For sedimentation tanks – regular maintenance should be undertaken to remove the accumulated sludge from the floor of the tank by opening the drain valve. If the sedimentation tank removal efficiency is less than 50% then the tank should be drained and cleaned and the floor valve checked, cleaned and greased.
	For roughing pre-filters – if the turbidity of the effluent is > 10 NTU, either the flow rate should be decreased or the filter should be cleaned. If the bed of the roughing filter is well designed to have sloping floors to allow easy exit of the water from the tank, the sediment can be removed by closing the outlet and filing the tank and then letting the water out quickly taking the sediment out with the water. A log should be kept of the flow rates using a V-notch weir.
	Slow Sand Filters (SSFs)
	For SSFs remove top layer of filter when flow becomes reduced. Continue over time until minimum depth is reached and then add additional sand. For more details and an operational checklist for daily, weekly, monthly and yearly tasks – see the MoWRIE/DWSU manual on SSFs (p47-53)
	Rapid Sand Filters (RSFs)
	For RSFs backwash regularly at specific levels of effluent turbidity to remove sediments
	Chlorination
	Maintain chlorine dosing equipment and dials to enable sensitive adjustment of chlorine dosages
Bulk – water storage and distribution system to collection point	Regular cleaning of tanks, pipes and drainage and soakage systems at supply points
	Repair of tanks, pipes, standpipes, drainage and soakaway systems
	Where chlorination is undertaken at storage tank – chlorinate and monitor residuals
	Access to tanks is only allowed for trained and specified personnel
	If tanks are to be painted on the inside surface – the paints must be approved by the SSMO as being non-toxic and for use in drinking water tanks
	Clean repaired pipes through swabbing the pipe section to remove solids, flushing and disinfection before re-filing. Refer to MoWRIE/DWSU manual for distribution networks for more details (p22-24).
	Use electronic leak detectors to establish where leaks are occurring and their relative size to prioritise repairs. Manual listening using some form of metal rod can also be used for metallic pipes by experienced personnel as an alternative method if electronic equipment is not available.
	For more details for bulk water storage and distribution system to collection point refer to MoWRIE/DWSU manuals and guidelines on: • HCWY with MP (p64-69) • LCWY with MP (p63-67) • BH with HP (p37-41) • HDW with MP (p45-49) • HDW with HP (p36-39)
Collection of water and transfer of water to household	In humanitarian contexts - provision of safe containers with lids for the collection and transfer of drinking water
	Regular cleaning of containers for the collection of water and transfer to the household
	Regular cleaning of the donkey cart water tank / tankers
Household supply and water treatment and storage	Replacement of filters or purchase of adequate stocks of chemicals / consumables for repair of whatever HWTS option is used
	Regular cleaning of drinking water storage containers
	For roof water systems – before the start of the rainy season: • Clean the roof or area used for collecting rainwater before diversion into storage tank, as well as gutters, pipes and overflow drains. • Clean the inside of tank with a brush and disinfectant or soapy water and rinse. • Mend any cracks and broken joints in guttering and pipework.

Table 10 - Practical strategies for improving DWS through monitoring, surveillance, documentation and feedback

Stage	Strategies
Water source	Undertake sanitary surveys / inspections to establish pollution risks over time
	Checking of stability of yield/drawdown (for boreholes) and variations in quality
	Undertake daily turbidity monitoring for surface water treatment & repeat jar tests when turbidity changes to establish optimum coagulant dosages
	Identify actions to respond to pollution risks
Bulk water treatment	Monitor the strength of chemicals over time (through results of jar tests)
	Monitor treatment efficiency every day and make modifications to dosages to respond to results
	Monitor structural integrity of tanks, pipes and associated units – and repair as soon as problems identified
Bulk – water storage and distribution system to collection point	Monitor structural integrity of tanks, distribution systems, drainage systems and soakaways for damage or blockage – mend and / or clean in response
	Monitor water quality at supply point – particularly for chlorine residual, turbidity and pH
	Monitor length of queues and whether an adequate quantity of water is being provided for the number of users - to prevent them looking for alternative unsafe sources
	Monitor water flow at taps – reduced flow over time might indicate siltation or air blockage
	Monitor effectiveness of drainage system and ponding of water – remedy immediately by cleaning drainage channels or improving collection platform to prevent ponding
Collection of water and transfer of water to household	Monitor the quality of water provided by donkey cart owners at household level
	Monitor the use of appropriate collection containers and appropriate use (i.e. using lids and regular cleaning) – increase hygiene promotion if risks seen
Household supply and water treatment and storage	Occasional monitoring of how well HWTS is being implemented and sustained
	Occasional monitoring of water quality at household level as part of monitoring of quality and pollution along supply chain – particularly for chlorine residual, turbidity and pH
	Monitor hygiene practices related to good hand-washing and cleaning of storage containers – increase hygiene promotion where gaps are seen
	Encourage households to ensure structural integrity of their piped systems and storage tanks (no cracks, leaks, ponding water pipes near to sewage pipes or solid waste pipes)
	Feedback from households / community WASH committees / community leadership and citizen's groups on problems with supply • Clear channel for reporting • Committee to respond to the complainant • Maximum time limit to remedy the problem

Table 11 - Priority areas for capacity building to respond to current gaps in DWS

Key areas for capacity building to respond to current gaps in DWS		Priority target groups
Logistics	• Dedicated vehicle or regular access to vehicle to be available for all teams responsible for DWS with access to funds for fuel and a maintenance plan and system	• Locality (dedicated) • State MoH (dedicated) • Federal MoH • SWC distribution network O&M staff • Laboratory staff
Funding	• Increased and dedicated funding for teams responsible for water safety – in both development and humanitarian contexts • Incentives for staff to work in and travel to remote places for DWQ monitoring	• Locality (dedicated) • State MoH (dedicated) • SWC/WTPs • Federal MoH • MoWRIE
Equipment	• Inventory of all water quality testing equipment in key laboratories across Sudan • Recall of broken and damaged equipment for central repair • Possible re-distribution of repaired equipment to training institutions or key State Institutions, Localities lacking equipment • Lab space at State level where it does not exist • Consider specific equipment for the analysis of algae	• Laboratories across institutions – specifics to be determined
Human capacity building – general		
General	Water safety plans – implementation, verification and monitoring	• Communities • Localities • SWCs and State MoH • MoWRIE and FMoH
	Sanitary surveys/inspections and monitoring – and associated reporting	• Communities • Localities • State MoH and SWCs
	Water quality testing - focussing on: • Giving practical experience of using the equipment available at the specific level and reporting • How to check the tablets in the field test kits • How to check the strength of chlorine • The setting up of permanent log books / record keeping on site as well as feeding up information to higher levels • Being honest about actual readings of water quality tests	• Localities • SWCs and State MoH
	• Operation and pro-active maintenance – for all stages in the water supply chain • Plus establishing a publicly accessible record of complaints / problems and actions taken • Build awareness and motivation for people to be able to demand their rights and push the drinking water suppliers to maintain systems	• Communities • Water point operators • Localities • WTP operators • SWCs and State MoH • MoWRIE and FMoH
	Processes for enforcement / activation of laws	• Communities • Localities • SMoH • SSMO
	Repairing common water quality test equipment (noting that Palintest have said that they are open to be available for the training on the Palintest/Wagtech equipment recently procured for the MoH and Localities)	• Key mechanics linked to laboratories in each State • National Public Health Laboratory

Human capacity building – along the water supply chain		
Water source and abstraction	How to reduce pollution risks and their responsibilities for O&M	• Water source caretakers • Community WASH management committee • Locality staff
	Construction of improvements to reduce pollution risks – cement platforms, drainage channels, soakage pits, fencing, cut-off drains	• Water source caretakers • Community WASH management committee • Community masons / builders • Locality staff
Bulk water treatment	Operation and pro-active maintenance for WTPs	• WTP operators • SWC staff
	Water quality monitoring of treatment processes	• WTP operators • SWC staff
	Optimising chemical dosages through jar testing (including for WTPs without electronic jar testing equipment)	• WTP operators • SWC staff
	Chlorination with gas	• WTP operators • SWC staff
	Chlorination with tablet or powder forms of chlorine – including how to mix appropriate solutions (Make 1% solutions, do jar tests and calculate dosages)	• Locality health affairs staff • MoH staff • WTP operators • SWC staff
	Testing and treatment of algae	• Laboratory staff in WTPs affected by seasonal blooms
Bulk – water storage and distribution system to collection point	Operation and pro-active maintenance of storage tanks, distribution systems and supply points for damage	• Water yard and water point operators • Community management committees • Locality staff • SWC and State MoH staff
	Jar testing for dosages of chlorine or for coagulation processes if it occurs on site	• Water yard and water point operators • Locality staff • SWC and State MoH staff
	Pipe design and hydraulics	• SWC or Locality staff involved in extensions / additions to piped networks
Collection of water and transfer of water to household	Hygiene promotion in the safe handling of water in transit	• Household members • Community WASH management committees • Locality staff • State MoH staff
	Effective cleaning and O&M of the donkey cart to prevent contamination and national regulations related to donkey cart use	• Donkey cart owners and operators • Water yard operators • Locality staff
Household supply and water treatment and storage	Hygiene promotion in the safe handling and storage of water at the household	• Household members • Community WASH management committees • Locality staff • State MoH staff
	Options for and operation and pro-active maintenance of HWTS / Point of Use water treatment options	• Household members • Community WASH management committees

		• Locality staff • State MoH and SWC staff
	Operation and pro-active maintenance of household rainwater harvesting and household piped systems	• Household members • Community WASH management committees • Locality staff • State MoH and SWC staff

Annex III - Reference for consistency of guidelines related to DWS

This section includes a number of areas where an inconsistency has been identified across guidelines in Sudan and a few where additional research was needed. The recommendations here should be used for reference when updating guidelines that have components related to SDW. For the background research and supporting references, see the *"Recommendations for strengthening Drinking Water Safety components of WASH sector guidelines"* report for more discussion on each issue and references for further information.

III.1 Minimum distances to prevent pollution

Table 12 - Recommendations for distances to sanitation for Sudan guidelines

	Currently in Sudan manuals / regulations (until November 2017)	**Revised recommended minimum distance (from December 2017)**	**Note**
Distances between groundwater sources and latrines or septic tank drain fields	30-50m (or one noted or the other)	30m = more than enough in certain circumstances (see notes). Where any one of those factors changes (e.g. septic tank used, or distance to water table only 5m or anything less than 10m, or where soil type is coarse sand), then a decision-making flow chart must be used that helps users consider vertical separation, lateral separation and how to mitigate residual risks.	30m will be valid where: (a) distance from base of latrine pit to water table is 10m or more, and (b) where soil type is clay, silt, fine sand or weathered basement, and (c) where sanitation is dry sanitation or pour-flush with fewer than 10 users, and (d) where it is not a densely populated urban area
Distance between bottom of a latrine and the water table	0.7m vertical distance	Ideally >5m in clay/silt/fine sand soils >10m in other soil types	This is not always possible – in case the distance is less, the decision-making flow chart can be used.
Distances from groundwater point source to soakage (i.e. length of drainage channel to soak-pit / animal trough etc)	Min 6m to soakage pit from edge of well platform and 2% slope	Minimum of 6m	
Minimum size of cement	1.5 to 2m radius from edge of hand-	1.5m from edge of hand-dug well rings or borehole casing, to edge	

	Currently in Sudan manuals / regulations (until November 2017)	Revised recommended minimum distance (from December 2017)	Note
platform around a well or borehole	dug well rings 0.985m from handpump head in borehole to edge of platform; slope 1:50	of apron	
Distances between clean water and wastewater / sewage pipes	Keep sewage 3m from any pipeline of drinking water	Water pipes should ideally always be laid in separate trenches or always be laid at least 50cm above sewage or wastewater pipes. This is so that if the sewage or wastewater pipes leak they do not leak on the drinking water pipe. Where possible keep all drinking water pipelines at least 3m away from any source of faeces such as a pit latrine or septic tank soakage field[49]. Likewise keep underground tanks as far away as possible from pit latrines and other possible sources of pollution.	WHO does not have a minimum distance between a water pipe and a pollution source, only to keep the pipe the 50cm above sewage or wastewater pipes. The general note added about keeping drinking water pipelines away from sources of pollution is to take care because the water supply may flow intermittently and hence there is a risk of ingress of contaminants at joints and leaks. Likewise of underground tanks are not well sealed there is also the risk of contamination.

III.2 Minimum chlorine residuals

Recommendations for Sudan guidelines:

1. The main recommendation is to maintain a free chlorine residual of 0.2 mg/l at the household level after 24 hours.
2. Increase the chlorine residual to lead to at least 0.5-1.0 mg/l residual at public standposts in any hot climate condition, irrespective of outbreak or normal conditions, and to monitor the effects along the water chain to check a) residuals in households, as well as checking b) the community acceptance of the chlorine taste/rejection levels; and then to adjust accordingly.
3. Likewise any water being distributed by tanker should be at least 0.5-1.0 mg/l at the point of collection by household members, so may need to be higher if there are intermediary steps. And then to monitor the effects along the water chain to check a) residuals in the furthest households, as well as checking b) the community acceptance of the chlorine taste/rejection levels; and to adjust accordingly
4. This means that the chlorine level will probably need to be higher than 1.0 mg/l when leaving the water treatment plant. The actual level will need to be established from testing down the distribution line to

[49] WHO does not have a minimum distance for pipes from pit latrines or other similar sources of pollution. It might be that pipes are above the level where the contaminants will seep into the ground, but there may still be risks. The 3m has been included as a recommendation where it is possible.

the tapstands are furthest households. Dosage levels at the end of the water treatment process before the water leaves the WTP may need to be 2 to 4 mg/l and will need to consider the length of the pipeline and distribution system; and to adjust accordingly.

5. To suggest that opaque jerry-cans[50] to be provided as non-food items in humanitarian situations.
6. The chlorination levels for water in donkey carts should be established locally depending on the chlorine demand of the water to ensure that the water by the time it reaches the household and point of use still has an adequate residual:
    - Some chlorine may be used in reactions with the water tank barrels, so testing should be undertaken along the water supply chain to confirm the end residuals.
    - Suggest start dosing at ¼ to 1 tablet per 200 litre and then adjust the dose based on the residual at the last point of delivery – aim for 0.5-1.0 mg/l, so that you will still have a 0.2 mg/l residual in the household storage after 24 hours or storage.
    - Repeat the testing of the required dosages at the hottest / coldest times of year and if the water quality changes.

III.3 How to retain chlorine residual levels for long pipelines

Recommendations for Sudan guidelines:

Technical details should be requested to be integrated into the next updates of the MoWRIE/DWSU guidelines. But in principle the most practical options for retaining chlorine residuals in long pipelines for Sudan are suggested to include:

1. To reduce the time that the water remains in long pipelines as part of the design process.
2. To add booster chlorination points along the pipeline route – which would probably require on-line injectors and some form of automated sensor (so not low tech).
3. To test the chlorine levels and chlorinate independently at each point of abstraction from the main line (i.e. in storage tanks before distribution).

III.4 Microbiological testing

Recommendations for Sudan guidelines:

1. *E.coli* or thermotolerant coliform should be used as indicator for faecal contamination, not Total coliform.
2. Total coliform and Heterotrophic plate counts (HPCs) can be used for assessing the cleanliness and integrity of distribution systems and the potential presence of biofilms, but not as an indicator of faecal contamination.
3. Hydrogen Sulphide (H_2S) tests are not a good indicator of faecal contamination, as the ability to form H_2S is too widely distributed within the microbial world and it can also be naturally present in the environment including in groundwater. Whilst the test leans towards the side of safety, it leads to false positives which can result in water sources being rejected for less safe sources or increases in cost to provide safe water. It is therefore suggested that if H_2S tests are used and positive results are attained, that the water should then be re-tested for *E.coli* or thermotolerant coliform to confirm the type of contamination.

[50] (i.e. not clear plastic as in the collapsible jerry cans sometimes distributed in humanitarian contexts)

4. Coliphage tests of certain kinds that identify particular F-RNA serogroups that are of only faecal origin could be used as faecal indicators for inclusion in verification and surveillance monitoring. But WHO (2017) also notes that due to some limitations they are probably currently more suitable at this stage to laboratory investigations, pilot trials and more validation testing rather than operational or verification monitoring. The absence of coliphages does not confirm the absence of pathogens such as enteric viruses and protozoan parasites.

III.5 Intervals for monitoring drinking water quality/safety

Recommendations for Sudan guidelines:

Note that the inconsistency in when wells / point sources should be sampled in the Sudan manual on DWQ and safety, 2016 – is also reflected in the data from different WHO documents. Hence there is a need for Sudan to decide on a specific regime that suits Sudan, to ensure that the recommendations are coherent.

For the recommendations see **Tables 13 & 14** below.

III.6 Should the sector refer to the SSMO standards or WHO guidelines or both?

Recommendations for Sudan DWQ standards:

1. The Sudan DWQ standards should be followed as standard practice and not the WHO guidelines, unless there are parameters that are of concern but have not been included in the Sudan DWQ standards.
2. The next time the Sudan DWQ standards are updated, to consider the 2017 updates of the WHO guidelines, especially for parameters that have been added or removed since the earlier versions.
3. The WHO guidelines are established based on an assumption that an adult will drink 2 litres of water a day with 50% of this being assumed to be boiled or in food. In very hot climates people may drink double this amount. So making some guideline levels stricter may be appropriate for some parameters. But WHO notes that it is only for some parameters (such as Fluoride or Arsenic) that it may be appropriate for modifying the levels based on the climate and volume of water drunk. This is because the proportion of such chemicals coming from drinking water is relatively high. But for many parameters where a person's intake from drinking water is very small compared to other sources, no adjustment is necessary. It also notes that for some parameters it isn't physically possible to measure them below a certain level. Hence these issues should also be considered when next updating the Sudanese DWQ standards.

III.7 Height of headwalls and depth of grouting for borehole casings

Recommendations for Sudan guidelines:

1. The headwall height for a hand-dug well with a handpump or a motor pump should normally be 75-80cm, unless in flood-prone areas in which case it should be 50cm above the flood line, with steps or a ramp to reach the handle if required to make it accessible by all users.
2. All boreholes should have a minimum depth of grout seal for 2-5m from the surface and increased efforts to ensure that all new boreholes have this grout included, as it is currently sometimes overlooked.

Table 13 - Recommendations for minimum intervals for surveillance and sampling of water sources and supplies

Water source type	Sanitary investigation / survey			DWQ sampling and analysis		Additional surveillance and DWQ sampling and analysis
	Community	Water-supply agency (WSA)	Surveillance agency	Water-supply agency	Surveillance agency	
Point sources						
Open wells for community supply	6 times per year	-	1 time per year (note 1)	Before selection of source – *full DWQ parameters*	• Before approval to use the source – *full DWQ parameters* • Progressive sampling of all sources over 3-5 year cycles (maximum)	• Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease
Covered dug wells and shallow boreholes with hand-pumps	6 times per year	-	1 time per year (note 1)	Before selection of source – *full DWQ parameters*	• Before approval to use the source – *full DWQ parameters* • Progressive sampling of all sources over 3-5 year cycles (maximum)	• Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease
Deep boreholes with handpumps or motorised pumps (Water Yards)	6 times per year	6 times per year (where they are managed by the WSA)	1 time per year (note 1)	• Before selection of source – *full DWQ parameters* • Daily test of chlorine residual (once pH and turbidity are established to be stable)	• Before approval to use the source – *full DWQ parameters* • Routine activity 6 times per year, increased if an outbreak. • Progressive sampling of all sources over 3-5 year cycles (maximum)	• Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease – *test pH, turbidity and chlorine residual daily*
Protected springs	6 times per year	-	1 time per year (note 1)	Before selection of source – *full DWQ parameters*	• Before approval to use the source – *full DWQ parameters* • Progressive sampling of all sources over 3-5 year cycles (maximum)	• Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease
Community rainwater collection systems	6 times per year	-	1 time per year (note 1)	Before selection of source – *full DWQ parameters*	• Before approval to use the source – *full DWQ parameters* • Progressive sampling of all sources over 3-5	• Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease

Water source type	Sanitary investigation / survey			DWQ sampling and analysis		Additional surveillance and DWQ sampling and analysis
	Community	Water-supply agency (WSA)	Surveillance agency	Water-supply agency	Surveillance agency	
					year cycles (maximum)	
Groundwater or surface water that is distributed through a piped network (Note that monitoring should be undertaken even if the water has not been treated or not consistently treated but still supplied through a piped network)[51]						
<5,000 population *(assumed community managed)*	12 times per year	2 times per year for groundwater sources; 4 times per year for surface water sources	2 times per year (at same time as DWQ testing)	Before selection of source – *full DWQ parameters*	• Before approval to use the source – *full DWQ parameters* • Testing of faecal indicator and basic parameters: 12 times per year	• Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease - *test pH, turbidity and chlorine residual daily*
5,000-100,000 population *(assumed water supply agency managed)*	If possible community representatives to check 2 times per year and feedback to water supply agency	4 times per year	6 times per year (at same time as DWQ testing)	• Before selection of source – *full DWQ parameters* • Operational and verification monitoring: See the **Table 14** below	• Before approval to use the source – *full DWQ parameters* • Testing of faecal indicator and basic parameters: 12 times per year per each 5,000 population	• Before starting to use the source – *full DWQ parameters* • Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease - *test pH, turbidity and chlorine residual daily*
>100,000 Population (assumed to be water supply agency managed)	If possible community representatives to check 2 times per year and feedback to water supply agency	12 times per year	12 times per year (at same time as DWQ testing)	• Before selection of source – *full DWQ parameters* • Operational and verification monitoring: See the **Table 14** below	• Before approval to use the source – *full DWQ parameters* • Testing of faecal indicator and basic parameters: 12 times per year per each 10,000 population plus an additional 120 samples	• Before starting to use the source – *full DWQ parameters* • Change in environmental conditions and increase in water borne diseases • Outbreak of water-borne disease - *test pH, turbidity and chlorine residual daily*
> 500,000	If possible community representatives to	12 times per year	12 times per year (at same time as DWQ testing)	• Before selection of source – *full DWQ parameters*	• Before approval to use the source – *full DWQ parameters*	• Before starting to use the source – *full DWQ parameters* • Change in environmental

[51] Water that has not been treated or is not treated consistently, but still supplied through a piped network may be a groundwater supply from a deep borehole, that has been established to be safe at the point of abstraction when first constructed. Over time the water quality may change, for example increase in nitrates or salinity and also when the water enters a piped network it can become contaminated through leakages in the piped network.

Water source type	Sanitary investigation / survey			DWQ sampling and analysis		Additional surveillance and DWQ sampling and analysis
	Community	Water-supply agency (WSA)	Surveillance agency	Water-supply agency	Surveillance agency	
	check 2 times per year and feedback to water supply agency			• Operational and verification monitoring: See the **Table 14** below	• Testing of faecal indicator and basic parameters: 12 times per year per each 50,000 population and an additional 600 samples	conditions and increase in water borne diseases • Outbreak of water-borne disease - *test pH, turbidity and chlorine residual daily*

Note 1: Where it is impractical to inspect all such facilities, a statistically significant sample should be inspected

Table 14 - Operational and verification DWQ monitoring by water supply agency in a treatment works and a piped network

	Water treatment plants	Storage tanks	Distribution points	Household
Test complete range of water quality parameters (physical, chemical, micro-biological)	For groundwater: • Test raw water before establishing WTP • Test every 6 months to check for changes • Test water at outlet of WTP to verify treatment processes effectiveness For surface water: • Test raw water before establishing WTP – test during each change of the season • Test water at outlet of WTP to verify treatment processes effectiveness – test during each change of the season	-	• Test at distribution points in response to complaints about taste, smell, colour changes. • Test if it is suspected that there is a problem such as from fluorosis, increased agriculture and risk of increased nitrates, new industries with risk of pollution from wastes, etc.	-

Test basic DWQ parameters (pH, turbidity, chlorine residual) at different stages of the WTP process (and temperature for the stage before dosing)	As a minimum test the DWQ twice each day and after each modification to the dosing regimen or change in weather (for surface water as this may affect the turbidity) at: • Raw water • After dosing • After coagulation before the filters • After the filters before chlorination • After chlorination (for chlorine residual)	Test chlorine residual in storage tanks daily	12 times per year at sample distribution points – prioritise sites: • Later in the network • Sites most vulnerable to contamination • Where there is a lack of persistence of chlorine residual • These may include: loops, low-pressure zones, dead-ends and sites known to be difficult	Test chlorine residual along supply chain to a sample of households who take the water from the end of the distribution lines – a minimum of 12 times per year
Undertake jar test to establish required coagulant dosages	As a minimum test the DWQ twice each day and after each modification to the dosing regimen or change in weather (for surface water as this may affect the turbidity).	-	-	-
Undertake jar test on chlorine to establish dosage requirements	• Check the required dosage daily using the jar test and / or each time the environmental conditions / source water changes in consistency / or the chlorine batch is changed • For groundwater where the consistency does not change once the dosage rates have been established, it may be possible to omit the jar test but modify the dosage based on any changes to the chlorine residuals (which may reflect change in chlorine strength) • Where possible tabulate dosage adjustments against residuals obtained – this can then be used to as reference for additional changes in dosage to increase the residuals • Establish the required residual at the outlet of the WTP by cross-checking by tests of the chlorine residual down the supply chain to tapstands and sample households to ensure a 0.2 mg/l free residual chlorine (FRC) at the households after 24 hours storage. All distribution points in the network should have a minimum of 0.5-1.0 mg/l FRC.	-	-	-

III.8 Paint acceptable for drinking water tanks

Recommendations for Sudan guidelines:

1. Storage tanks used in plants for packaged/bottled water should be made of inert materials approved for food contact such as ceramic and stainless steel that prevents any deterioration; and painting should not be allowed.
2. Only certified non-toxic paints should be permitted for the painting of the inside of any form of tank that carries drinking water, including donkey carts and tankers.
3. Sudan needs to establish a certification process for paint supplies / waterproofing materials that can be used for drinking water tanks that they are non-toxic.
4. Key laboratory specialists such as from the National Public Health Laboratory, the SSMO, the MoWRIE GWD lab and others (such as from the University of Khartoum Chemical Engineering Department), should form a committee to discuss the need for establishing specifications for paints for use in water facilities and then the committee to make a proposal / plan as to: a) The mechanism to be established for this; and b) which laboratory should be strengthened to be able to undertake the testing and certification process. This will be a complicated process to set up, but it is an important one.

III.9 Good practice in the regulation of the packaged/bottled water industry

Recommendations for Sudan guidelines:

The following recommendations are for taking forward good practice in Sudan rather than specifically for updating the guidelines. It is suggested that external support may be useful for Sudan to strengthen in this area.

Good practice for bottled drinking water is understood to include (Williams et al, 2014):

1. A formal cross institution coordination body for the regulation of drinking water – involving all key institutions
2. Clarified roles and responsibilities including in particular establishment of the lead unit and who has the primary authority for regulating drinking water and who should issue certificates and enforce abuses of the regulations
3. A structured monitoring regime and database to facilitate monitoring and tracking compliance
4. Formal guidance on the regulations and associated requirements and capacity building established for bottled water producers
5. Where possible some form of a mandatory certification mark for bottled water products
6. Some form of opportunity for consumer feedback on products in the market

III.10 Specifications for health and safety equipment for handling chlorine and storage

Recommendations for Sudan guidelines:

1. To strengthen the recommendations for personal protective equipment (PPE), storage and handling of chlorine and the management of accidents when using chlorine, including a face mask with a chlorine specific respirator (specific recommendations are in the revised FMoH Chlorination Protocols) – these should be strongly emphasised

III.11 Identification and removal of algae

Recommendations for Sudan guidelines:

1. Undertake a specific targeted study[52] involving a international expert on algae (and not a sales person who may have a bias towards over-emphasising the problems) – who can help experts in country build on existing knowledge and experience of the Khartoum SWC[53], working with the team there and the National Public Health Laboratory and other SWCs to identify: a) What problem exists; b) In which areas of Sudan does it exist; c) For how many months of the year; d) Is it a significant problem that poses risk to health or is it a minor problem that is already being covered by existing water treatment processes; and e) what modifications are needed for treatment processes to respond to this problem?
2. Consider whether river bank infiltration could be used to remove most algae before it arrives at the WTP (such as jetted well intakes) – but might not be possible for large urban WTPs due to high flows.

[52] This will then help to determine if any further action would be needed, or can be used to allay the public fears if there is a larger algae bloom problem again in the future. If the problem is mainly only due to sugar factory wastes then a solution may be to ensure these wastes are treated and do not get into the Nile so the blooms do not happen.

[53] Fathelbari, M.O (2014) *Algal Removal Strategies and Treatment Options in Drinking Water Bodies (River Nile), Khartoum State – Sudan, July 2014*, Final Paper, 37th International Postgraduate Course on Environmental Management for Developing and Emerging Countries, Technical University of Dresden

Annex IV - References

The following are documents specifically referred to in this strategy:

Sudan - laws, acts, regulations, policies, strategies, plans:

- FMoH and MoWRIE/DWSU (2017) *Water Safety Plans 2017*
- FMoH (2017, draft) *Sudan National Health Policy, 2017 – 2030*
- Republic of Sudan (2001) *Environmental Conservation (Pollution) Act of 2001* [translation]
- Republic of Sudan (2001) *School Health Act, 1974* [translation]
- Republic of Sudan (2011) *WASH Sector National Strategic Plan, 2012-16*
- Republic of Sudan, Council of States (2016) *Local Government Act, 2016* [translation]
- Republic of Sudan, FMoH (2016, final draft) *Sudan National Sanitation and Hygiene Strategic Framework*
- Republic of Sudan, FMoH, Directorate of Primary Health Care, Environmental Health & Food Control Department (2015) *National Environmental Health Strategic Plan, 2015-2019*
- Republic of Sudan, Ministry of General Education, Federal Ministry of Health and UNICEF Sudan (2016, draft) *The National School Health Strategy, 2016-20*
- Republic of Sudan, National Assembly (2009) *Environmental Health Act, 2009, Order Articles* [translation]
- Republic of Sudan, Union Government Council (2003) *Local Government Law, 2003 (temporary)*
- UNHCR (2017) *South Sudan Regional Refugee Response Plan*, January to December 2017
- UN-OCHA (2017) *Humanitarian Response Plan, Sudan*, January to December 2017
- UN-OCHA (2017) *Multi-Year Humanitarian Strategy, 2017-19*

Sudan - Guidelines – FMoH:

- FMoH (2013) *Drinking Water Chlorination Protocol*, General Directorate of Essential Health Care, Directorate of Environmental Health and Food Control, Department of Water Hygiene and Safety, published with support of GAVI, WHO and Federal Directorate of Health Promotion
- FMoH (2016) *Manual for Drinking Water Quality and Safety*
- FMoH (no date) *Manual of Environmental Health in Emergency*
- FMoH (no date) *Summarized Drinking Water Chlorination Protocol*, Environmental Health and Food Control Department

Sudan - Guidelines – MoWRIE/DWSU:

The following technical guidelines were published by: PWC, MIWR-GONU and MWRI-GOSS – all are drafts from April 2009. However as the institutions have now changed, they have been referred to throughout the report as: MoWRIE/DWSU documents. The series include:

- *Some Technical Guidelines and Manual of Improved Small Dams for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of Improved Hafirs for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of Spring Development and Roof Water Harvesting (Draft)*
- *Technical Guideline and Manual for Hand Dug Wells with Handpumps for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual for Hand Dug Wells with Motorized Pumps for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of Borehole with Handpump for Field Staff and Practitioners (Draft)*

- *Technical Guideline and Manual of Low Capacity (Mini) Water Yard – Borehole with Motorized Pump for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual for High Capacity Water Yard – Borehole with Motorized Pump for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of Slow Sand Filtration System for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of Drinking Water Treatment Facilities for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual for Drinking Water Distribution Networks for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of School Latrines for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of Latrines for Rural Health Institutions for Field Staff and Practitioners (Draft)*
- *Technical Guideline and Manual of Household Latrines for Field Staff and Practitioners (Draft)*

Sudan - Guidelines – WASH Sector Emergency Guidelines (2017):

- Introduction
- 6.1 – *Emergency Water Supply*
- 6.2 – *Emergency Water Sources Selection*
- 6.3 – *Water Safety Plans*
- 6.5 - *Rehabilitating & Operation and Maintenance of Water Supplies*
- 6.7 – *Emergency Water Treatment*
- 6.8 – *Water Distribution*

Sudan - Guidelines – School WASH:

- Republic of Sudan, Ministry of General Education and Federal Ministry of Health (2016, draft) *National Guidelines for Implementation of an Effective School Health Program,* MoE, FMoH, UNICEF Sudan

Sudan – research, data, reports:

- Fathelbari, M.O (2014) *Algal Removal Strategies and Treatment Options in Drinking Water Bodies (River Nile), Khartoum State – Sudan, July 2014*, Final Paper, 37th International Postgraduate Course on Environmental Management for Developing and Emerging Countries, Technical University of Dresden
- FMoH (2005) *National Strategy for Community-based Development Initiatives Program (CBI),* Sudan, Directorate General of Primary Health Care, FMoH
- Karrar, A.N.A and Yousif, A.E. (2017) *Survey to Assess the Quality & Safety of Bottled Water in Sudan, 2017*, General Directorate of Primary Health Care, Environmental Health and Food Control Department, Water Quality and Safety Section, Federal Ministry of Health, Sudan
- Newtech Consulting Group (2017) *Water Sector Reforms & Institutional Capacity Development Program, Inception Report*, Ministry of Water Resources, Irrigation and Electricity, Sudan
- NewTech Consulting Group and Mott MacDonald (2015) *Port Sudan, Water and Sanitation Strategic Investment Program, 2016-2022,* November 2015 (Updated with Annex 5, June 2016)
- No author (2017) *Tariff Study – Volume IV, Key Findings, North Darfur State*
- Sarour, M. E. M. E. (2009) Adequate safe water and sanitation for all; A legal system to protect water and sanitation in Sudan, November 2009, *Workshop on Water and its Relation to Health and Sanitation Organisation*, General Secretariat of the Council of Ministers

- UNHCR (2017) *Sudan – Refugees from South Sudan*, 31 Aug 2017
- Urban Water Administration Offices (2017) *Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala*
- WFP and UNICEF (2016) *The Case for Investment in Nutrition in Sudan*, February 2016

Global:

- House, S & Ree*d, R (1997) Emergency Water Sources, Guidelines for selection and treatment*, WEDC, Loughborough University, UK
- Hutton, G. (2015) *Personal communication*, based on work undertaken for the World Bank in 2015
- Hutton, G and Varughese, M (2016) *The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation and Hygiene* - Data catalogue entries for Sudan, World Bank http://www.worldbank.org/en/topic/water/publication/the-costs-of-meeting-the-2030-sustainable-development-goal-targets-on-drinking-water-sanitation-and-hygiene
- IWA (2012) *Water Safety Planning for Small Community Water Supplies; Step-by-step risk management guidance for drinking-water supplies in small communities*
- Williams, A.R. And Jalloh, M.B. Jalloh, M.F. Saquee, G, Pratt, S. Fisher, M. Vapnek, J. And Jusu-Sheriff, Y (2014) *Improving the Regulation, Monitoring, and Quality of the Packaged (Sachet and Bottled) Water Industry in Sierra Leone; and Sensitising the Customer Base*, Final report, University of North Carolina at Chapel Hill and FOCUS 1000
- WHO & UNICEF (2015, draft) *JMP Green Paper: Global monitoring of water, sanitation and hygiene post-2015*, Joint Monitoring Program, WHO & UNICEF; and UNICEF
- WHO (2017) *Climate-resistant Water Safety Plans*: Managing health risks associated with climate variability and change
- WHO (2017) *Guidelines for Drinking Water Quality*, Fourth Edition Incorporating the First Addendum
- WHO (2017) *Safely Managed Drinking Water – Thematic report on drinking water 2017*
- WHO (2017, draft) *Equity in Water Safety Planning, A guide to integrating equity considerations into the water safety plan process,* Draft version, 27 September 2017
- WHO and IWA (2009) *Water Safety Plan Manual, Step-by-step risk management for drinking-water suppliers; and* WHO
- WHO and IWA (2012) *Water Safety Planning for Small Community Water Supplies; Step-by-step risk management guidance for drinking-water supplies in small communities*
- WHO and UNICEF (2017) JMP data for access to drinking water
- WHO and UNICEF (2017) *Safely Managed Drinking Water – thematic report on drinking water 2017*
- WHO Regional Office for the Eastern Mediterranean (1997) *Healthy Cities, Guidelines for the Development of Healthy Cities Projects and Activities,* WHO-EM/PEH/501/E/L

For a full list of references referred to during the process of development of this strategy, refer to the contextual analysis report that supports this strategic framework.