Groundwater and Drilling: Insights from over 50 countries

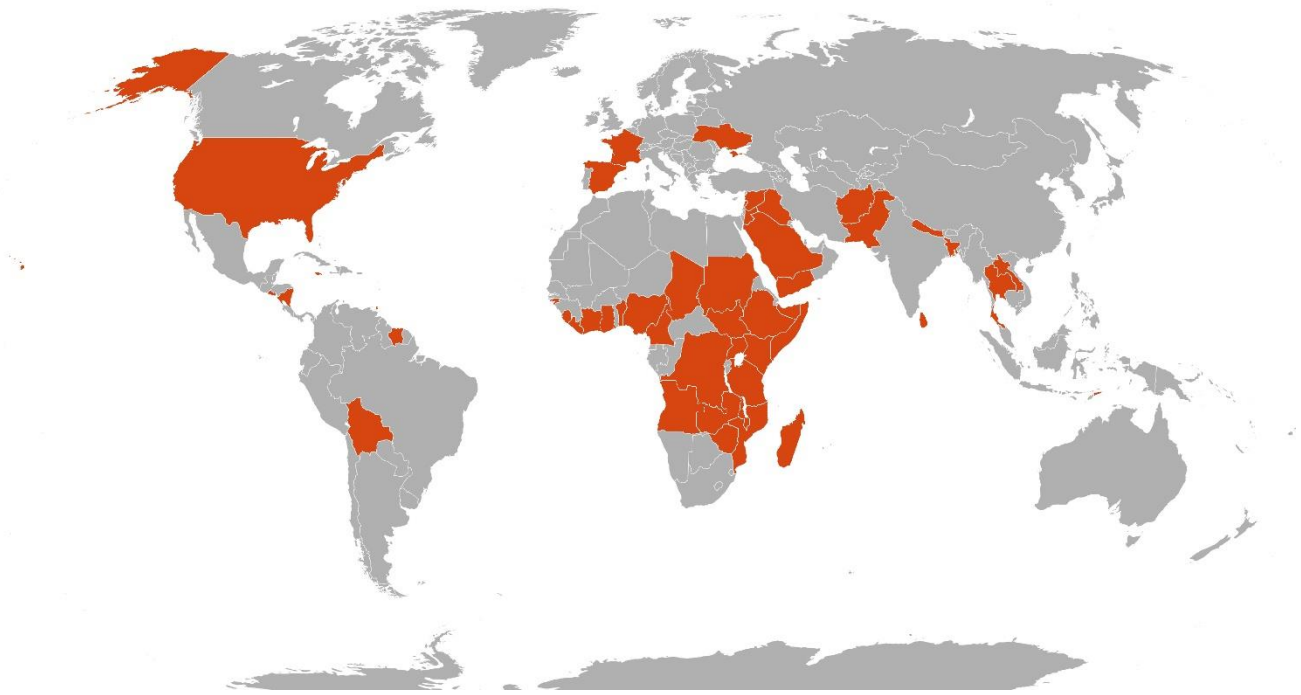


Figure: Map of countries covered by this report

Dr Kerstin Danert, Skat Foundation

April 2020

SKAT FOUNDATION, VADIANSTR. 42, CH 9000 ST GALLEN, SWITZERLAND
WWW.SKAT-FOUNDATION.CH

Disclaimer

The information presented in this report has been drawn from the information that was shared by participants of the 2018 and 2019 online courses on the *Professional Management of Water Well Drilling Projects & Programmes* hosted by UNDP Cap-Net and managed by Skat Foundation. The information has not be verified through additional studies, and Skat Foundation does not take responsibility for any errors or any mis-representation.

Sponsors and partners

This document synthesises the information that was shared by participant on the 2018 and 2019 editions of the online course on professional management of water well drilling projects and programmes. The courses made possible thanks to funding contributions by UNICEF, Skat Foundation, Lotteriefonds St.Gallen, United Nations High Commission for Refugees (UNHCR), WaterAid UK, Oxfam UK; in kind support by the Water Integrity Network (WIN) and the British Geological Survey (BGS) and hosting and facilitation by UNDP Cap-Net on their virtual campus. This course built on the 2018 version, which was developed as part of a Project Collaboration Agreement (PCA) between UNICEF and Skat Foundation (2017 to 2019).

This is one of two documents. A 'sister' document setting out the process of the 2019 course is also available: Danert, K (2020) **Professional Management of Water Well Drilling Projects and Programmes Online Course 2019: Process Report, Skat Foundation, St Gallen, Switzerland,** Available at: http://www.rural-water-supply.net/en/

Contents

List of Tables, Figures and Boxes

Abbreviations

BoQ	Bill of Quantities
CoP	Code of Practice
DHS	Demographic and Health Surveys
DRC	Democratic Republic of Congo
gw	Groundwater
JMP	Joint Monitoring Programme
Lao PDR	Lao People's Democratic Republic
MICS	Multiple Indicator Cluster Survey
NSPMS	National Social Protection Monitoring Survey (Yemen)
PCA	Project Collaboration Agreement
RWSN	Rural Water Supply Network
ToR	Terms of Reference
UN	United Nations
UNDP	United Nations Development Programme
USA	United States of America
WHO	World Health Organisation

Acknowledgements

Groundwater is hidden until it is extracted up to the surface. Despite its enormous importance to human life, societies, the economy and the natural world, information on groundwater has remained just as hidden from view.

This report has been made possible thanks to the efforts of the 181 participants that participated in the Skat Foundation/UNDP Cap-Net online courses on professional drilling management in 2018 and 2019. Thank you all for the hours that you spent reading, reflecting, asking others for information and writing your assignments, as well as posting your responses, ideas and questions on the online discussion forum.

In addition to the few weeks that I spent pulling this information together, I estimate that the combined contribution of the participants to this report was over 700 working days, i.e. 3 years of work. If you combine these with the time that the facilitators spent, you realise that it equates to about the time to undertake a PhD full-time. It is incredible what we can achieve together. Thank you participants!

A big thank you to Dr Jean Pierre Sandwidi, Ivann Milenkovic, Dotun Adekile, Tianaharivelo Rakoto, Dr Moustapha Diene, Dr Charles Serele, Justine Haag and Dr Kirsty Upton for your tireless work as course facilitators, guiding the participants, responding to their questions and marking their assignments. It was such a pleasure to work with you. Thanks also to Mika Jouhki for your support with communications.

A huge thanks is extended to Damian Indij at Cap-Net for your insightful and calm guidance as well as facilitation of the process from start to finish. Thanks particularly to Stephanie Theis for your invaluable work as assistant course manager.

The two courses were developed and able to take place thanks to financial support by UNICEF, Skat Consulting AG Projektfonds, Skat Foundation, Lotteriefonds St.Gallen, United Nations High Commission for Refugees (UNHCR), WaterAid UK, Oxfam UK. In-kind support was provided by the Water Integrity Network (WIN) and the British Geological Survey (BGS). The course hosting and facilitation was made possible by UNDP Cap-Net on their virtual campus.

Thanks to IHE-Delft and Rafael Chavez Garcia Silvia for enabling me to review Raphael's final draft Master's Thesis, which enabled an expansion on the groundwater dependency references.

A big thanks to my colleagues within Skat Consulting AG, who bore with my at times rather noisy enthusiasm as I pulled this report together.

Last, but not least, I would like to mention José Gesti Canuto, who while working for UNICEF, had the vision and saw the potential of developing an online course on this topic! Thank you José.

Select Quotations

It is very important to shift from ticking boxes alone to minimum requirements & quality assurance (course participant, 2019).

Low quality can be considered from two perspectives – some clients are not learned enough and fall victim to poor materials. Others are learned enough get involved in shady deals that compromise quality (course participant, 2019).

There is need to raise awareness among clients/non-groundwater specialists about the complexity of borehole drilling and about what is involved in good construction. As long as clients remain 'in the dark', about this, they will continue to push drillers to reduce their prices and encourage short cuts (course participant, 2019).

Summary

It is perhaps a reflection of the hidden nature of groundwater itself, that information on the resource, its management and development, or its governance can be so hard to find. The two online courses in 2018 and 2019 on the *Professional Management of Water Well Drilling Projects & Programmes* have enabled a wealth of information on groundwater from over 50 countries to be shared and collated. This report synthesises the experiences and insights shared by the 181 course participants that took the two courses.

The reliance on groundwater by the populations of many countries is considerable, but the data available does not provide a full picture of the status quo. Data on the proportion of the population that rely on groundwater from a point source (i.e. spring, hand dug well or borehole) is available on the website of the Joint Monitoring Programme (JMP) of WHO and UNICEF. This data is drawn from national surveys and censuses. Participants from Somalia and Yemen believed that the actual groundwater dependency in their respective countries is much higher. Alternative figures and data sources were shared from participants in Jamaica and Trinidad and Tobago. Participants from Bolivia and Mozambique wrote of recent changes of interest in groundwater by government.

Self-supply, whereby households take care of their own water needs was mentioned as important for populations in Afghanistan, Nepal, Sri Lanka, Timor Leste, Zambia and Zimbabwe. The lack of knowledge of what constitutes a good quality borehole by individuals that invest, as well as a lack of understanding of what this costs have long-term implications for the service and groundwater resources. Efforts to address this problem are taking place in Zambia.

The use of groundwater data from maps, and records of previous drilling activities was noted as important. However accessing such information is often very difficult to obtain and out of 42 countries, only 14 (33%) were believed to have national groundwater databases. In some of these cases, the databases are old and not comprehensive. Encouragingly, there are also initiatives underway to upgrade, or establish groundwater databases in some countries.

Experiences of difficult hydrogeological settings and the challenges of drilling in hard-to-reach communities were shared, with specific examples mentioned from Bangladesh, Ethiopia, Sierra Leone, South Sudan, Sudan, Sri Lanka, Syria and Timor Leste. It was noted that in Lao PDR, groundwater can be found everywhere at shallow depths, apart from the plateau area where one needs to drill to about 60m. Concerns about groundwater pollution was expressed from participants working Bolivia, and concerns about reductions in groundwater quantity were shared from El Salvador, Yemen, parts of Somalia and Florida (USA).

Borehole siting practices vary between countries and organisations, with some clients contracting the work out separately to consultants and others relying on the drilling company to undertake siting. A lack of skills and knowledge, professionalism, and equipment as well as particular challenges of working in insecure contexts was noted as the main challenges with respect to siting. There was considerable discussion about who should be responsible for siting, and when it should ideally take place. The importance of addressing land issues when siting was also noted.

The 'four steps to better drilling contracts' promoted and detailed within the course are i) procurement plan; ii) contract award; iii) contract management and iv) post-construction monitoring & reporting. Among the participants, there was recognition of the importance of pre-qualification, pre-bid meetings, sit visits, good communication between the client and contractors throughout the process, as well as the value of minimising the distance between boreholes drilled under one contract. However, organisations struggle with insufficient or inexperienced staff and unrealistic deadlines. Corruption is also major impediment to drilling professionalism, with numerous examples as well as ideas to combat it shared. Improving transparency, undertaking pre-qualification (with due diligence), registration and licencing, supporting drillers associations, undertaking

inspection, use of penalties, paying proper salaries and raising skills were all put forward as suggestions to prevent, or reduce corruption. From the four steps listed above, experiences of post-construction monitoring was the most limited.

Payment (or not) for dry boreholes or poor water quality is a contentious issue, and prompted lively online discussions and considerable reflections within the assignments. Some participants held on to their belief that dry boreholes should never be explicitly paid for by clients, while others took a different approach, recognising the risks to the drilling contractor, particularly in difficult hydrogeological environments, and citing examples of the inadvertent problems caused by non-payment–particularly with respect to reductions in construction quality. During the course, some participants changed their opinions on this subject.

Drilling supervision was discussed widely, with reflections on who should supervise, noting that in some cases there may be more than one person/institution involved, with overlapping responsibilities, while in other cases drilling supervision is being neglected. Stories of supervision shared from several countries highlight staffing shortages vis-à-vis need, a lack of skilled supervisors, the practical difficulties of undertaking supervision in remote areas, inadequate logistics, a lack of budgeting for proper planning and supervision, travel restrictions due to security concerns and corruption. Comparisons between full time and part time supervision were made, and while full time supervision was recognised as desirable, funding realities and attitudes of management, political leadership or donors mean that part-time supervision is more common. In several countries, borehole cameras are rare or not available at all. There was recognition that communities can support drilling supervision, but that this needs to be handled with care, and while they can record what is taking place if given enough information, that communities cannot replace professional supervision. Encouragingly, there are also good practices of drilling supervision, including oversight of junior staff by experienced supervisors, examples of clearly defining the milestones for part time supervision and making good use of checklists. There were several calls for more training on supervision to take place.

The sharing of information on the institutional (and legal) framework provides insights into the status quo within several countries, although the information is not comprehensive and it has not been verified. Notably, many countries have set up protocols, policies and regulations that are in line with the principles of cost-effective boreholes that the Rural Water Supply Network (RWSN) published in 2010. However, with few exceptions, the level of implementation and compliance with regulations are low. Zambia, Uganda, Malawi and Kenya show great efforts and progress with Trinidad and Tobago standing out in terms of licencing and training. As a federal country, particular states in Nigeria, including Lagos and Kaduna have set up regulatory commissions. In sharp contrast, Somalia, a country facing ongoing conflict is being left behind. Zimbabwe and Bangladesh were shared as example of countries with regulations in place, but challenges in getting them widely known and enforced. In many countries, the situation is mixed. Examples were shared of NGOs and specific development agencies adopting good practices on their projects, while public sector projects being plagued by corruption. Guidelines and standards for borehole drilling exist in several countries. Participants from Yemen, Lebanon and Cameroon were vocal about the need for these to be developed.

Although the courses did not deliberately set out to elicit information on the drilling industry, some caveats of information were shared from Ethiopia, Lao PDR, Sierra Leone, South Sudan and Zambia. It is worth noting that each country has its own particular history and context, and that this needs to be taken into consideration when striving to improve professionalism. Participants shared that manual drilling is common on Bangladesh and Nigeria is being piloted in South Sudan and has potential in parts of Mozambique.

Private drilling companies face challenges with respect to finance (estimating costs and determining prices, cash flow, bank guarantees and payment delays), staffing, management, equipment maintenance, competition, time

delays in project implementation, as well as challenges entering the market. However, there are experiences of businesses being supported with loans, tax relief, accessing equipment and quality materials. Drilling associations are considered a potential way of improving professionalism, and participants noted that they have been established in Chad, DRC (manual drilling only), Kenya, Mozambique, Nigeria, Thailand and Uganda, whereas in many countries there are none.

According to participants, there are weaknesses in the skills, knowledge and experience of staff responsible for siting, drilling, supervision, data collection (especially by drilling contractors) and project management in many countries. People tend to enter the drilling industry without any formal practical training and thus learn on the job.

Challenges with respect to drilling in conflict, emergency and humanitarian contexts include planning, getting to the field, risks of losing equipment, fluctuating funding and conflicts between host and displaced persons. In countries that have faced protracted crisis, human and equipment capacity can be very low.

Having taken the course, engaged in dialogue with others and reflected on their own contexts, participants have ideas for specific actions that they can take as individuals, or which can be done by their respective organisations.

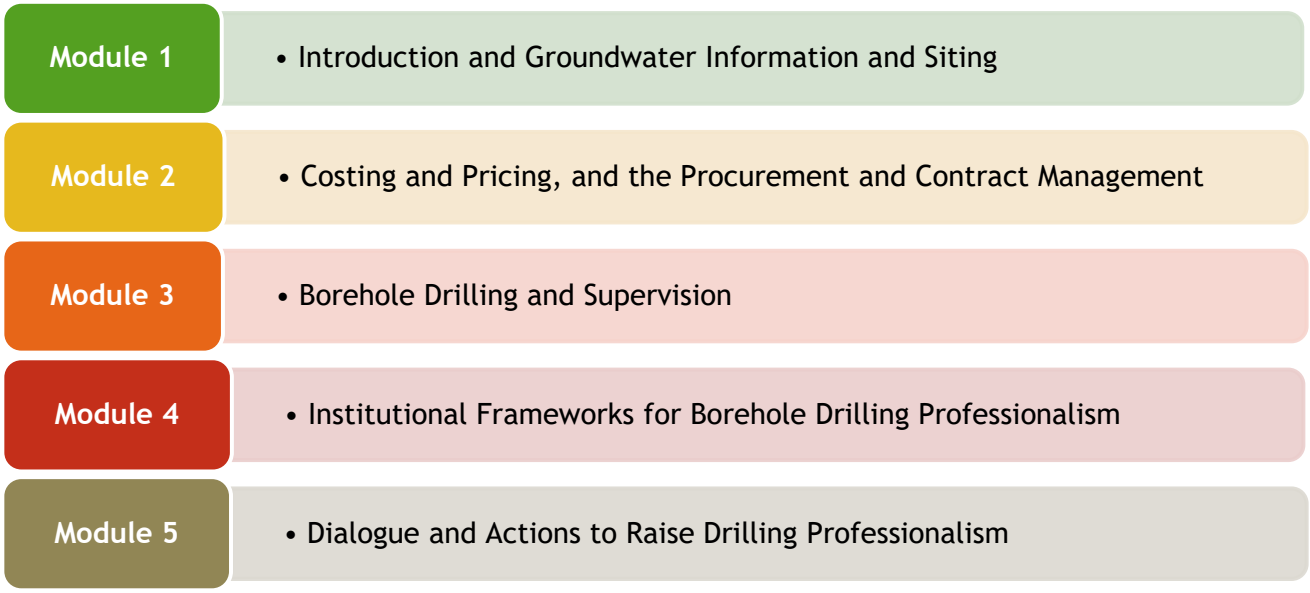
Despite the immense challenges presented the willingness to engage in dialogue and actions that gives cause for hope. As put so eloquently by Dotun Adekile, a course facilitator: "*The sustainable groundwater development conversation has been on for decades and will continue beyond our times, but we must make our own contribution - we must continue to advocate for good practice*".

Every action – every attempted action to improving drilling professionalism counts.

Introduction

Skat Foundation, together with UNDP Cap-Net have managed and hosted two online courses entitled "**Professional Management of Water Well Drilling Projects and Programmes**". The courses, which took place in 2018 and 2019, have enabled 181 participants, working in at least 50 countries, to learn more about this important topic. The course provides participants with the opportunity to learn about good practices, while enabling them to reflect on the way things are done in their respective organisations and countries. The five course modules (Figure 1) build up to a final assignment whereby participants engage in dialogue with others and explore actions to improve borehole drilling professionalism by themselves, within their own organisations, or more widely by local and national authorities in the countries that they work.

Figure 1 Course modules



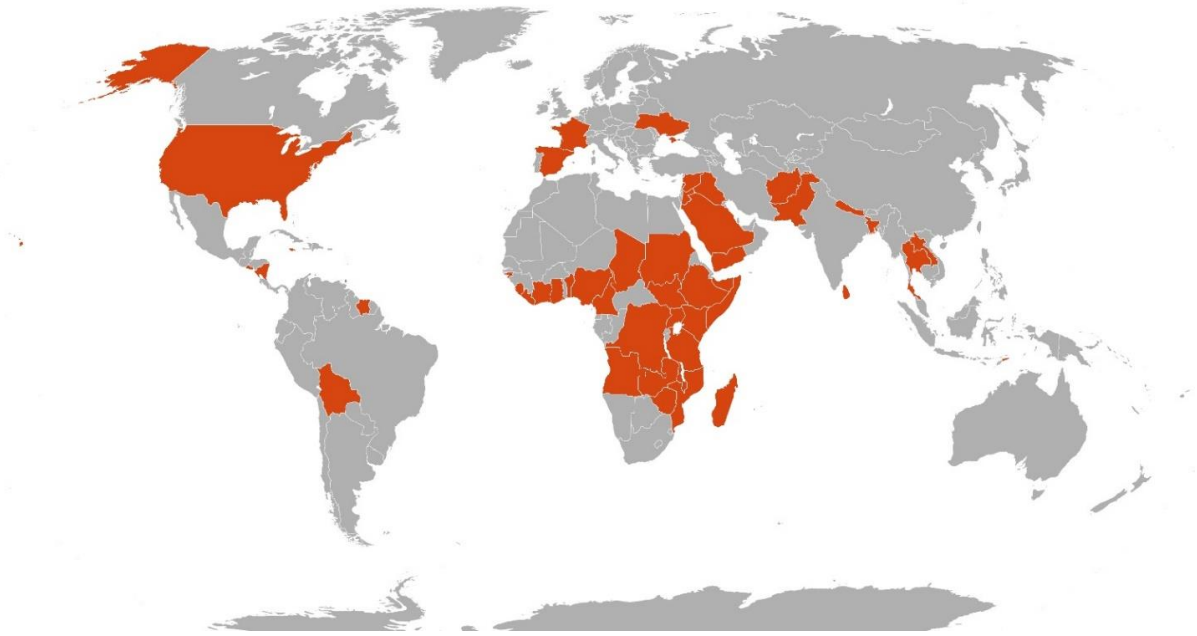
One of the advantages of this online course, in opposed to short face-to-face training, is that it reaches across countries, and all of the inputs by participants were written down. Each module includes a forum discussion and assignments. The postings and submissions provide a rich source of information, much of which is not currently documented elsewhere. For the 2018 course, the content shared by the participants was synthesised and incorporated into the course report (Danert and Theis, 2018). This report informed at least two academic studies (Liddle, 2019 and Garcia Silva, in press). However, the report title, which emphasised the course, meant that the information about groundwater in different countries remained largely unknown by a wider audience.

This report focuses on the information that was shared by the participants. It synthesises the observations, examples, insights and opinions made. It has been written for those working on groundwater who want to know more about policies, practices and perspectives in drilling and groundwater from around the world.

The information presented is drawn from assignments and the online discussion forums of the five modules of the 2018 and 2019 courses. The year in which the information was shared is indicated in brackets after the quotes (e.g. 2019 refers to a participant of the 2019 online course). The report was compiled manually by the author drawing on grounded theory analysis, a social science research method. It is very important to note that the information shared by participants has not be verified through additional studies.

For more detail of the courses themselves, including the methods used, facilitation, participant engagement and course results, see Danert and Theis (2018) and Danert (2020).

Figure 1 Map of countries covered by this report



The report is structured to consolidate the perspectives and issues raised by participants on both courses into distinct topics:

- Chapter 1 (supported by Annex 1) draws together data and perception of the reliance on groundwater for drinking water supplies.
- Chapter 2 provides some insights into Self-supply, an issue that was not explicitly covered in the course, but which was of importance to several participants.
- Chapter 3 sets out reflections on the use of groundwater data, and (together with Annex 2), provides a resume of the countries for which course participants stated that groundwater databases exist (or not).
- Chapter 4 summarises information shared on difficult hydrological settings as well as specific concerns about groundwater.
- Chapter 5 describes attitudes towards, and experiences of borehole siting.
- Chapter 6 summarises participant inputs regarding procurement and contract management, including a section on corruption, the 'four steps to better drilling contracts' that are central to the course, dry (or failed) boreholes and payments. Annex 3 consolidates reflections on adherence to the four steps from participants that systematically reflected and reported on them.
- Chapter 7 focusses on drilling supervision, drawing together the perspectives and experiences on aspects including who supervises, borehole cameras, supervision challenges and community support.
- Chapter 8 synthesises information on the institutional and legal framework, which is also summarised in tabular form, country, by country in Annex 4.
- Chapter 9 looks specifically at drilling, and covers the drilling industry, running a business, drillers associations and manual drilling.
- Chapter 10 provides a synopsis of specific capacity concerns and ideas that were raised.
- Chapter 11 draws together inputs that were made with respect to drilling in conflict, emergency and humanitarian contexts. Although not a core part of the course, participants frequently alluded to the particularities of working in such situations.
- Chapter 12 touches upon the dialogue undertaken and actions proposed by participants to improve drilling professionalism. These are further Annex 5 and 6.

1. Reliance on Groundwater for Drinking Water Supplies

Estimating the proportion of the population relying on groundwater in the country is one of the first questions posed on the course. In cases where groundwater reliance was estimated, there were at times considerable discrepancies between estimates and data from national surveys (e.g. Box 1). Participants were encouraged to look up the specific country table on the website of the Joint Monitoring Programme (JMP) of WHO/UNICEF[1].

Box 1 Examples of discrepancies between national survey data & perceptions of groundwater dependency

- *"Following collapse of central government in 1991 and subsequent collapse of public water systems, majority of population rely on ground water sources (about 80 – 90% – my own estimate)"* Participant (2018 Course), **Somalia**. This does reflect the 2016 Somalia High Frequency Survey, which estimates that 11% of the population rely on groundwater point sources, even considering that the trucked water (serving 23% of the population) may also rely on groundwater.
- *Discrepancies with respect to the data for **Yemen** (2018 Course) were shared with the World Health Organisation (WHO), which compiles the Joint Monitoring Programme (JMP) Data:*
  - Question to JMP: *"A participant from Yemen estimates groundwater use in the country to be significantly higher (70-75%) rather than the survey estimate of 37%".*
  - JMP response (abbreviated): "*Good to hear that the survey data are leading to some interesting discussions. The Yemen Country File[2] indicates that the most recent data source we had was the 2013 DHS survey which indicates e.g. 14.6% of the population using improved wells, and another 22.3% using unimproved groundwater (springs and wells). The results of this survey are similar to the previous household surveys in the country file (NSPMS 2013, MICS 2006). It's important to note that in these surveys people are asked what the main source of drinking water for their house is, and it's possible that people use a non-groundwater drinking water source (e.g. bottled water, 10.3% of respondents, or tanker truck deliveries for 14.1% of respondents) while still accessing groundwater for other purposes. Our data files don't collect this level of details, but the published reports sometimes do. Unfortunately the attached Yemen DHS 2013 report shows that the survey didn't ask about use of non-drinking water sources. And of course … the surveys can't provide information on the source of water used for piped systems, so again if piped supplies (about 30% of the population, from DHS 2013) are drawing on groundwater resources, that wouldn't be reflected in the survey data.*
  - Response by participant from Yemen *"We in Yemen have lack of updated data on all kind of surveys, which is causing inaccurate information. As I explained… Yemen does not have many sources of water such as rivers and lakes, so if 37 % of people using groundwater, which is the only water source for water, from where the remaining 63% of people getting their water?*
- *"In my county **Yemen**, it depends on the geographical location as coastal areas depend 100% on groundwater and mountainous areas varies as they depend on groundwater, surface wells, springs and rain water"* (2019).

A challenge across the globe is that comprehensive data on groundwater reliance for drinking or other domestic uses is not readily available. Data is only available for a few cities (Adelana *et* al, 2018; Foster *et* al, 2018), and there are studies providing insights into private borehole use in some peri-urban areas (e.g. Grönwall, 2016; Chakava et al, 2014. Nganyanyuka *et al*, 2014 and Nyarko *et al,* 2008).

Most national surveys and censuses data on the use of groundwater point sources (i.e. springs, wells and boreholes) focus the main (or primary) source of drinking water for a household. Figure 1 presents this data for rural sub-Saharan Africa populations. Annex 1 provides data for all countries. Unfortunately, this data does not

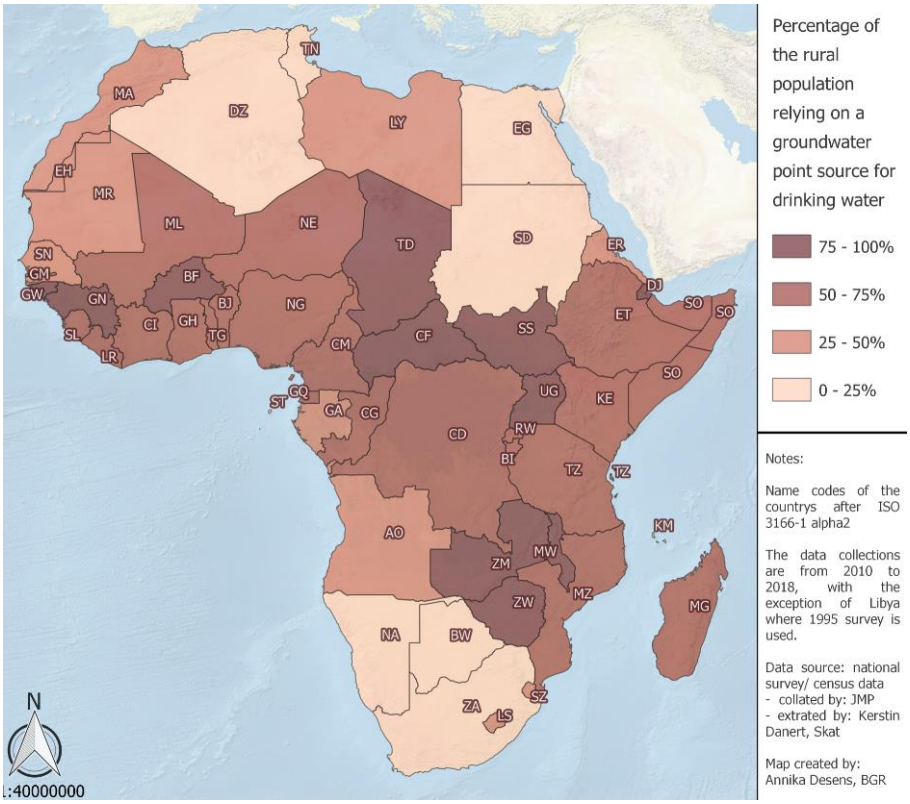
[1] You can access the Joint Monitoring Programme (JMP) Country Files on: https://washdata.org/data. Click on map to select country, download "Country file", and see the "Water Data" tab.

[2] https://washdata.org/data/country/YEM/download

provide a true picture of groundwater reliance for two main reasons: (i) Secondary or backup sources are not included and (ii) the data does not show the extent to which groundwater is used for piped supplies or packaged water. Both of these may be considerable, as noted by course participants:

- *"A publication entitled 'Water Resources Assessment of **Jamaica'** carried out by the U.S. Army Corps of Engineers Mobile District and the Topographic Engineering Center, suggest that 92% of the water piped to all sectors (agricultural, domestic, industrial and tourist) comes from ground water resources"* (2019). See Millar *et al* (2001) for more details. This does not show on the survey data (Annex 1).
- In **Lebanon**, drinking water supply is mostly based in groundwater, but there is no specific reference to this as water establishments so not report on the source, and the National Water Strategy (2010) does not include such detailed information related to the source (2018).
- "*Based on JMP data in 2016, 51.5% of drinking water in **Thailand** is packaged water which is similar to the data I have seen from National Statistical Office. I know that the big source of water they use for bottled water is groundwater*" (2019)
- In **Trinidad and Tobago,** approximately 32% of the national water supply comes from Groundwater[3]. The dependence on groundwater in the country has increased significantly (2018).

Figure 2 Percentage of the rural population relying on a groundwater source for drinking water in Africa



In the 2018 course, two participants noted a change of interest in groundwater:

- In **Bolivia**, water from aquifers is exploited in the eastern and very eastern areas (Chaco), where there are no glaciers. The water crisis in La Paz in 2015 led to the exploration of wells and aquifers as an emergency measure. The interest in groundwater in the country is growing, but from mid-2017 to early 2018 the rains intensified and the lagoons filled and low temperatures allowed the glaciers to freeze, which has relaxed the need to consider groundwater for the time being.

[3] Water and Sewerage Authority, Water Resources Agency's Groundwater Master Plan 2013

- Maputo, **Mozambique** (population 1.2 million) – water authorities are planning to drill 46 boreholes in different areas of Maputo to mitigate the water shortage that experienced due to low rainfall and reduced volumes of water in the Pequenos Libombos Dam.

2. Self-supply

Self-supply, i.e. households taking care of their own water needs, was not explicitly part of the course. Self-supply provision is rarely reflected in national statistics but was mentioned by participants:

- In **Afghanistan**, "*the water supply of about >85% inhabitants depends exclusively on local, individual groundwater sources, obtained predominantly from deep wells by water pumps and shallow aquifers, mainly, by hand-pumps… inhabitants in urban areas are have local individual groundwater sources at their house premises for domestic and small agriculture uses. … in rural areas during the drought season in 2018, people [used] groundwater for agriculture where the water table [dropped]"* (2019).
- *In Kathmandu (**Nepal**) "although there is the piped water supply which is intermittent, most of the household have their own boreholes for other domestic use. … individual boring doesn't require any permission and hence do not have any institution managing these records"* (2019).
- In some parts of **Sri Lanka**, *"there are individual households with boreholes on their land installed with motorized pumps. This is one of the threat the authorities are concerned"* (2019).
- *In **Timor Leste** ground water potential is yet to be understood. … there are some deep tube wells and all of them have been built by development partners. But in the capital Dili many households have their own shallow ground water source mainly for non-potable purposes. There are no dug wells but pumps directly fitted to shallow borehole and these are done at the expenses of the house owners. Observations show scaling and salinity in this water. We are trying to help government build better standards on utilizing multiple water sources and lack of data on availably and quality remains a challenge"* (2019).
- In **Zambia**, "*in larger urban areas with its many unplanned settlements where boreholes are often in very close proximity to septic tanks and pit latrines"* (2019).
- **Zimbabwe**:
    - *"in urban areas [in **Zimbabwe**], the situation is being exacerbated by … the provision of adequate amounts of treated water for the growing urban populace which is now turning to more local means of finding water."… The Environmental Management Agency published an article highlighting the issue of groundwater pollution advising against using ground water for drinking purposes[4]"* (2019).
    - In ***Zimbabwe**, "cities … are currently experiencing water supply challenges … and currently relying heavily on groundwater, especially the City of Harare with more than 4 million people"* (2019).
    - The situation prevailing on the ground in **Zimbabwe** is *"individual boring doesn't require any permission and hence do not have any institution managing these records" as nobody follows the regulation and the Zimbabwe National Water Authority (ZINWA) does not have capacity to monitor these individual borings.*
    - Farmers contract drillers to drill on their farms, but they do not have knowledge on how to supervise the drilling of boreholes (2019).

Lack of knowledge by individuals about what constitutes a good quality borehole, and what it realistically costs to drill, coupled with the desire for a low price can be problematic, with long-term implications, e.g:

[4] https://www.ema.co.zw/index.php/238-threats-to-underground-water-contamination.html

- *"Private organization such as house owner, private company etc. … squeeze the driller work for a low price. Sometimes, client offer low price borehole and they do not consider quality; hence, driller reduces some work such as gravel packing, well development, back filling. It … reduces the quality of borehole. As a result, such borehole's life period is very low and it does not give desired discharge and quality of water"* (Nepal) (2019).
- **Kenya***: "When customer wishes to spent less they tend to use less qualified drillers who do not employ professionals but rather engages less qualified crew on site who have got no idea of what they are doing, no drillers logs are taken, documentations of struck aquifers is neither done. When it comes to borehole construction, it is purely guess work where screens and casings are alternated … regardless of formation. At the end of the day the work is compromised and poorly done"* (2019).
- **Kenya** *"It is crucial to conduct awareness for the general public on professional groundwater development, provide guidance on costs for borehole drilling in different areas, and have framework to hold drillers who cheat their clients to account"* (2018).

By regulating the drilling industry, **Zambia** is trying to address this problem: "*before the introduction of ground water regulation, most drillers were doing short cuts. The prices were very low, borehole were only cased up to 12-15m, poor gravel pack was used (quarry dust instead of course sand), development was poorly done and in most cases no Test pumping was carried out. No sanitary seals were installed resulting in easy pollution of borehole water especially in places like Lusaka. This was worsened because most clients were going for cheap drillers who were not regulated*" (2019).

3. Groundwater Data and Groundwater Database

Participants recognised the use of groundwater data from hydrogeological and geological maps, and records of previous drilling activities as extremely important. However, many participants stated that getting such information could be very difficult. This reality is exemplified in the following statements:

- *"it is so disheartening sometimes that resources are spend drilling in areas where there is poor groundwater potential, missing those areas where the resources may be utilized to tap available water, which can be used to even cover those areas without (2019)".*
- **Timor-Leste**: While ad hoc groundwater extraction from shallow unconfined aquifers is common along the coastal belt, there are only a few examples of groundwater access though deep confined aquifers. Hence, if groundwater is properly mapped and utilized there would be a dramatic change in water availability and quality to help realize safe water as defined in SDG 6 (2019)

Participants from Bangladesh, the Democratic Republic of Congo (DRC), Ethiopia and Nicaragua as well as Trinidad and Tobago share their experiences of groundwater data (or lack of it):

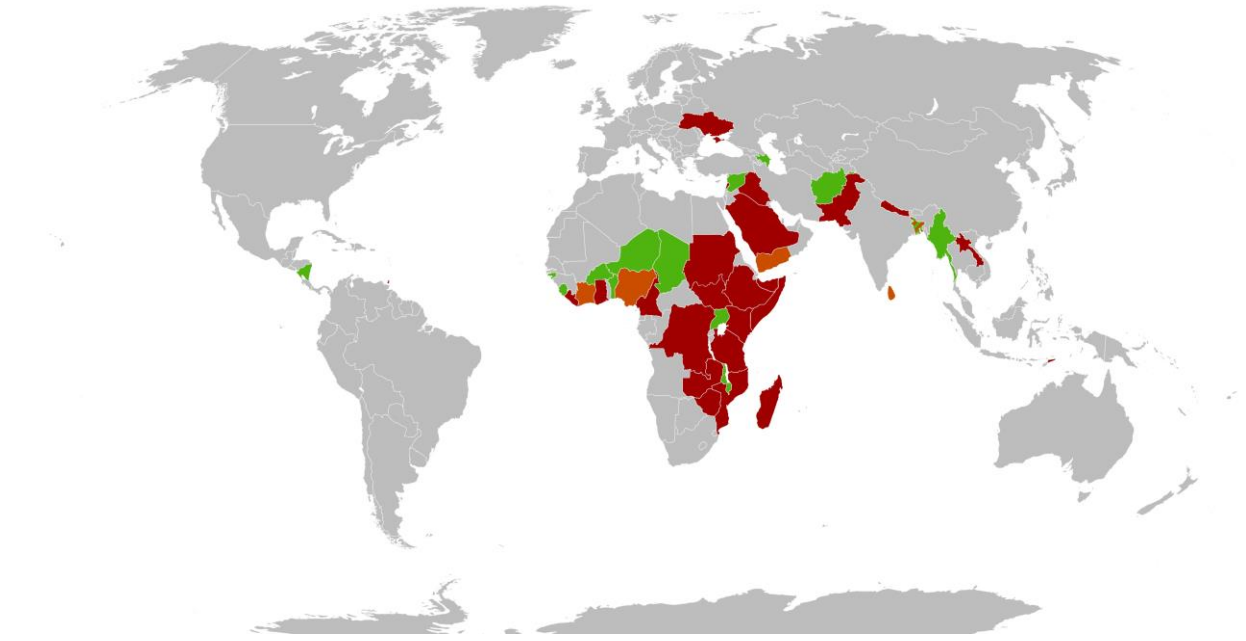
- "*I had drilled 300 hundred DTW and STW in a part of **Bangladesh** (Sylhet). I was working as manager. I have gathered all the boring data. filed it into 4 copy. I have shared one to local DPHE (Govt. body for Water and sanitation), One copy to Chairman of the union, One copy to the user group and one copy for the official record. These 300 hundred water point representing the hydrogeological situation of the two upazila (sub district). Now DPHE and any other NGOs and Chairman are using the data for ongoing new water point installation work. It is really a good experience for me*" (2019).
- *"[For Coxs' Bazar, **Bangladesh**] there is lack of reliable data on ground water potential and this affects proper siting to ensure productive boreholes, [for the refugee settlements]* (2019).
- In **DRC**, "*The challenges [we] and the driller [face] are that in some area[s] there are no information available about the geology and hydrogeology of the drilling site. This can lead to issues when elaborating the costing and in the field during the work as it can be deeper than expected hence a change in specification*

and cost. Sometimes, the information are available but the published paper is not accurate enough having the contractors to estimate cost. The more information about the hydrogeology of the sites the better to avoid these kinds of conflicts later" (2019).

- In **Ethiopia**, *"At regional as well as regional level data management for the boreholes are not well done and missing in most of the cases. …geologists and hydrogeologists do the proper well log on the field and submit their report to the concerned department. However, in most cases as the documentation is very poor those data you do not get after a year unless you get from that expert who did [it]. … Some times that staff may have changed office or lost the data in such cases we loose everything"* (2019).
- *"The main problem that we face [with siting] is lack of data… data obtained throughout the drilling is not public… companies to not allow access to the information"*. The most critical communities (without a water supply system) are in the central and Atlantic regions of **Nicaragua**, but no groundwater studies have been carried out, and so basic data is lacking (2018).
- In **Trinidad and Tobago**, there is a *"blame game where every time someone is looking for data with respect to wells, persons have to search throughout the organisation to find it, and nobody has it, most times you are sent on a wild goose chase"* (2018).

Lack of a centralised borehole database or inventory makes it difficult for new drilling projects to learn from pervious experiences. One of the questions in the discussion forum module 1 (in 2019 only), and in Module 5 (both years) was whether a groundwater database exists in the country. Responses were obtained from participants in 42 countries, in which 14 (33%) a national database exists and 23 (55%) do not. In five counties (12%), participants had different opinions as to whether a groundwater database exists or not. The latter illustrates that that even if a groundwater database exists, it may not be well known, used, or the database may not be considered useful at all. Alternatively, participants may believe the something is a groundwater database, when in fact it is another type of database, e.g. for surface water or water points. There are also cases where, for strategic reasons, borehole databases are only available for government staff. The responses summarised above are visualised in Figure 3 and detailed in Annex 2.

Figure 3 Response to question - Is there a national groundwater database in your country? (2019 Course)



Discussions also touched on the "*best way to bring together data on groundwater from … students of higher institutions*" (2019):

- *"Consider partnering with Universities … and ensure that sharing research is one of the conditions"* (2019)
- Continue *"to advocate that academic studies on groundwater be put on the institutions' websites so that they are available to the public* (2019)".

4. Difficult Hydrogeological Settings and Concerns about Groundwater

Providing water in hard-to-reach or difficult hydrogeological settings can be particularly difficult, e.g.:

- *"One difficulty we have is the challenging hydrogeology in areas where some of the hardest-to-reach, marginalised communities live. Sometimes the hydrogeological data is not available to inform siting/drilling which can affect the yield of boreholes and the water quality. We have recently had one instance of high fluoride concentrations in very deep groundwater. This is a challenge if shallower groundwater is at greater risk of microbiological contamination. How to balance these two issues?"* (2019)
- Lack of willingness of the client to offer direct financial compensation for drilling dry boreholes in high-risk areas "*has resulted in the cost of drilling for NGOs being very high per borehole … One borehole we drilled … to 95m and very low yielding … the contractor refused to drill another one arguing the water was enough. Mediators had to be brought in to solve the dispute … At the end … the borehole was accepted with its low yield because, the project was in its final month of implementation and the driller was arguing he could not drill another borehole* [without] *… a variation … on the cost, [which] the NGOs side could not allow. The community was left with a very low yielding borehole, that had high chances of drying out completely in the drier months of the year. … Past experiences from records indicated that this was a high risk area, but that was not considered in the bidding process",* **Zimbabwe** (2019).

However, there ways to address this problem were also shared, e.g. "*Since no parties willing to take the risks of drilling dry boreholes in high-risk areas, I think it would be better to separate the task of sitting and drilling work, and sitting companies should take the role of supervision. This will allow each contractor to be more responsible for their given task and increase high chances of finding wet boreholes*" (2019).

Specific geographic areas cited as particularly challenging with respect to the hydrogeology are:

- In **Bangladesh**, *"some part of Sylhet, Jessure, Narail ground water is contaminated with high concentration of Arsenic, Iron etc."* (2019). *"High arsenic in sources … is a widespread issue in Bangladesh, but arsenic concentrations vary from region to region and also with depth in an aquifer (concentrations are often much higher in young shallow alluvial deposits), so siting by experienced hydrogeologists is very important* (2019).
- *"Chattogram District [**Bangladesh**] which is a coastal district and saline water intrusion is one of the major concern in that area in aquifer* (2019). *Shariatpur District [Bangladesh] … is a river erosion region and saline water interruption is one of the real worries around there in the aquifer* (2019).
- *To overcome the challenge of salinity in the North of **Chad** (Lake Chad basin), we attempted to use a conductivity meter during drilling of a borehole and we could measure the conductivity at every layer of soil as we drill (the drilling was done manually using percussion techniques)… due to the high level of salinity it was agreed with WASH partners to recommend a borehole with less or equal to 3000 µS/cm regardless of the WHO standard of 2500 µS/cm so as to cover for the water demand in those areas* (2018).
- *"As the great Rift valley is passing through our country [**Ethiopia**] we are having very complex geologic formations in which we are facing great problems in drilling"* (2019).
- Across the Turkana County, **Kenya** there are huge potential along the rivers but high salinity and fluoride have been identified as the key water quality issues when drilling boreholes. In the area of Kerio, there are high chances of high salinity boreholes (2019).

- *"In parts of **Kenya**, groundwater is saline and mostly steel pipes are used for casing of the boreholes. The steel casing will rust due to saline water and therefore will not last longer only for 2 to 3 years"* (2018).
- *In Kambia district [**Sierra Leone**], some of the boreholes have been abandoned by the community people due to the present of iron and manganese in the water* (2019).
- *"**Sierra Leone** is underlain by Precambrian Cratonic rocks of the Archaean Basement Complex making it difficult to access ground water. Generally, this makes drilling a borehole is very much expensive in the country. The cost between $10,000-$15,000 USD"* (2019).
- Siting of boreholes has been very challenging in the areas of Eastern Equatoria, **South Sudan (2018)**.
- *"In Khartoum [**Sudan**], you, within a 2-3 km radius, you could either have good quality water or too saline water unfit for human consumption"* (2019).
- In **Sri Lanka**, *"Ground water particularly in the South Eastern, Eastern and North Eastern regions is known to have high iron content. Most of tube wells in these areas had been fitted with iron removing filters of which sustainability and quality had been a challenge. In the North Central region, ground water was known to have high fluoride content causing fluorosis among the consumers. In the Northern region salinity was the main challenge as fresh water lens is known to be floating on brackish water floating across limestone aquifer".* (2019)
- *"In **Syria**, the main risk we faced is the level of water table is not stable as it depend on the rain season rate, for example some boreholes have abundance of water this year might not provide water next year if it is dry season"* (2019).
- **Timor-Leste:** *"Many cities where groundwater usage is high are near coastal belt thus the unregulated extraction has resulted in salinity due to sea water intrusion"* (2019).
- In **Trinidad and Tobago**, *"we always have to be cognizant of the fact that saline intrusion is a possibility… this occurred in one of the well fields where 12 producing wells saw their salinity increase to over the acceptable WHO standard for potable water. As a result, the well field was shut down for 15 years for it to recover.. the authority tries to avoid siting coastal wells but where they do, a number of observation wells must be drilled along with the production wells in order to monitor salt water intrusion*" (2018).

In contrast, one participant pointed out that In **Lao PDR**, groundwater "*can be found everywhere when drilling to 25-35m depth … [apart from] plateau area (to drill up to 50-60m depth).*"

Particular concerns about groundwater quality and quantity were raised by participants from Bolivia, El Salvador, Somalia, the USA and Yemen:

- Infiltration of pollutants into the groundwater is a concern in parts of **Bolivia**, particularly from the mining industry, of which remediation is difficult and costly.
- In **El Salvador**, *"deforestation is the main cause of drying aquifers" (2019)*
- **Benaadir** (covers **Mogadishu** with a population of 2.4 million), **Somalia** – mainly coral limestone geology, the population relies nearly 100% on groundwater. Following the collapse of the public water distribution system, which was based in high-yielding boreholes from neighbouring Middle Shabbele region, Mogadishu reverted to use un-centralized hand dug wells and small scale reticulated systems. The number of wells established within the city and groundwater abstraction has increased since the collapse of the government. AWD/cholera has become endemic in Banaadir region and is largely attributed to the use of contaminated groundwater sources. Water wells tap the shallow coral limestone aquifer, which is mostly contaminated. The absence of a sewerage system forces the majority of residents to rely in pit latrines and unlined septic tanks. According to various recent studies, there is also evidence of a growing trend of increase in electrical conductivity of water collected from wells in Banaadir, possibly due to sea water intrusion.

- **Sana'a, Yemen** is facing what has been described as a "race to the bottom", with "every man for himself" when it comes to capturing the remains of the decreasing groundwater resources in the city. The combined output of the 125 wells operated by the state-owned Sana'a Local Cooperation for Water Supply and Sanitation barely meet 35% of the growing city's needs. Concerns are being raised about the increasing pressure on groundwater, combined with falling water tables. Alas, data is lacking on groundwater withdrawals, storage, quality as well as aquifer characteristics. Meanwhile, there is a drive to pump large quantities of groundwater to sell.
- **Florida, USA** "*is surrounded by water with many lakes and springs … Most of the population believes we will always have plenty of water, and does not think about our aquifer. However, problems arise for coastal towns, which experience saltwater intrusion into aquifers, and for central towns above limestone formations, which experience sinkholes caused from cavitations from excessive withdrawals. The public trusts the engineers and municipalities to manage these problems and minimize breaks in water access*" (2019).

5. Borehole Siting

Participants extensively discussed who should be responsible for siting, and when it should take place. The online course promotes the practice that reconnaissance and siting, as well as engagement with the end users should be carried out before a drilling and pump installation contract is prepared.

Participants reported on practices of siting by the client, and practices of siting by the driller. Siting practices vary between countries, and organisations, with some contracting out the siting separately, and others including it in the drilling contract. In cases where the driller sites the borehole, the driller usually directly bares the cost of a dry well. An example from **Zambia**: *"… when the contractor does siting, we hire an independent supervisor to supervise the works. This is done especially that we don't pay dry boreholes. we only pay for wet boreholes meeting the minimum specified yields"* (2019). It was noted that while it is better for the programme management to know all the drilling sites in advance, which also helps detailed budgeting, the disadvantage is that there are more contracts to manage (i.e. siting, drilling and supervision).

The main challenges put forward with respect to borehole siting were inadequate skills and knowledge, a lack of professionalism, lack of equipment and challenges of working in insecure contexts (Box 2). Concerns about capacity have been mentioned in relation to many aspects of borehole drilling management, and this crosscutting topic is discussed in chapter 10 and security challenges are included in chapter 11.

The importance of addressing land issues in the planning stage was raised by participants, e.g. "*the land owners claim that they sold off the area to drill but without access road… [and another] land owner wanted to be compensated 100% before the driller can start work*" (2019).

Box 2 Main issues raised with respect to borehole siting

Inadequate Skills and Knowledge

- *"most people who site wells and boreholes are not really conversant with siting"* (**Zambia**) (2019)
- *"In most instances, the siting is not carried out appropriately and even where it is carried out well, the interpretation is very poor because of proper understanding of what the results actually mean* **(Somalia)** (2019).
- *"most… involved in conducting surveys for borehole siting and drilling are mostly not trained in this regard … no proper knowledge of geology/hydrogeology"* (**Nigeria**) (2019).

Professionalism

- *"Professional activities carrying out, upstream, by hydrogeologists and some investigators – before, during and after borehole siting and drilling – need to be given more attention concerning aspects of capacity building*

and more financial/material aid….borehole siting and drilling are extremely linked to professionals of groundwater to avoid premature failures" (**Cameroon**) (2019).

- *"Some of the main challenges we face [across **southern Africa**] is the poor professionalism of some of the drilling companies we work on but also the very inefficient ways of monitoring, contract allocation and borehole approval. So for example we see poor construction and inadequate monitoring by partners which leads to borehole approval with poor quality"* (2019).
- *There is concern about the validity and reliability of drilling data in **Malawi** (2018)*
- *One driller in **Somalia** estimated that less than a quarter of drilling activities are based on professional-grade hydrogeological, geophysical and environmental assessment/studies. (2018).*

Equipment

- In **Malawi**, "*not many private organisations have geophysical survey equipment" (2018).*

Security

- In **Somalia**, "*security factors constrain ability to fully follow a logical approach to siting, [with the need to] minimise exposure [and time] for consultant teams in the field … in insecure areas. [This] affects quality of the [drilling] works and success rates*" (2018).

6. Procurement and Contract Management

The course module on *Costing and Pricing, and Procurement and Contract Management* is structured around *four steps to better drilling contracts* as set out in RWSN's 2014 publication **Procurement and Contract Management of Drilled Well Construction. A Guide for Supervisors and Project Managers** (Adekile, 2014); and animated video (RWSN, 2016). The four steps are summarised in Figure 4. This clear and systematic approach was appreciated by participants, e.g., *"The Government should support the establishment of central procurement guideline that considers in detail all the four steps shown in the video*" (2019). Notably most countries have their own government procurement guidelines. The importance of communication was noted, i.e. "*Establishing and ensuring the continuity of regular communication between the contract sides – especially the client and the contractor during the contract lifetime*" (2019).

Participants of the 2018 course emphasised the importance of (i) pre-qualification, (ii) understanding bidding documents, (iii) communication, (iv) separate siting and drilling contracts, (v) trying to reduce distances between boreholes constructed within one project to save time and reduce travel/transport costs, and (vi) third party monitoring (Box 3).

Box 3 Important aspects to consider in contract management (2018)

i. **Prequalification** is done at an early stage, involving checks and verification of company details, history, equipment and personnel by the procurement section before being approved by the Authority.
ii. Bidders **failing to understand** the bidding documents, especially the technicalities involved and tending to make mistakes, which results in the rejection of the bids; incomplete bid documents or a competent contractor submitting bank statement instead of bank guarantee and being disqualified.
iii. The advantage of **regular meetings** between drillers and the client to avoid misunderstandings; we always have communications with the contractor; of recent, monthly contract performance meetings have been introduced for review of progress of work by all stakeholders..
iv. **Separation of siting of the boreholes and drilling contracts** ensures the responsibility of dry/low yielding boreholes of poor water quality is not transferred to the driller.
v. **Reducing the distance and travelling time** between borehole sites can save money, make supervision easier and less hazardous. If the work is in similar geology it will may require identical drilling techniques.
vi. The importance of a third party consulting firm to undertake **supervision and rigorous evaluation**.

Specific in-country challenges relating to insufficient expertise or staff, unrealistic deadlines and long-term monitoring, are summarised in Box 4. Forum postings and assignments frequently referred to low capacity and lack of resources for effective supervision. Challenges with site accessibility due to rains or the community not allowing their gardens/farms to be passed through were also mentioned in a few cases. Problems of low staff moral were mentioned by participants from several countries as affecting procurement and contract management (2018).

Box 4 Specific in-country contract management challenges

- Staff at DG-Eau/**Benin** lack means to go to the field regularly for supervision, even at decentralised level (2018).
- In **Ghana** all government organisations are mandated to comply with the Public Procurement Act (Government of Ghana, 2003). By law, every project has to be advertised in the newspapers for an expression of interest, not less than two weeks before the submission date. It is an enormous burden on contractor and consultants to meet the deadline of 14 days (2019).
- Supervision in **Kenya** is challenged by inadequate transport and allowance to enable fieldwork (2018).
- Lack of professionals (hydrogeologists) to cover the demand in **Nicaragua** (2018).
- Experience by drilling contractor in **South Sudan**: There is no enough time to visit the site and see the locations to be drilled, the tender document has no design or other details and worst with NGOs where there is no enough time to prepare all necessary documents due to very short deadlines given by the donors (2019).
- The Dams Implementation Unit (DIU), **Sudan** in charge of water infrastructure in the country is relatively new and lacks expertise in hydrogeology/groundwater to properly plan, design & supervise implementation (2018).

Box 5 summarises other challenges for procurement and contract management from the client perspective.

Box 5 Additional challenges and solutions

1. In the case of **emergencies**, procurement plans may have to be rapidly revised (2018).
2. The usefulness of **Long Term Agreements** with construction service providers that are pre-qualified and judged to be competitive (2018).
3. The importance of **assessing the financial capacity** of contractors as the contract work is paid in repayment mode (2018).
4. The difficulties encountered by **district government staff** responsible for daily supervision, but who may not have the contracts, no authority over payment, and so cannot hold contractors accountable in the field; lack of resources for central government staff to go to the field (2018).
5. Selecting technically competent but foreign consultants (i.e. who do not come from the project areas) presented a challenge as they required **security escorts** to undertake their assignment (2018).
6. The **lengthy nature of the procurement and contract award process**; cumbersome processes that only allow contractors to win one lot, but they tender for many; the paper work takes a lot of time; the administrative slowness; development of a plan and delays in funding disbursement (2018).
7. **Payment** (of contractors) on time is an issue in long duration drilling programmes, and is sometimes due to a lack of responsibility by the **funding agency** to provide financial resources on time (2018).
8. The challenge of paying to send qualified personnel to the field within the guarantee period **after the grant** for the actual construction has expired (2018).
9. The need for **special conditions** in the contract to ensure quality (e.g. hot weather concreting; what to do if it rains (2018).
10. Contractors bid with the documents of **qualified professional key** staff strength and equipment capabilities but at times when the supervisor goes to the field, they do not see qualified professionals and equipment on site (2019).

Corruption

The consensus on the module *Costing and Pricing, and Procurement and Contract Management* from participants' online postings and supported by assignments submitted (in 2019) is that corruption is a bane of progress in the sector, e.g.

- Corruption "*is a major challenge in all aspects of development and can destroy a nation*" and "*a thorn in the flesh with regard to the success of any given business with equal competitors who lack integrity* (2019).
- "*Many briefcase companies are being awarded drilling contracts because of corruption. Legitimate companies can barely compete"* (2019).
- *"Contractors who are politically in line of the government of the day are bound to win contracts even if they are not qualify"* (2019).
- *"The most serious challenge private drilling companies' face is the issue of corruption in the awarding of contracts"* (2019).
- *"The biggest challenge for private sector drilling businesses is balancing getting a contract and maintaining organizational reputation [because] of corruption pressures"* (2019).
- *"Corruption is the greatest challenge to securing of contract by competent organizations …most projects are shared among politicians as a patronage for their contribution during elections"* (2019).
- *"There are usually allegations of political interference and contracts awarded to contractors without the requisite capacity to deliver the desired results. Whilst these sorts of allegations do not often have … evidence, it is [common] to see contractors … fail to deliver quality boreholes. There are also instances of seeming collusion between procuring government partners and contractors. The result … (though lacking evidence) [is that] contracts [are] awarded to contractors with adequate capacity"* (2019).
- An audit of PPEA II in Benin, a programme funded by the Netherlands Government includes issues related to borehole drilling and its management (2018).

Table 1 provides examples of corrupt practices, as well as experiences and ideas to combat or minimise it.

Table 1 Corruption: a bane of progress for providing quality water supply services

What happens?	Experiences and Ideas for combatting corruption
• Government pre-qualification has become personalized. • Large bribes offered by non-competent firms; competition from established drilling companies who are ready to give "kickbacks", this makes it difficult for small enterprises. • "*if you don't give commission to the department or some representative to secure the contractor, then you will not be awarded the contract, it is very rare that contractors secure contract without giving 10% of the contract value*". • Uncompetitive pricing and high corruption by unscrupulous private drillers … affects mainly	**Improve transparency** • Strengthen transparency and information flows, improve mechanism of service accountability … bids should be opened and evaluated with the highest degree of water integrity. • Both the client and the drilling company should be transparent in their dealing. There must be mutual communication from both parties in which all the necessary and needed information to the procurement is made available at all time. • Enable bidders to witness the opening of the bids and take note of quotes to reduce the chance of evaluators tampering with the bid figures to favour corrupt companies. **Pre-qualification and due diligence** • There should be two levels of prequalification before bids are issued covering technical and financial capacities of the companies. A company should first be technically qualified and show evidence of funds to implement a contract. • Undertake equipment inspection as part of the due diligence exercise. The Procurement Committee verifies what was indicated in the bid document. The only challenge is some contractors may show good equipment which may be borrowed. **Registration and licencing**

those business that want to maintain professionalism

- Confidential information is released to a contractor for him to win the contract.
- Tampering of bidding documents after they have been submitted.
- [Recently] … the contractors also bribe the client supervisors so that they use below standard casings and may escalate the amount of gravel packed, the time they conducted well development.
- Senior staff and politicians responsible for contracting borehole drilling contract the works to themselves and later sub-contract to a real driller with equipment for less amount (as low as only 2/3 of the real value of the contract).

- Set national standards, policies making it mandatory for all private drilling businesses to be registered following a thorough assessment of the businesses.

Drillers association

- Set up of a self-regulatory body/association/institute of drillers to help with professional regulation.
- Consider companies with experience and team's expertise even if they are asking for more money than other ones during procurement procedures.

Inspection

- Close field monitoring and inspection has to be in place and to ensure a more sustainable of the project.

Penalties

- Enforce penalties for flouting the procurement act
- Make it illegal for anyone wanting to have a borehole drilled to use unregistered service providers.
- Fining and blacklisting supervisors who sign wrong certificates.
- Those that are still taking bribes should be dismissed and charged to court.

Salaries

- I think those who are monitoring the process to make sure laws are reinforced should be paid better[5].

Skills and experience

- I think having more skilled people within both local/international NGOs and government who understand what it takes to site and construct boreholes, and who can supervise their construction, would reduce the risk of corruption/cutting corners and costs.

Four steps to better drilling contracts

The assignment gave participants the opportunity to reflect on the extent to which the four steps to better drilling contracts (Figure 4) are being followed. Annex 3 provides a summary of select self-assessments of the four steps submitted by 17 participants.

Figure 4 Four steps to better drilling contracts

[5] "For instance, if I'm in charge of regulating laws and code of ethics for contractors and I'm paid like $200 [per month] and with high cost of living, I might take bribe in order to match up to the cost of living in the country. I have to pay for transportation, rent, utilities (water and energy), and medication and family responsibilities. Low pay is a recipe for bribery and corruption. Until Africa starts to pay employees better, we are probably wasting our time to talk of stopping corruption and bribery.

Procurement Planning (including cost estimation)

Participants shared that within their organisations, the procurement planning experiences were good overall. Estimating costs was recognised as challenging but extremely important, e.g., "*the drilling work was set based on our previous experience, thus does not really reflect the actual or current situation on the ground. I think it would have been better to spend more time to prepare cost estimation based on rapid market survey on the project site to reduce potential risk*" (2019). *"The contractors who are far below let's say 15% less than the Engineer's estimate should not be given work* (2019)".

Donor pressure to keep costs down to unrealistically low levels was also mentioned as leading to compromises, which has affected construction quality, e.g.: "*Cheap and unrealistically priced boreholes have often failed. The contractor tries everything possible to use substandard materials ranging from gauge of the casings and linings, to quality of gravel pack, shallow depth and poor mix ratio of cement to sand for the grouting. The level of supervision by the client is usually low in such conditions resulting in the delivery of substandard boreholes that soon silt-up or even dry not long after their completion and commissioning*" (**Nigeria**, 2019).

One participant shared a story about what can happen when there is a lack of flexibility within the contract with respect to borehole design, a problem that starts with procurement planning: "*The obvious weakness [we faced was] the lack of opportunity for redesign of boreholes after the award of contracts. There was a case of a site that the contract was based on estimated depth of 60 metres but on the conclusion of geophysical survey, the indicated depth to drill to aquifer was 250 metres. This caused the facility to be relocated from the original site and it did not go down well with the intended beneficiary* (2019).

In order to ease access, participants recommended categorizing drillers according to the volume or complexity of the drilling and ability to access sites (2018). A drilling contractor from **Uganda** explained: "*We need to bid for work in more than 50 districts, which is cumbersome and costly. Drilling operations should be clustered regionally and a contract framework for at least three years with varying annual rates to take care of inflation should be put in place*" (2018).

Contract Award

Pre-qualification

Pre-qualification of contractors is being undertaken by a sizable number of organisations, some of whom undertake inspection of their equipment alongside other due diligence measures. As an example, competence verification visits of drillers *"presented an opportunity to identify false, fictitious and fly by the night contractors. These do not possess any known verifiable address and they are not in possession of any kind of equipment whatsoever"* (2019).

Another participant stated, "*We do not systematically check all documents before the tender but we check if the company has a technical approval that is issued by the Ministry in charge of water and if it is still active. … we check the company's experience, technical skills of human resources, equipment. But these checks do not go as far as knowing whether the equipment is at the company or whether it will lease or subcontract with another company. This way of doing things does not allow us to avoid screen companies, because they can also apply without having all the equipment on their own which can lead to delays in the execution of works*" (2019).

To try to prevent corruption, *"my current organization insistence on a central procurement process starting a pre-qualification exercise that focuses on technical (skills and equipment) and financial stability. The new approach has reduced the incidences of corruption but [not] completely as such officers and officials still twist the hands of qualified contractors to implement some lots for the officers/officials (2019)".*

Pre-bid meetings

Pre-bid meetings between the client and contractors are a common occurrence, but not done by all. The following quotes illustrate the value of pre-bid meetings to two participants:

- "*I think the point of pre-bid meetings during procurement is also a good practice and an opportunity to get prospective contractors on the same page as the client with regards to expected outcomes and required standards… The pre-bid meeting will help to clarify expectations and contractors can factor this into the bids they submit and in the eventual borehole construction*" (2019)
- *"The pre-bid meeting is an essential component. It enables the clients to be asked questions that they may never have even thought of before, and also build formal communication channels, which are really important"* (2019).

Site visits

Going one step further, in one organisation, *"contractors were required to attend a compulsory site visit to the selected sites [where] discussions were held, minuted and all agreed changes incorporated into the tender document"* (2019).

Contract Management

The participants shared a wide range of experiences of their procurement and contract management processes, with some articulating considerable frustration at the status quo, others seeing scope for improvements, and some confident that their processes are very effective. Sub-contracting, whereby a company is awarded a tender, but then hires someone else to do the work was mentioned several times, particularly in Bangladesh and Nigeria.

From the perspective of the client, contract management can be very challenging, e.g. *"… some contractors quote very low prices during the tender process in a bid to win the contract on the basis of lowest bids. Once given the contract, they then proceed to take shortcuts like using chippings for gravel packing, sometimes slotting casings to serve as screens instead of using real screens, etc. Some of the drillers after collecting mobilization, end up not delivering on the contract and causing so much heartache for the client"* (2019). However, the same participant noted ways of preventing this scenario, i.e. *At the procurement stages, the prices allocated to the materials and the different components must be determined to be realistic and not too low to deliver the right quality. Once that is confirmed, after contract award, professional supervision should help to prevent contractors … using poor quality materials and equipment"* (2019). This example clearly illustrates the linkage between proper procurement planning and contract management.

Professional supervision of the drilling works (discussed in chapter 7) was also noted as an essential component of good project management (2018 & 2019).

Monitoring & Reporting

Many participants mistook the fourth step (monitoring & reporting) as end of project inspection. The fourth step actually concerns post-construction mounting and support. Of those who did clearly understand this step, many mentioned the lack of mechanisms for post-construction monitoring of boreholes and pumps, or support to communities in operation and maintenance in their respective countries, e.g.:

- In **Ghana**, usually, monitoring does not continue after the borehole is completed. Some Civil Society Organizations carry out some water quality monitoring of the boreholes they have funded and sometimes functionality surveys are carried out by the Community Water and Sanitation Agency for specific funded projects but there is no systematic monitoring and reporting of boreholes after construction (2019).
- Across many countries, we see "*limited capacity (human, technical and financial) of district local governments to undertake ongoing monitoring of borehole functionality and service levels*" (2019).

- Post installation monitoring by line departments in **Pakistan** is rare; NGOs quit the area after completion of the project; respective line departments tend to visit big schemes with major issues (2018).
- The **Sierra Leone** Water Company (SALWACO) prepared a Sustainability Plan for each borehole to help increase functionality and ensure sustainability involving: (1) formation of water management committee, (2) training water management committee; (3) technical training to caretaker; (4) provide O&M manual; (5) provide key spare parts; (6) monitoring functionality and testing water quality every three months; (7) provide major repairs and maintenance. However, there are budget constraints to adherence (2018).

Payment (or not) for dry boreholes or poor water quality

Payment (or not) for dry boreholes is a contentious issue, and discussions can tend to feel emotionally charged. The course facilitators took the stance that "*a dry borehole is not always the fault of the driller. Some terrains are just difficult for water. The best hydrogeologists in the world can still site dry holes. Therefore, the risk of drilling a dry hole should be shared between the driller and the client. Supervision is essential. Once the supervisor certifies that the driller has done his work as specified and the borehole is unproductive through no fault of his, he should be paid for the work done up to the point of the borehole being declared abortive according to [work done as set out in] the bill of quantities*". Box 6 shares diverse experiences and opinions of course participants regarding payment or non-payment for dry boreholes.

Payment per meter, as set out in a Bill of Quantities (BoQ) was proposed:

- "*The _____ contracts state a depth of 70 m instead of meter payment. Some boreholes have a depth of 30- 40 m due to the present of potential aquifers …. in certain areas. The money for the balance 40 – 30m that is [not] drilled is not accounted for. I would preferred the meter payment method because the extra distances can be added to give an additional borehole instead of sharing the money amongst [actors]*" (2019).
- "*… considering even with geophysics it is still possible to get dry borehole, I find normal to pay for dry borehole… this means technical people need to explain management that it is entirely possible to pay [for] drilling meter. … However paying dry borehole should also be with conditions, verified in the field (hence the importance of supervision), that the dry result is outside of the driller control. … these conditions (must be clearly define in the contract) and how to verify them … that's for me is the question i'm not sure how to answer*" (2019).

A response to the above question came from another participant:

- "*Had there been the provision of borehole camera survey before final payment to the contractor, the real condition compared to the design and quality of works like placement of casing, screen, welded joints, etc. can be checked and payment made*" (2019).

A participant working in Cox's Bazar in Bangladesh shared experiences of perverse outcomes in the case of non-payment for boreholes with arsenic: "*Now clients (even government agency) [are] asking for arsenic free water. … Driller can not take the responsibility of water quality. According to me it's not the fault of driller hence compensation should be considered. Very bad practice; driller collecting water sample from a safe source for laboratory testing and submitting the positive result for bill claiming. The arsenic presence borehole is finally considered as safe water point and open for use. Finally, the user is victimized. Hence, compensation should be considered always*".

Box 6 Payment, partial-payment or non-payment for dry boreholes

Reasons for not paying contractors for failed/negative boreholes:

- *"**fear** associated with paying for dry boreholes… may not mind submitting claims for dry boreholes, and not bother doing a good job… hence no payment for dry boreholes"* (2018).
- *"We were requested by our **donors** that we need focus on projects where the value for money would be maximized"; "many donors are ignorant of the nature and complexity of groundwater"* (2018). *"Some Donors do not want to spend on dry boreholes …. How do you incorporate this cost in proposals"* (2019). *Programme design is "result based"… …and based on specific per capita cost of providing the service…investment without any result (i.e. dry or very expensive) is not acceptable by many donors (or is considered no progress to achieve planned results). Some donors don't accept or recognise the risk of drilling negative boreholes"* (2018).
- **Embezzlement**: *"government still pay for dry boreholes which the money is shared amongst themselves. A percentage goes to the contractor and the other goes to the project manager and top management"* (2019).
- The **cost for the negative borehole** leaves an uncomfortable situation dealing with contractors; not paying for negative/failed boreholes forces contractors to exaggerate the cost for successful boreholes; *"…my organisation does not pay for failed boreholes. All the risks are in the contractor side. For this, in the bedrock area, the unit cost of borehole is high* [for a given area] (2018).

Consequences of not paying for dry/failed or negative boreholes

- *"**high financial proposals** because we do not pay for dry drilling"* (2019). *"Poor or lack of compensation for dry holes leads to the drillers charging exorbitantly for the wet holes, or it leads to them doing short cuts in their work as they try to recover costs incurred in dry holes"* (2019). *"the contractors include the cost in the successful boreholes. They add around 20-30% cost and … the client indirectly bears the cost"* (2019). *"… the price of boreholes going up because of the no water no pay approach" (2019)*
- *"Failure of the clients to pay for dry boreholes and this forces the contractor to **cut corners**"* (2019). *"…the contractor compromises on the quality of the borehole by using low quality casings and screens to cover for the cost and in some cases not doing full casing … [resulting in] boreholes which are not cost effective and the community eventually suffers loss of improved water supply* (2019).
- *"The boreholes siting is some time is responsibility of the contractor's in order to give them a full responsibility for boreholes success or fail. This kind of **responsibility is so difficult** in some condition and produce conflict and miss understands during payment especially for dry hole"* (2019).
- *"Apart from the price of boreholes going up because of the no water no pay approach, the driller often walks away with **vital information** on the dry borehole since he is not paid for them* (2019).
- As only positive boreholes are paid for, there is a risk that boreholes which do not produce enough water are validated (2018). *"Sometimes the drillers equip low yielding boreholes if there is no adequate supervision. Eventually the client loses the investment and the community suffers"* (2019).
- *"Lack of willingness of the client to offer direct financial compensation for drilling dry boreholes in high risk area, made one of the companies I worked with to abandon the project after they realized that it was not profitable",* (2019).
- *"[Contractors] use short cuts and drill in the areas where they can get water easily. This means that needy communities do not benefit from the boreholes* (2019).

Attitudes and practices regarding payment/non-payment for dry boreholes:

- Allocate a percentage of the cost for the failed borehole according to the zone of risk (2018)
- Client pays 50% (quite a common practice, and support from others); client pays 100% (if it is not the fault of the driller); client pays 35% of the cost of contract; paying 50% may not be fair to the client, as the driller may not have incurred 50% of the cost (2018).
- Payment depends on previous success rates (2018).

- While payment for dry boreholes is good for the drilling companies, there is need to protect the client (contracting entity) from undue loses (2019).
- Government and the non-governmental organisations now prefer wet hole contracts with the risk of a dry hole is passed on to the contractor and not paid for. This makes the bidding process unfair. Dry holes should be paid for (2019).
- There are no clear policy regarding the payment of dry hole (**Chad**) (2019).
- The country should make boreholes supervision mandatory and separate of siting from drilling thus paying for dry boreholes (2019).
- "*If the … client will not pay or compensate the contractor for drilling dry borehole, in most cases the contract will be cancelled if the client is a private individual because the cost will be too high* (2019).
- *"My experience is that we don't include the cost of dry in the proposals and we are only concentrate delivering on wet boreholes. If supervision is weak, contractor cut costs and compromise on quality. I think we need to change the way we do proposals. The other thing is to separate sitting from drilling* (2019)".

Payments

Participants frequently cited payment delays to the drilling contractors as a problem (Box 7). It was noted that lack of timely payments has caused causing some reputable and competent contractors not to bid for certain contracts (2018). Participants did not just raise problems, but also proposed ideas for improving procurement and contract management (Box 8). Participants also shared numerous practical challenges faced by those that run drilling businesses, alongside solutions. These are summarised in Chapter 9.

Box 7 Payment realities

In **Ghana**, "*the contractors payment is based on the depth of drilling, the cuttings, types and quantities of materials used in the construction of the wells etc. all of which will have to be validated and approved by the consultant of the supervisor (same as the person(s) who did the siting"* (2018).

UNICEF **Madagascar** has a policy of "no data no payment" for boreholes (2018).

We noticed that … it takes more than forty days [for payment], may be because of the long procedures. In fact, we can't drill the next one because we don't have high financial capacity (2019).

Pakistan Public Procurement Regulatory Authority does not allow payment for dry boreholes (2018).

The government of **Cameroon** is in the process to request that payment of any borehole shall be based on an acknowledge (sic) of data reception by its services (2018).

In accordance with the prevailing guidelines (for UNICEF **Malawi**), the contractor is responsible for siting and geophysical assessment of the area. This is so because the organization does not pay for dry or low yielding boreholes (2019).

In **Yemen**, there are organisations that avoid drilling boreholes and prefer rehabilitation to avoid high costs (2018).

Box 8 Improving procurement & contract management practical experiences and ideas

Procurement

1. Ensure that **pre-qualification** checks the quality of the drilling equipment (2018). Incorporate 'post qualification' by inspecting the premises and equipment of companies that are technically responsive on paper before final selection (2019).
2. Ensure that the **procurement planning phase** adequately takes the local context into consideration and procurement plan is prepared that manages the risks faced in a variable and changing climate (2018)
3. We are thinking of the drilling **company staff signing availability statement**…visits to premises will certainly be made. This will help identify brief-case companies (2018).
4. Procurement processes can be **time consuming**, and cause significant delays in implementing an emergency drilling programme. Having pre-qualified vendors in the first place can significantly cut on the time spent in the process (2018).
5. Preparing procurement **bid documents** diligently, rather than through copy and paste (2018).
6. Holding a **pre-bid meeting** also referred to as an information meeting or pre-bid conference (2018).
7. Publishing the **results of the tenders** (2018).
8. "*In my country [Lao PDR], **one bid package of max. 20 boreholes** are contracted for one drilling company in order to minimize risks of delaying of project, company financial or technical problem e.g. old/small or worn out drilling machines as well as reviewing company profiles*" (2019)
9. "*I have always believed that one way to cure the corruption of component and enforce transparency is when the funding agencies also have **competent profession[al]s** such that they can supervise the final outcome of a bidding process*" (2019).
10. In very countries, have a **provincial, regional or state level call for bids** if the total cost of estimated work is within the threshold of the regional office. This would speed up the process as less bidders will apply than for a national tender, and regional WASH and supply specialists can work on it swiftly. This will release also some workload on the Central office.

Contract management

1. We must always do hydrogeological studies (and geophysical if necessary) (2018)
2. State the time that the contractor has to repair damage within the contract (as part of the **defects liability**) (2018).
3. Reconsider how to better deal with the **risk of drilling dry boreholes** (2018).
4. Improve **drilling supervision**; contract management is the main reason behind the high rate of construction failure after completion – supervision remains a key issue (2018). There is need to *"increase the **incentive** for supervisors to prevent false reports"* (2018)
5. Ensure that there is monitoring and reporting **after construction** by the state or national agencies (2018).

7. Drilling Supervision

The following statement from the forum discussion (module on *borehole drilling and supervision*) encapsulates what is particular to borehole drilling projects and why supervision is so important:

- *"I think drilling borehole … has [a] similar lifecycle of any other construction project, but the difference is borehole drilling deals with unforeseen material and layers underground, this is why the experience and the expertise in this type of projects became essential … along with skills in project management"* (2019).

- *Many contractors (even supposedly good ones) work based on their 'experience'. Whilst [this] is very useful, adherence to technical specifications is key. I have been on drilling sites where the drillers just place screens and casings based on what they normally do rather than based on the need of the specific aquifer and borehole they have drilled through or materials for gravel packing are just sourced from where the contractors can easily access rather than sources with the right materials"* (2019).
- *"Drilling supervision is like the belt that holds a good pair of trousers on place at the waist, without which one will not be confident in walking about and being productive"* Mumuni Kere Osman, UNICEF Ghana (2018 Course Participant).

The level of investment in the borehole itself can also affect the investment in supervision, e.g. "*if the borehole being drilled is intended to be used for public in such a way the anticipated yield capacity of the borehole is high and hence drilling supervision require close follow as the money invested is high"* (2019). Another participant explained that for bigger scheme development, the professional supervisors are properly placed with funding (2019).

While most participants understood supervisors to be working on behalf of the client, for some, a supervisor is a member of the drilling team (which could be government-owned or private enterprise, or an NGO). The second definition may be an overhang, or ongoing practice of government undertaking the drilling works, with works oversight by a 'supervisor'.

In general, participants provided good reflections on what could be improved within their particular organisation, including the use of a supervision checklist. Specific learnings were "*some weakness that I noted from the experience in our context, in view of what I learnt from this module is that, the driller and supervisor sometimes sharing resources especially logistics and intimate closeness might lead into sabotage of the project and hence compromise the quality of the work."* (2019). "*Proper supervision helps to generate information for decision making and lesson learning*" (2019).

Who supervises?

Government projects either use their own staff for supervision, or contract the work out to a consultant, or consultancy firm. What they do can depend on what is stipulated by the particular donor. Notably, "*private consultants also cost more than the government officers would"* (2019).

One unfortunate example was shared whereby "*The [government] did part-time supervision for the construction and pumping test of the boreholes but the {donor] project manager insisted that, the project should involve consultant as per contract requirement. The [government drilling} company withdrew its staff and hired the consultant. The consultant was unable to provide proper supervision of the project due to lack of adequate … experience [and] expertise to carry out the work in four districts. Because of poor supervision, the contract was terminated and the entire project [came] to an end with uncompleted work"* (2019).

Participants working for UN and NGOs that fund the drilling programmes of partner organisations tend to hand over responsibility for supervision to the partners, but may provide technical support. The partner organisations becomes the client of the drilling works. There were very few examples of direct implementation (whereby the UN or NGO own a rig), but several examples of the UN or NGO contracting out drilling directly. In the latter case either in-house staff or consultants or, in the case of larger contracts, consultancy firms undertake drilling supervision. Three contrasting examples are:

- Lack of involvement of the Ministry of Agriculture and Underground Water in drilling supervision in **Iraq** (2018).

- Rural Water Supply and Sanitation Agency (RUWASSA) in **Nigeria** is the client and supervisor for UNICEF projects (2018).
- Regional and district government, as well as UNICEF, or consultants working for UNICEF are all involved in oversight or supervision in UNICEF-funded programmes in several countries for (2018).

Two examples were shared of three people from different organisations all undertaking drilling supervision (i.e. from local government, state government and external; from control office, UN agency staff and consultant).

There were several cases of overlapping roles. For example, "*in some instances, the contractors receive recommendations and instructions from two or more UNICEF persons. It needs to be channelled somehow in order to have one focal point from start to finish. Otherwise, it raises confusions both for UNICEF and for the contractors*" (2019). Cases of clarity were also cited, e.g.. "*There is no overlap in the coordination as both the [government] Agency and Third-Party Supervisors are guided by the same set of rules and reports from both end up with UNICEF. The report of the Third party is used validate that of the Agency supervisors*" (2019).

Supervision stories

Box 9 provides some insightful stories about drilling supervision, emphasising the importance of that it needs to be undertaken well. It is also important to ensure "*Motivation of the supervisors who sit in field from morning to evening and Monday to Sunday*" (2019).

Full and part-time supervision

Some participants set out their supervision processes in considerable detail, explaining, for example the checks on the drilling equipment and materials as well as many other aspects. Participants described experiences of full-time and part time supervision. Typically:

- "P*art-time is used because the financial resources to hire a consultant for full-time supervision are not available*" (2019).
- *"Part-time or milestone type of supervision is the most frequent practice adopted due to the usually large number of boreholes, spread across the country and consequently, many contractors handling different lots. It would be too expensive to attach a supervisor to each borehole from start to finish if works are to be delivered within the best drilling period of November to May for best accessibility*" (2019).

Two participants reflected that the milestones for part-time supervision could be more clearly defined, e.g.

- *"Supervision is normally part-time and unfortunately not always linked to the milestones". "Our practice has been part time supervision with random checks (apart from the selection of screen and pumping test)"… This is an area which I will consider to improve if I ever is in that supervising position again; to make it clear which milestones that has be done in the presence of the supervisor" (2019).*

Challenges of drilling supervision

The biggest challenges raised by participants with respect to drilling supervision were:

- inadequate skills and experience (Box 10)
- inadequate means to supervise (Box 11) or
- both of the above.

Box 9: Stories of drilling supervision

*In **Cameroon**, UNICEF is addressing weaknesses in the contract setting out eight key steps for "minimal supervision" or part time supervision, i.e. validation of siting, pumping test, handpump and pipe reception, wall construction, technical reception, temporary reception, technical visit before final reception and final reception … samples for water analysis should be taken with the participation of a national water inspector who is mandated for this (2018).*

*"According to me, [we] need more consultants for this type supervision specifically. They could be organised per provinces. Here in **DRC** one province is often the size of a country"* (2019).

*In **Ethiopia**, although site selection for drilling is done by hydrogeologists "…* drilling supervision is not properly conducted and sometimes guidance is provided to the drillers by telephone communications from offices… because of lack of hydrogeologists in the government offices… the government doesn't have sufficient budget to employ the required number of hydrogeologists… [and] when the hydrogeologists gain experience they move to other organizations who pay better. "; *"*The primary objective of drilling supervision is to certify payments" *(2018).*

*"[Supervision and inspection] has been challenging in **South Sudan**, despite the measures put in place in contract management. Regarding boreholes drilling it is difficult reach all drilling site in the rural areas due to poor infrastructure network. This is risk which anchor within the contract therefore, we depend on the local community reporting system although they communities maybe lacking expertise to access whether the contract has abided with the contractual provision outline in the contract"* (2019).

The stories below have had the country removed for confidentiality:

"There was one time that a Municipality (local government) invest in a water system project … to supply a community. In the first stage, a hydrogeological study was hire and the drilling site was defined. In a second stage, the procurement was oriented to complete the construction of the different components of the system (well construction, conduction line, storage container, distribution network). … the community was involved during the whole process. At the beginning, the water well rate was around 11m^3/hour, but after few days of completion, the discharge rate decreased considerably. Then, the contractor assumed the replacement of the well, as the community inferred the failure to a bad implementation of the gravel packing. All this happen because there was no supervision involved and neither the municipality engineers were trained for that" (2018).

"The success of a borehole is greatly depend on the supervisor … Most of the failures that have occurred in the recent project of drilling 36 boreholes in ____district is as a result of poor supervision. [This] can lead to low yield due to improper placement of screens, poor design and poor well development. [The government as client] has had failed projects not because of the lack of experience engineers and geologists but the absence of good management systems. From my experience, one of the factors that contributes to the failure of many projects in ___ is the absence of power and authority by the field supervisors. Corruption and bribery are common in managing projects … After the top management has taken a share of the project money, the engineer or geologist is just there as a spectator without any power to effect proper supervision and this is seriously affecting the work of the technical people in the country. This … usually kills the spirit and passion of the supervising engineer/geologist in the country" (2019).

"Most staff supervisors have the duty of handling many project at the same time" (2019).

There is …"*a lot of room for improvement …. Supervision is mostly inadequate and sometimes lacking particularly from the Government Agencies. As a result, sometimes, defects and non-adherence to standards and agreed contract terms are picked up very late. In a very recent contract, a number of cases of open wells were detected only when the personnel of the funding agencies went around on spot check… This was … a violation of the contract terms"* (2019).

"Many times construction happens without much support and few supervision. The clients come to the site at the beginning and at the end for construction signup and no other times, this leads to many corners being cut and poor site management and construction. Better supervision structures need to be put in place and regular site visits, checklist and quality control is needed" (2019).

"Some organisations drill boreholes without planning or costing for supervision and training. Shortage of skilled staff to best supervise drilling of boreholes is also another problem. In general, there is a lack of portable gadgets necessary for supervision like water depth dipper, portable water quality testing kits, measuring tape, stop watches, and safety measures in controlling children and even adults in rural areas is still a problem. Welfare of drilling staff also needs a lot to be done especially by private drilling contractors" (2019).

Box 10 Drilling supervision realities in terms of skills and experience

- In **Burkina Faso**, inexperienced people are often sent to oversee drilling, development and pumping tests. The companies manage to deceive these inexperienced people and after the commissioning, many problems are encountered because the boreholes are regularly out of order for bad equipment of the drilling or bad installation of the pumps. The superstructure plan is sometimes not respected because the supervisor was absent during construction (2019). In Burkina Faso, the supervisors are qualified but not well paid by the head of the office. Most complain about their remuneration, which sometimes leads to drilling companies corrupting them by offering them visits in the same vehicle to avoid fuel, or offering food on site. Drilling companies can thus corrupt the supervisors or to have them accept certain equipment that does not comply with the standards. This has a big impact on the quality of the drilling (2019).
- In **Chad**, consultants are well experienced and mostly engaged in big drilling projects. There are both local consultants from firms within Chad and international consultants mostly from Regional countries. However, some consultants have more expertise on surface water and are less knowledgeable about groundwater. Nevertheless, they are still hired to supervise drilling projects (2019). See also Chad (the means to supervise above).
- At district level in **Ethiopia** there is a lack of hydrogeologists. Supervision is undertaken by junior geologists with limited experience and minimal backup from zonal and regional water offices. There is a critical shortage of senior hydrogeologists in all government structures and little capacity building to enhance/upgrade the skills of government geologists/hydrogeologists. However, government is employing more geologists at all levels (2018).
- Participants in **Ethiopia** and **Guinea Bissau** stressed the cost-effectiveness of experienced government staff, rather than the private sector, undertaking drilling supervision (2018).
- In **Ghana**, drilling supervision is undertaken by a consultant belonging to the same organisation that was contracted to undertake the siting, or geophysical investigation. Supervisors are normally expected to have a minimum university degree in Geology or related field and about two years' experience in drilling supervision. Drilling supervision is supposed to be full-time. Alas sometimes consultancy firms do not feature supervisors with the required level of education and experience, which can compromise the quality of the work (2018). In Ghana, the consultants procured by the Government implementing agency have the requisite qualifications for professional borehole supervision (2019).
- Lack of technical skills, experience of background in drilling to be able to professionally supervise borehole drilling in a number of countries; lack of technical training for drilling contracts to collect and report data appropriately in **Lebanon** (2018).
- In at least one state of **Nigeria**, most experience by supervisors have been learned on the job. Most supervisors may not have gotten enough experience before he or she is sent into the field for actual supervision (2019)
- Insufficient geologists and hydrogeologists supervisors in **Nicaragua** (2018).
- Lack of data recorder/record keeper by drilling enterprises operating in **Somalia** (2018).
- Very limited knowledge of drilling by government supervisors in **South Sudan** (2018).
- Sometimes consultants (supervisors) have problems handling villagers (2018).
- Limited training and expertise of local hydrogeologists and water engineers in **Somalia** (2018).
- A mandatory requirement for a drilling supervisor in **Trinidad and Tobago** is that they have a degree in Geology/hydrogeology/mechanical engineering and/or possess at least five years drilling experience (2018).

Box 11 Realities faced regarding the means to supervise properly (staffing, finance, time and logistics)

- **Burkina Faso**
  - Sometimes complicity is created between the supervisor and the drilling company. The supervisor does not have an independent means of transportation; he is transported and fed by the drilling company. In this case, it is no longer very strict in controlling the work of the drilling company (2019).
  - Private control offices that supervise are qualified but they are not very well equipped (e.g. no camera, first aid kit, piezo probe, pH meter, iron control disk), do not have adequate logistics for transport and do not have a good compensation (quality / price ratio) and so are subject to corruption (2019).
- **Cameroon**
  - insufficient financial and logistical resources of government limit its ability to adequately monitor (supervise) borehole construction adequately (2018)
  - lack of adequate equipment for drilling supervision (2019).
- **Chad** – water Monitoring Assistants, based as provincial level, work for the Ministry responsible for water affairs. They play an important role in drilling oversight and are the first force to supervise any driller, they also collect data by filling the drilling supervisory sheets, and they know the camps and the villagers. They are good at mobilizing the villagers and capable of undertaking pre- and post-drilling training and sensitizing the users about water and sanitation projects. However, most of them are not so knowledgeable about the technicalities of hydrogeology and have not been trained or mentored in drilling supervision. Further, most province councils or local department face acute logistic constraints and there is a shortage of this cadre of extension workers (2019).
- **Ethiopia** – *"lack of supervision equipment and transportation (2018). Drilling supervision … are done at random …. Junior experts without good exposure to drilling supervision works are in most cases assigned to monitor the drilling activities. As there is no senior expert to guide them, they may guide the drilling work in wrong direction. They may not well identify the samples and may wrongly arrange casing arrangements"* (2019).
- **Kenya** – the District engineers, who supervise are not well facilitated and are forced to depend on the contractor for logistics; meanwhile Technical engineer (at regional level), who coordinates the drilling process tends to be well facilitated but is not available all the time to supervise (2018).
- **Malawi** –
  - Though the aim is to be available on site all the time, in practical terms this has proved difficulty at times as the organization simultaneous awards three to four contracts, which are running concurrently to meet set targets (2019).
  - The district Water Office may be hit by logistical problems and personnel shortages in the office. UNICEF is responsible for providing enough funds for supervision at the agreed rates with the District council and also provides capacity building support to the field supervision staff. However, government lack technical capacity in interpreting the design and specifications. To address this, UNICEF assigns staff to monitor and verify critical activities (e.g. siting, borehole development, pumping test, gravel pack, casing installation and sanitary seal). Prior to payment the certificate of completion by the district, the construction report by the contractor, and the verification report by the UNICEF Engineer must be submitted (2018).
  - The main challenge with Government staff is usually understaffed and underfunded to adequately support full time supervision (2019).
- **Mozambique** – due to lack of resources (financial, human resources and time) the supervision only happens sporadically and not on a daily basis. Transport, allowances and equipment is very poor which hampers the entire supervision role and quality of works. The government staff (supervising) have other regular responsibilities and tasks and so supervision normally comes as an add-on. Time and engagement are many times a problem and a challenge. (2019).
- **Nigeria** –

  - Non-release of allowances/transport for state and local government authorities hampers the supervision (2019).
  - Both Government agency and Third-Party supervisors face significant challenges with transport, allowances and equipment. It is more pronounced with the Agency supervisors, who sometimes rely on the contractors to transport them to their sites and occasionally bear the cost of their feeding while in the field. Despite receiving funding for supervision logistics, the agency management in some states has not not been giving the supervisors the adequate funds to cover their costs (2019).
- **South Sudan** –
  - Hiring of a consultant for the drilling planning, bidding document preparation, contract management and supervision is justified when regular funding for drilling campaigns is envisaged for several years, as was the case from 2013 in UNICEF (2018).
  - Limited logistical support for government supervisors makes it difficult to go to the field (2018).
- **Trinidad and Tobago** –, there used to be 24-hour supervision, but it was reduced to 12-hour supervision to cut costs: this, coupled with a lack of cameras to photographs drilling or drill cuttings has been a source of contention when disputes had to go to arbitration (2018).
- **Yemen** –, Qualified consultant undertaking full-time supervision with responsibilities including approval of siting, informing the district water office and checking drillers' records regularly (2018).

Borehole camera

Participants were asked to write about how a borehole camera could be used to ensure drilling quality. One illustrative response was: "[it] *can be used to ensure drilling quality. It allows us to see the part that we cannot see unless we become a tiny diver".* Although the question of experience of a camera was not specifically asked, six participants in the 2019 course referred to this, of whom only one had specific experiences of a borehole camera, while the other five explicitly stated that they had no experience, i.e.:

- *"I only know one drilling company that has [a borehole] camera"* (**Uganda**).
- *"I have never used the borehole camera"* (**Bangladesh**)
- *"In my work we never used borehole camera but I've few experiences during training abroad"* (**Bangladesh**).
- "*Actually have no experience with the use of a borehole camera"* (**Nigeria**)
- "*Have never used a camera before*" (**Zimbabwe**)
- "*I'm not sure about the use of borehole camera as I have not be opportune to witness such drilling; there is no camera used in drilling wells in the country*" (**Sierra Leone**).
- One participant referred to the use of a borehole camera as part of a research project in **Uganda, Ethiopia and Malawi**.

Supervision oversight

There is need for oversight of the supervisors, which is not always easy to fund, or organise, e.g.: "*The supervisors themselves need another layer of supervision. In practice, what we have done is to have this layer of supervision provided by the contracting Government partner who carries out spot check supervision. This layer of supervision is also paid for by the funding agency. [However], given the relatively large numbers of the boreholes, the capacity of the Government partner in terms of numbers of personnel and logistics is inadequate to fully and properly carry out the needed spot checks* (2019). Several participants from UNICEF offices (e.g. Iraq and Nigeria) mentioned the use of third party monitoring, referring to the hiring of technical persons, also known as facilitators, for oversight, or end of construction inspection. However, third party monitors do not always have a specialisation in borehole drilling, and may not be equipped with a borehole camera (discussed below).

Several participants used the assignment to undertake a critical analysis of milestone supervision, setting out the weaknesses at key stages. (2018). Very detailed reports of the supervision process were submitted by participants from several countries (2018 & 2019), including weaknesses of the approach.

Additional challenges

It was pointed out that the "*client or donors can underestimate the need for proper siting and design, proper supervision*" (2019) and "*Many Organizations (clients) … try to [squeeze] budgets in the name of savings*" (2019). Other supervision concerns related to planning, corruption, security and contract terms (Box 12).

Box 12 Additional challenges faced with respect to drilling supervision

Planning and costing

Ghana - The challenge, which I have observed…, *"is usually with the manner in which they quote for the supervision. The rates are always so low that it is almost impossible for the consultant to be in the field to supervise all the activities. Mostly, aside the siting and drilling, the rest of the work is left for the contractor to complete and submit a report to the consultant. This can compromise the quality of work and lead to over pricing from the contract and possibly poor work. … The weakness can also result from the nature of the evaluation of the tender documents in selecting the drilling supervisor. Where attention is placed on the least cost, it affects the quality and calibre of professionals that would be engaged in such work"* (2019).

Corruption

- Increasing the drilling depth of the borehole and receive some money from contractors (2018).
- Connivance between the drilling supervisor and the consultant (2018).
- The proximity in a small country between the drillers and controllers (2018).
- Government staff may be compromised to enforce standards (2018).
- Some contractors may be politically connected and hence uncontrollable (2018).
- When supervisors come from the same community as the drillers they may be compromised (2018).
- When areas cannot be controlled externally (due to or security) supervisors may be compromised (2018).

Security

- Travel restrictions for security limit drilling supervision in **Iraq** and **Somalia**. The result is "remote monitoring and supervision". Alternatives include hiring local consultants not held by UNICEF's security restrictions (2018).

Contract terms

- In **Cameroon**, sometimes confusion in the tasks of the supervisor could arise because of every donor having their own standards and designs of borehole drilling and their own supervision's procedures (2019).
- *"It was surprising but strange to find that the [drilling team] did not have a contract document on site… they did not have the specific details required for the special borehole they were to drill"* (2018)

Community support to drilling supervision

There was some discussion on the role of the community to support the supervision process, as well as challenges with this (Box 13). More than one participant mentioned that sometimes consultants have problems handling villagers properly (2019). This emphasises the reality that siting and drilling supervision, particularly in rural areas is a social, as well as technical job requiring particular skills and sensitivities. This is an area worthy of more attention in training, as well as in Terms of Reference, job descriptions and staff selection.

Box 13 The role of the community to support (or monitor) the drilling supervision process

- The implication of community in the monitoring can be improved; community have some selected members as watchdogs, especially those with basic literacy and numeracy knowledge (2018).
- The use of community to supervise with the community able to raise any issue which they feel is compromising the drilling process and even refusing the contractor to leave the site until the work is done to standard (2018).
- The villagers with the water point committee are always on site (2018).
- Villagers are not fully empowered to control the contractors and are left out in decision-making
- Importance to get complementary information from the community (2018).
- Lack of community involvement in Trinidad and Tobago together with the site being cordoned off means that the community sometimes think that the government agency is secretly drilling for oil and stealing from their natural resources (2018).
- "*In **Zambia** (government programme), communities play a passive role of supervision by recording number casings and rods used cement bags and hours pump testing. These are shown to the project manager, supervisors and area mechanics*" (2019).
- *"In many rural areas of **Cameroon**, the villagers are well placed to track the drilling as they are always on site as beneficiaries of the water points being drilled. If they are given pre-drilling training to help them track properly, and have some external technical support, they are able to follow the work. However, most villagers are illiterate and their numeracy skills to documents specifications are low. More so, the villagers are not fully empowered to control the contractors and drillers, neither are they involved in project decision making"* (2019).
- It would be important for the client to put in place a mechanism to ensure that the consultant is doing their job properly, experienced staff are in the field. This mechanism could integrate beneficiary communities with drilling and partially supervise the project owner to ensure that everything is in compliance (2019).

Good practices for drilling supervision

A key point made was the need to find financial incentives to invest in drilling supervision. Several good practices and ideas were also shared, e.g.

- *"One contractor is hired per district and the supervision by staff is full time. The supervisor is equipped with transport means i.e. motorbike or sometimes a car depending on the weather"* (NGO in Uganda: 2019).
- *"It is really important the clarity on who is involved, reporting to and expected results in order to have a functional drilling with little interferences and misunderstandings"* (NGO working across several countries 2019).
- *"Normally the level of expertise and experience are set for the one responsible for the whole project. Then the consulting company are free to use their more junior hydrogeologist for supervision of drillers, but with the overall quality guaranteed by the senior hydrogeologist/project manager"* (Participant reflecting on working for a range of clients in Sweden, 2019).
- *"A strength of good drilling supervision is in making use of set formats and checklists for record keeping and quality assurance. This ensures that data recording is done well and also holds the driller to account for meeting the technical specifications. It also can be helpful in identifying the cause of borehole failure or something gone wrong and documents it, rather than a finger-pointing blame game between client and drilling contractor that can take place if this is not documented"* (Nepal, 2019).

- Supervisors need their own logistics. In the case of contracting supervision, this needs to be included in the tender document (2019). Building the cost of supervision into the bill of quantities and cost of the boreholes. (2019)
- There is need to make good use of the warranty, or defects liability period (2018).
- Consider training local NGO staff to supervise the realization of the boreholes rather than relying on consultancy firms, which may not properly remunerate their staff or provide them with sufficient transportation and allowances (2019).

Noting that "*An experienced Driller can easily hoodwink an inexperienced Supervisor*" (2019), and that "*if the supervisor is younger, and perhaps less experienced, it can be difficult for them to go up against drillers, who may use their position of power to influence the supervisor* (2019), there is need for:

- Support from the senior management to help the junior hydrogeologists not being deluded by an experienced driller (2019).
- Occasional visits to the drill sites by senior project personnel to reinforce the Supervisor's authority with the Driller (2019).
- Young drilling supervisors to be supported by senior project personnel (2019).

8. Institutional (and Legal) Framework

This chapter provides an overview of what was shared about the institutional and legal frameworks. Annex 4 tabulates the responses of the participants, country by country.

Participants reflected on the institutional (and legal) frameworks that relate to groundwater resources management and groundwater development. In some countries, groundwater legislation is completely lacking or weak, while in others there has been considerable progress. Participants expressed the need for institutions and departments to be established. The challenge in many countries is the implementation and enforcement of policies and regulation, a problem that is not peculiar to sub-Saharan Africa and Asia but also experienced in Europe. One participant (from Nigeria) was not aware of any regulatory framework for borehole drilling practices in the country prior to taking the course, despite their existence.

Examples of countries with and without drilling regulation

Zambia is at the forefront of introducing groundwater regulations, alongside Scotland, Uganda and Malawi where there is considerable work in progress. The lessons learned from Zambia (both positive and less so) will be important for other countries" (2019). "[In **Zambia**, with] *the introduction of the groundwater regulations, much sanity and improvement has come to the drilling profession. The prices are moderate (not too low) and all boreholes are to be cased to the bottom by all players in drilling. …The drilling companies are now licensed and bound to set conditions"* (2019).

In **Zambia**, the "*government came up with a body (Water Resource Management Authority) to regulate the use of ground water by registering of boreholes, applying for permit to drill a borehole. [This is] … then evaluated by the WARMA committee as to whether it is the chosen site for the borehole is no near any contamination source as the contamination may contributes to public health problems*" (2019).

Zambia's groundwater laws, compel all Drilling companies to be registered in the Driller's Association and licensed by a Government regulator-Water Resources Management Authority (WARMA). The drilling firms are expected to case all drilled boreholes to the bottom (be fully cased). If its discovered that it was not done so, the company can be penalized or its drilling license revoked. This way shoddy works are eliminated or reduced due to regulations (2019).

Malawi has also witnessed considerable effort: the Water Resources Act 2013 Part IV, Section 69 includes requirement to submit all data pertaining to the borehole to the Water Resources Authority and new Standards and Guidelines were developed [6] (2018). It has been difficult to have National Code of Practice for Water Well Construction in **Nigeria** widely accepted and practiced, which may due to the size of the country, with a population of about 200 million and the federal constitution which gives control of water resources to both the state and the national governments. However, Lagos and Kaduna have set up water services regulatory commissions and regulating drillers in their states and it is hoped that regulation at state level, sizes will be more effective than at national level. **Kenya** also has a framework for licencing drillers.

While regulations may exist, there were mentions of poor compliance, e.g.:

- In **Zimbabwe**, while these are regulations, *"the biggest challenge now is that the level of compliance is very low to almost non-existence. The fact that drillers and the owner of the borehole are not being compliant has actually resulted in loss of lives. A borehole was drilled without receiving authority from the Catchment Council, no water quality test was done and it was only known after it caused the last cholera outbreak … that the cause was a contaminated borehole"* (2019).
- *"in **Bangladesh** we have lots of guidelines or standards for borehole drilling and it is easily understandable but not widely circulated. In my personal view there is no organization/institution, which is in frontline to strongly enforce that published guideline"* (2019).

Box 14 Legislation applied to borehole drilling and rehabilitation in Trinidad and Tobago (2018)

The **Certificate of Environmental Clearance Rules,** 2001 (legislation generated from the Environmental Management Act Chapter 35:05) stipulates that: all contractors must submit a finalized Scope of Works (SOW) and a detailed scheduling prior to drilling or rehabilitation of any borehole to the Environmental and Management Authority (EMA) of Trinidad and Tobago at least 20 works days prior to the start of the project.

Contractors must submit an **Emergency Response Plan and Job Safety Analysis**, set up temporary enclosures to exclude public from work site and implement efficient waste removal and sediment removal during drilling or rehabilitation. The **Occupational Safety and Health Act** 2004 stipulates that all personnel during drilling or rehab works must wear full Personal Protective Equipment (PPE) and conduct tool box meetings at the beginning of every shift.

All drillers and all drilling crew are required to have their PLEA Passports, a **health and safety training course** in Trinidad and Tobago. Prior to the start of project, the contractors must have their rigs certified and if requested by the client, all drilling pipe, drill collars, subs etc. must be x-rayed to ensure that there are no cracks. All contractors must be prequalified in order to drill for the government of Trinidad and Tobago. However, in the case of an NGO or private user, it is not mandatory for a registered contractor to drill for them.

In contrast, it was noted that there is a *"near total lack of a regulatory framework in **Somalia**, coupled by weak capacity of government"* (2018).

[6] i.e. ***Standard Operating Procedure for Drilling and Construction of National Monitoring Boreholes***, Document No 06GW01/2012; ***Standard Operating Procedure for Aquifer Pumping Tests,*** Document No GW02/ 2012; ***Standard Operating Procedure for Groundwater Level Monitoring,*** Document No GW03/2012; ***Standard Operating Procedure for Groundwater Sampling,*** Document No GW04/ 2012; ***Standard Operating Procedure for Operation and Management of the National Groundwater Database,*** Document No GW05/2012; ***Standard Operating Procedures for Groundwater Use Permitting,*** Document No GW06/2012; ***Standard Operating Procedure for Drilling and Construction of Production Boreholes,*** Document No GW07/2012; ***Technical Manual - Water Wells and Groundwater Monitoring Systems*** – all published in 2016 by the Ministry of Agriculture, Irrigation and Water Development, Malawi. With the permission of the Government of Malawi, this information was put on line (on the RWSN website - http://www.rural-water-supply.net/en/resources/details/807 and circulated to the RWSN Online Groundwater Community.

Organisations that were mentioned playing a role in regulation of groundwater resources, drilling and abstraction are listed in Table 2. Note that the validity has not been checked, and that the list is not comprehensive.

Table 2 Institutions with a role in regulating groundwater, drilling and abstraction

Country	Institution
Bangladesh	Water Resources Planning Organization (WARPO) is an apex organization under the Ministry of Water Resources, dealing with nationwide water resources planning.
Côte d'Ivoire	National Office for Drinking Water
Ethiopia	Ministry of Water Irrigation and Energy
Ghana	Water Resources Commission
Iraq	Directorate of underground water
Jamaica	Water Resources Authority
Kenya	Ministry of Water and Irrigation and Water Resources Authority, Ministry of Water and Sanitation
Madagascar	Ministry of Water
Malawi	National Construction Industry Council & Malawi Institute of Engineers (2019)
Sierra Leone	Newly developed National Water Resources Management Agency (2019)
Sri Lanka	Water Resource Board (2019)
Thailand	Department of Groundwater Resources
Trinidad and Tobago	Water and Sewerage Authority (WASA) Environmental and Management Authority (EMA)
Uganda	Directorate of Water Resources Management in the Ministry of Water and Environment
Yemen	Ministry of Water)
Zambia	WARMA is supposed to issue a permit to drill to a client. This is now law. WARMA also inspects the drilling chips collected from each site as well the completed/filled in borehole completion reports.

Guidelines and standards

The importance of guidelines and standards for borehole drilling was appreciated by participants on both courses, e.g., "*These are important for drilling organizations of a country because they would explain national standards, situation and protocols to be followed by both foreign and national practitioners in the drilling of boreholes –including the supervision - and water supply sector at large*" (2019).

Participants raised the need to improve guidelines and regulations in **Yemen**, to establish guidelines for well drilling in **Lebanon** and **Cameroon.** E.g.: *"In **Cameroon**, there is a lack of national standards and guidelines that would have guided in the development, use and management of drilling supervision of boreholes and that would have also spelled out the need for … hydrogeological data management*" (2019).

In contrast, **Malawi**, has developed a suite of documents providing technical guidance and setting out standard operating procedures[7]. **Zimbabwe** also has standards[8]. Although guidelines have been issued in **Zambia** there are participants who stated that there are drillers not following them. Likewise, the "***Nigeria** Government has*

[7] The technical guidance & standard operating procedures for drilling for Malawi are available on: http://www.rural-water-supply.net/en/resources/details/807

[8] SAZ Zimbabwe Standard ZWS 678:2013, Development, Maintenance and Management of Groundwater Resources.

guidelines and standards for borehole drilling … but it is not all of these rules are well followed due to lack of enforcement from Government and penalty for organization that deviate from the set-out rules" (2019). Similar views were expressed by participants in other countries (Annex 4).

Drilling restrictions

In Dhaka (**Bangladesh**) no one is allowed to drill personally for getting water, rather the water supply and sewerage authority has the responsibility to provide water among the city dwellers. Where outside the capital borehole boring work is allowed with and without the worry of government (2019).

Borehole numbering

Borehole numbering was mentioned in the course, but not looked at extensively. An encouraging experience was shared from **South Sudan:** Unique identification number; every completed borehole have some form of physical identification marker or plate, with a number with conforms to national borehole numbering system. However, after the 2013 South Sudan crisis, partners including UNICEF uses serial system with a prefix of the project or State/county/payam followed by GPS coordinates then a serial number, then shared with national system known as Water Information Management (WiMs). The borehole number is stamped into a metal plate on the stands/pedestal and also embedded in the borehole platform along with other data such as static water level, final borehole depth, yield, drawdown, data of completion and client name (2019).

9. Drilling

The drilling industry

The course did not set out to explore the drilling industry in specific countries, but some insights were shared:

- **Ethiopia**: there are "*over 15 private contractors for drilling who are local as well as international companies. Company from India, Pakistan, Turkey, China, USA and many locally owned drilling companies are now engaged in the drilling activities*" (2019
- In **Lao PDR**, with the support of Drilling Expert Mr. Kene Mason in 1991, UNICEF imported 13 drilling machines (PAT101, 201, 301 and TH5 the strongest machine) for 10 provinces with training and capacity building. Some are still functioning or need repairs.
- In 2014, there were only five drilling companies in **Sierra Leone** (2019).
- *"About 400 boreholes were drilled in **South Sudan** during 2003-04, with average productivity of only 10-15 boreholes per rig per year. These low figures illustrate the challenges associated with drilling in remote areas with high mobilization and implementation costs, as well as severe time restrictions imposed by the impassable roads during the long rains*" (2019). Today, "*drillers tend to invest in overcapacity drilling rigs, and several of them retain more staff than they can use on a regular basis. High capacity rigs are expensive, but allow the drillers to bid on more jobs, and reduce the risk of having to call in a more powerful machine when difficult conditions are encountered. Similarly, certain minimum staffing is required to undertake larger drilling projects, but much of this capacity then sits idle during periods of weak demand"* (2019).
- **Zambia** has a huge number of drilling companies in the capital city (Lusaka) competing for few contracts. "*On the road from the airport into Lusaka, I counted thirty four drilling companies on one side of the road. There was also an equal number on the other side. And they were all from India*." (2019)

Running a drilling business

The types of challenges faced in running drilling business, can broadly be grouped into eight types (Box 15).

Box 15 Types of challenges faced in running a drilling business

1. **Financial**

Costing and pricing

- *"…most companies bidding do not apply some of the pricing and costing considerations as discussed in the reading materials… [and] we end up with unrealistic bids"* (2018)
- There is a lack of disaggregated information on well drilling costs, and "turnkey" contracts, so the costs incurred by the company are not disaggregated (2018).
- *"…contractor tends to front load costs in the drilling phase so that in the event a dry hole is drilled, he will get the majority of the money from the contract" (2018).*
- *"The contractor in many times underestimates the cost in order to win the contract, this limits the use of experience experts who can deliver quality results. Hence quality is compromised* (2019).

Cash flow

- Cash flow is a significant challenge for drillers. Significant amount of their capital is tied up in equipment. Overhead costs can also be high, especially for larger contractors with large teams of experienced staff, along with the cost of maintenance of equipment (2019).
- *"… [it is] at times difficult for the contractor to operate due to payment of the first slice after 30% completion. This payment sometimes is made after receipt of materials on site for drilling and some clients such as government fail or delay the payment* (2019).

Bank guarantees

- *"weak state regulation requires … official letters of credit for the import of all equipment, parts, and accessories. Letters of credit incur bank charges set at 3.5 percent of the cost and freight' value of the imported goods"* in South Sudan (2019).

Payment delays by client

- *"Extreme delay in payments for contracts executed for the governments. This may result in privately owned businesses becoming bankrupt. If companies are paid in time … they [can] execute more projects* (2019).
- *"All contracts that are sponsored by INGO and international community like IMF, DFID, World Bank and others can pay contractors on time. While contracts sponsored by the Government of _____ cannot pay on time. For this reason, some reputable contractors do not bid for protects that are completely sponsored by Government. This is means there is little chances for projects sponsored by Government to be constructed with high professionalism and completed on time"* (2019).
- *the important issue apart from transparency in the procurement process, is that governments need to keep to timely payment not to discourage the serious bidders"* (2019).
- *The delayed payments are also a major cause for over pricing especially in economics with volatile exchange and inflations rates (2019). The big challenge our organization [NGO] face is to make payments on time as the work is done and the required justification document submitted. Sometimes the situation is related to bank transfer or the first time of vendor creation"* (2019).
- *… in some places in Tanzania … some contractors who have worked with local government agencies like district councils [experience] that the district councils owe them payments … sometimes it can take even some years after they have successfully completed the implementation of projects"* (2019).
- *The delayed payments to contractors not only affect their ability of continuing their work on site(s), but also create a kind of mistrust between the client and contractor in the long run"* (2019).
- *If a large contract, which constitutes a large percentage of the company's income, is delayed in payment, this can cause difficulty for the company, especially when it has likely invested a lot of time to prepare a bid and mobilize staff for the large contract"* (2019).

2. **Staffing**

- *"…contractors bidding and claiming that they have all the professional staff and equipment… [but] when supervising, you don't see those kind of professionals or equipment on the ground"* (2018).

- *"…contractors exaggerate the depths of drilled boreholes to cover for the cost of unsuccessful boreholes - this is mainly linked to poor supervision during drilling"; "depths reached given by drillers are sometimes questionable"* (2018).

3. **Management of drilling enterprises**
   - Problems faced by drillers who may encounter problems in the field, such as loss of drill bits, and *"expect the wrath of their bosses in town who know nothing about drilling but signing pay cheques"* (2018).
   - *"contractors …not being paid for abortive …has always been [an] area of concern… however we also face the issues with false claims from contractors about capacity in terms of equipment and human resources"* (2018)
4. **Maintaining drilling equipment**
   - *"… biggest challenges to maintain the business would be around the procurement and operation & maintenance of the equipment required for drilling and material transportation. Drilling sites are far from workshops and specialised shops"* (2019).
5. **Competition and rivalry**
   - *"On the field, many drilling companies are often reluctant to collaborate amongst themselves"* (2019).
   - *"Each company seeing the other one as a potential competitor or as its future rival in the procedures of procurement and contract award"* (2019).
6. **Long time between tendering and contract award**
   - A centralised tender review process is meant to be transparent and using a clear method for marking. However, the downside of this is that it takes excessively long. Between the call for bidders to the selection of the winners, months can pass, which can be very frustrating … to wait for the results with no work going on. It takes even longer if the bids are divided in different lots (2018). "*For the contractors, the time between bidding and receiving a response … is also too long and it can raise questions about the transparency and corruptions suspicion can arise from non-selected contractors* (2019).
7. **Bid documents and pre-bid meeting**
   - *"a … business may face the challenge of understanding the documentation and processing for bidding …, access to information, inadequate networks/referrals and corruption in contract awards and management" … A pre-bid meeting may help contractors to understand the bid documents and … ask questions".* (2019).
8. **Entering the market**
   - *"… if you are a new company, its difficult to win contracts besides having the equipment and experienced personnel as most contracts state that they want a company with at least 5 years experience. This … makes it difficult for the companies to sustain the cost of … expensive drilling equipment and the staff"* (2019).

One participant also raised the issue of mistrust and poor staff treatment within drilling companies: "*The drillers complain about little salaries and how late the salaries come out… and harshness and ill-treatment of staff by the company owners. Mistrust takes centre stage whether the owner of the company feels the workers steal"* (2018).

Improving the status quo

Participants also proposed ideas for improving and support private businesses through preventative maintenance, loans, tax exemptions, sharing of equipment, donor financial support to help companies establish and quality assurance mechanism for drilling materials (Box 16).

Box 16 Improving and supporting private enterprise – practical experiences and ideas

1. *"Small business should include **preventive maintenance of equipment** in their business plan (including the costing in their offers), train and enforce maintenance and risk management SOP (standard operating procedure) for staff at field level, have a network of suppliers for the key spare parts (especially the ones difficult to find locally), know who stock spare part or not and how long it take to get new ones. All these should be considered in the development of workplans when responding to tender"* (2019).
2. *"in Jordan companies were able to **borrow money from banks**, based on the agreed contract and the stamp from the client, to cover necessary costs, especially for procurement and initial staff cost before the first payment from the client comes"* (2019).
3. *"the enterprises must be supported by different mechanisms, like **tax free opportunities** and so on, since the investment is very huge and develop policy which is inclusive of promotion mechanisms"* (2019).
4. *Given that most drilling equipment used in DRC is old and run down, "it would be good if there is a efficient **network of drilling equipment** made in Africa with a good after sale policy"* (2019).
5. *"loans to purchase equipment would be the most practical way in which donors could help undercapitalized local drillers. By linking the loans to borehole contracts, the drilling company could provide appropriate discounts on each borehole. This approached was successfully experimented by UNICEF [in **South Sudan**] with support from EC funding where three rigs were bought and donated to the local private national drilling contractors"* (2019).
6. **Zimbabwe** Farmers Union is trying to trying to **build a database of drillers** who have done well for their farmers, so that they can refer their farmers to those that are professional (2019).
7. In **Trinidad and Tobago** there is a stringent Quality Assurance/Quality control regime in order to import drilling materials thus substandard materials aren't allowed in (2018).

Manual drilling

Information on manual drilling was given in the course materials, but was not a major focus. Nevertheless, some experiences were shared:

- *"Recently I've seen a manual drilling work in a hilly remote place at Chattogram district in **Bangladesh**. There is no way to send heavy mechanical drilling equipment at that place. Most of the drilling work [is] done without any supervision by a professional driller and they promote the manual drilling within local people. They have a syndicate to operate the manual drilling and promote the practice in nearby areas.* (2019).
- **Mozambique**: *"Our challenge as private sectors here in Mozambique is that the government considers machine drilling only and don't turn their necks to manual drillers, whereas we are doing more smarter job. I had an opportunity to repair some of the machine-drilled wells and I found out that many of them are not too deep and they have mud which was a common factor yet they charge way higher and deliver not much good work…*(2019)
- Manual drilling has been going on for well over thirty years in **Nigeria** and it is only in the last few years that some government projects started engaging manual drillers (2019).
- *"Borehole drilling in **South Sudan** is quite expensive ranging from 18,000 to 24,000 USD (i.e. 60 – 100m deep) whereas deep wells of 150 – 200m can go upto 40,000 USD , this is due many underline factors including accessibility and security. Due to the funding constraint many INGOs and National NGOs*

including UNICEF piloting manual drilling in some low risk areas (i.e. > 75% success). such as the Sudd Basin with high water tables of less than 10m" (2019).

Drilling associations

With relatively little documentation available on drilling associations, the courses provided a starting point for an inventory of where they exist and what they have done. The importance of associations was also recognised, e.g.:

- *"… the absence of association is exposing the contractors to many risks that might affect the continuity of projects, and could even threaten the contractor company itself, where the contractors are not well organized and protected, … [and] there is] the weak sharing of technical information related to water wells drilling business" (2019).*
- An association/society in water industry in each country should be taken seriously - to ascertain if people who're getting borehole contracts are well trained specialist who could handle the job perfectly or whether they are mere briefcase contractor (2019).
- There is need for more dialogue between the government, regulators, drilling contractors, consultants, international and local NGOs and also the beneficiaries; government should help stakeholders to meet and discuss the problems (2018).

Annex 4 includes an overview of where drilling associations have been established, and where participants wrote that none exists. Associations in Ethiopia, Kenya, Nigeria and Uganda (Box 17), as well as Chad, DRC (manual drilling only), Mozambique and Thailand may provide examples from which others could learn.

Box 17 Drilling Association Examples

In **Ethiopia** there is drilling association and Waterworks association (2019).

*"In 2003 the **Kenya** Water Industry Association (KWIA) was formed; drillers represent over 40% of membership. KWIA is active and reputable, promoting good governance and an associative culture … members include the premier water sectorstakeholders (manufactures, suppliers, contractors, consultants, etc.) and main functions includes 1. Lobbying/advocacy with collective representation to government (e.g. waiver of VAT from Borehole Drilling & Equipping 2003-2013), and 2. Services to Members (e.g. business promotion, conferences, study tours, skills development such as Operational Safety & Health Guidelines, website and a biannual magazine). To demystify the National Code of Practice and make guidance more accessible/understandable for both drillers and customers, a **Code of Conduct** for Drilling in Kenya has been drafted by KWIA"* (Tom Armstrong, Course Facilitator, Kenya).

In **Nigeria**, one of the major problem in the industry is superiority of one association to others. We have two recognized association-Borehole Drillers Association of Nigeria (BODAN) and the Association of Water Well Drilling Rigs Owners and Practitioners (AWDROP) who both shared nearly same vision in setting a standard for the industry but could not combine to form one due to their differences. They have contributed a lot towards building the water industry but still need supervision and support hands from Government to oversee some operations (2019).

There is a **Uganda Drillers Contractors Association (UCDA)** but it was not known by all Ugandan participants (2019)

10. Capacity

A key issue raised by participants throughout the course was weaknesses in many countries in the skills, knowledge and experience of staff responsible for siting, drilling, supervision, data collection (especially by drilling contractors) and project management. It was noted that people generally enter the industry, whether on the contractor or client side, without any formal practical training and thus learn on the job:

- Entrepreneurs are usually traders and many staff received an informal training in the field (**Niger**, 2019).

- The staff in the ministry [in **Nigeria**] may not always be trained in management of borehole drilling projects. Most of them were structural engineers and highway engineers. A very few were knowledgeable on borehole drilling projects (2019).
- In **Malawi**, "*the cadre that is usually delegated by the District water office to undertaken borehole supervising are General Certificate of Education holders (GCE) but have undergone some form of on the job training on borehole drilling. …they are usually seasoned water monitoring assistants who have been trained on borehole drilling within the government institutions*" (2019)

The need for technical training was emphasised, and was frequently suggested for action (Annex 5 and 6):

- "*Need capacity building training of drilling contractors; need regular training of client and staff; train the technical staff in what they do in the field*" (2018).
- The main challenge identified in Bangladesh is the lack of technical training of drilling contractors to collect and report data appropriately (2019)
- There are few known institutions offering drilling as a course. This has hindered many organizations to find qualified drillers, except those with 'learnt on the Job' qualification. (Zambia, 2019)
- *"The WASH sector must from time to time undertake a skills assessment of the government staff mandated to supervise borehole construction in order to tailor made training to ensure the right skills are imparted* (2019).

Despite the need, very few examples of training institutions were given (Box 18). A participant from **Jamaica** shared their good experience *"…it takes many years of experience to be effective drillers. Workers at the company have been there for over twenty years and have undergone extensive training. I personally think they can overcome the challenging of finding skilled persons for the job by offering internships or succession training programs* (2019)

Box 18 Training Institutions and Initiatives

Ethiopian Water Technology Institute has been established to strengthen professionals, which includes one to two month training courses on drilling technology, drilling machinery maintenance, conducting groundwater investigation, drilling supervision, how to operate/use/borehole camera. Future plans include a long-term training program for drilling engineers.

Zimbabwe: A massive training programme was rolled out in my country through UNICEF where drilling supervisors from government and NGOs where trained on proper siting and drilling of boreholes before a Rural WASH project that was implemented from year 2010 to 2015 in an effort toachieve the Millennium development Goal on water supply. The project was funded by DFID.

In Florida State, **USA**, there is continuing education in the drilling sector (2019).

However, a lack of incentives within the private sector for trained staff was raised as a concern by others:

- *"some (companies) … only care about money not capacity building, fear[ing] to employ those who would be knowing what to do in fear [of] high pay"* (2019).
- "*another problem facing the private sector is unwillingness to invest in the training and development of their staff accordingly. Private companies hardly pay or encourage their staff to develop their skills and knowledge in the borehole drilling* (2019).

A participant from **Chad** stated *"Contractors bidding and claiming that they have all the professional staff and equipment but in reality during supervision, you do not see that kind of professionals or equipment on the ground* (2019). This was echoed by another participant *"…a private company usually provide highly competent staff on the list when they submit a bidding document. However, they sometimes work in several different locations under*

multiple contracts, they are not always able to deploy the qualified staff mentioned as per their bidding documents. As a result, they dispatch someone who does not have enough capacity on-site leading poor quality of the work" (2019).

A lack of enough experienced hydrogeologists in the country to site and supervise drilling works was mentioned specifically by participants working in **Bangladesh**, **Chad** (2019), **Kenya** (2018) **Lebanon** (2018), local government staff in **Nigeria**, **Sierra Leone** (2019) **Somalia** (2018 & 2019), Eastern Equatoria State of **South Sudan** (2018) and **Zambia** (2019) among others.

Logistical problems were also highlighted as a capacity contraint, e.g. in the Kasai Central province in **Democratic Republic of Congo,** the area under the responsibility of the Provincial government is very vast, and they cannot control all the boreholes being drilled (2019).

Lack of professionals within drilling companies was also cited, e.g.:

- "*… most of the drilling company barley employ geoscientist as one of their staff let alone a retrained engineer to supervise …. [and they shift] the blame to geophysical company that carries out the preliminary investigation*" (2019).
- *"briefcase companies are doing drilling without knowing the Geo-Hydrology of the location. Especially, those who worked in remote village areas are worked blindly"* (2019).

11. Drilling in Conflict, Emergency and Humanitarian Contexts

Drilling in conflict, emergency and humanitarian contexts was not specifically addressed in the course, but a number of challenges and important issues were raised by participants. Planning can be difficult, getting to the field can be challenging due to security concerns, which can affect construction quality. There are risks of losing equipment, funding streams can fluctuate, there may be conflicts between host and refugee or internally displaced person (IDP) populations and in countries that have faced protracted crisis, human and equipment capacity can be very low (Box 19). One participant recommended hiring services when and where needed to be fit for purpose (2019), while another placed even greater emphasis on proper procurement planning (2019).

Box 19 Examples of issues faced when drilling in conflict, emergency and humanitarian contexts

Planning difficulties

"Preparing a procurement plan in a humanitarian context where there is ongoing conflict presents many challenges, including difficulties in collecting data (2019).

Procurement and contract management challenges

"in the emergency context I [is] difficult to assess contractor within short period of time and need to involve driller as soon as possible and cant able to follow the normal process" (2019); *"… lack of time to so proper hydrogeological studies and to the bidding/procurement process by a humanitarian organisation* (2018).

*"After the collapse of central government of **Somalia** in 1991, All government owned rigs were destroyed during the civil were, and from that period few private people … started to import second hand rigs which some of them even were very old. INGOs were the only entities … supporting drilling of boreholes to vulnerable communities affected by conflict. Lack of many companies in the ground forced to INGOs to deal the few companies without any competition and this resulted that the companies manipulate the way they want to manage the drilling as INGOs expatriates were not able to supervise due to security concerns. This has given an opportunity the private drillers to not follow the clauses in agreement and misuse the fund".*

Capacity constraints

"The needs to drill or rehabilitate boreholes can far beyond the capacity of the humanitarian sector actors, making prioritisation extremely difficult" (2019).

*"After eight years of the **Syria** crisis, there is lack of expert companies that are able to implement drilling projects. In addition, sanctions and currency inflation affect the cost estimation, while sanctions have also negatively affected the import of modern machinery".*

"The cost of new drilling equipment and critical economic situation in the north of Iraq is prohibitive to investment by the private sector (2018).

Challenges for field work

In **Somalia**, *"security factors constrain ability to fully follow a logical approach to siting, [with the need to] minimise exposure [and time] for consultant teams in the field … in insecure areas. [This] affects quality of the [drilling] works and success rates"* (2018). In such contexts, one driller estimated that less than a quarter of drilling activities are based on professional-grade hydrogeological, geophysical and environmental assessment/studies (2018).

Somalia *… drilling companies need to deal different actors who are controlling most of rural areas in Central Somalia. The companies should follow and respect/accept the conditions and rules that groups have developed. If the company does't follow their conditions is not allowed to do any work in that location.*

"We found ourselves many times working in situations of social unrest and armed conflict, access to sites is difficult if even possible, delaying plans and timeframes beyond donors deadlines. Also true for seasonal and environmental limitations to access (typhoons, monzon, floods, etc). …bilateral relations can become quite troublesome and clear transparent communication is essential" (2019).

South Sudan: "*Road infrastructure is poor with movement severely limited for 3-6 months during the rainy season. Until recently, the roads were littered with landmines, and security remains uncertain in several regions* (2019).

Risk of equipment loss, costs and insurance

"… a challenge to business owners is the risk of losing their rigs and others machines due to theft or destruction. I work in a crisis prone area where borehole contracts can be awarded in volatile areas and I have seen situation where drilling rigs are seized, stolen or destroyed as a result of attacks … a proper knowledge of the sites … will help mitigate these occurrences. …, properly registering … machines with insurance companies will help augment such losses" (2019).

"security conditions and the contractors are not willing to deploy the machinery" (2019)

"I once queried a drilling contractor why he quoted five times the engineer's estimate for drilling a borehole in the Niger Delta. His response was that he ran the risk of losing his equipment. Yet he was the only one prepared to take the risk. The high price was his insurance" (2019).

Funding constraints and opportunities

"In the humanitarian sector we tend to be restricted to available funds, and those can fluctuate enormously from one year to another. The capacity to retain the experienced and qualified staff, keep the equipment in good shape … have huge influence on the ability to perform. … you might end up with expensive equipment after a big investment seating in a warehouse under the dust rendering it unusable for the future".

"Emergency and short validity of grant of 6 months or a year. … paying attention to the seasonality of drilling … Considering the short grant duration, it creates a risk of having non-eligible bills and not being able to pay the drilling company for all of its expenses" (2019).

"…For the driller, it means having more pressure regarding implementation duration but it could also mean more leverage to increase some cost during the implementation when unplanned works need to be done (2019).

Conflict between refugee and community populations

"Low involvement of the community were the drilling was done. Briefly the drilling of boreholes was done in the community surrounding the refugee camp but water was meant for refugee camp. Initially there was an agreement between the host community and organizations that the community would have been given their drilled boreholes later as the compensation for the land where the drilling was done and pipeline passed. Since the drilling of boreholes for refugees came first this created a tension with host community as some did trust what was being said, the situation which was risking the all project including its sustainability" (2019).

12. Dialogue and Actions

In concluding the course, in the final assignment, participants were requested to engage in dialogue with people from a different stakeholder group, understand their perspectives on topics of their choice, and reflect on actions that could be taken by themselves and within their organisations to improve borehole drilling professionalism. This echoes the *UNICEF Guidance Note on Water Well Drilling* (Danert and Gesti Canuto, 2016), which considers dialogue and action as being essential to improve professionalism within an organisation, or country. Annex 5 and 6 provide an overview of the different topics discussed, types of stakeholders interviewed, and ideas for action.

Participants shared specific ideas for actions that they themselves or their respective organisations could carry out. The actions put forward cover the entire scope of the course, from training or capacity strengthening to establishing associations; from VAT reductions to informing others of what has been learnt; and from improving supervision to establishing a national groundwater database. The assignment also provided an opportunity for dialogue with others on contentious issues such as 'no water no pay', payment delays or procurement bottlenecks.

Despite the immense challenges, these numerous actions give cause for hope. "As put so eloquently by Dotun Adekile, a course facilitator: "*The sustainable groundwater development conversation has been on for decades and will continue beyond our times, but we must make our own contribution - we must continue to advocate for good practice*". Every action – every attempted action – is an important step towards the professional management of borehole drilling projects and programmes.

References

(2018) Stated by participant of the Online Course on the *Professional Management for Water Well Drilling Projects and Programmes* in 2018

(2019) Stated by participant of the Online Course on the *Professional Management for Water Well Drilling Projects and Programmes* in 2019

ADEKILE, D (2019) *Online Training Course on Professional Management of Water Well Drilling Projects and Programmes – Facilitator's reflections*, Internal Report prepared for Skat Foundation

ADEKILE, D. (2014) *Procurement and Contract Management of Drilled Well Construction. A Guide for Supervisors and Project Managers*, Rural Water Supply Network, Switzerland, Available at http://www.rural-water-supply.net/en/resources/details/431

ADELANA, S., TAMIRU, A., NKHUWA, D., TINDIMUGAYA, C., OGA, M., (2008). *Urban groundwater management and protection in Sub-Saharan Africa.* https://doi.org/10.1201/9780203889497.pt3

CHAKAVA, Y., FRANCEYS, R., PARKER, A., 2014. *Private boreholes for Nairobi's urban poor: The stop-gap or the solution?* Habitat Int. 43, 108–116. https://doi.org/10.1016/j.habitatint.2014.01.012

DANERT K., GESTI CANUTO J. (2016) Professional Water Well Drilling. A UNICEF Guidance Note , Unicef , Skat Foundation, Available at https://www.rural-water-supply.net/en/resources/details/775

DANERT, K AND THEIS, S (2018) *Professional Management of Water Well Drilling Projects and Programmes Online Course 2018, Report for Course Participants,* UNICEF-Skat Foundation Collaboration 2017-2019, Skat Foundation, St Gallen, Switzerland

DIENE, M (2019) *CONSULTANTS REPORT – Online course on "Professional Management of Water Well Drilling Projects and Programmes – an Overview*", Internal Report for Skat Foundation

FOSTER, S., BOUSQUET, A., FUREY, S., (2018). *Urban groundwater use in Tropical Africa - A key factor in enhancing water security?* Water Policy 20, 982–994. https://doi.org/10.2166/wp.2018.056

GARCIA SILVA, R, C (in press) *Hidden figures What the current national survey data do not tell us about groundwater use in urban Sub-Saharan Africa*, MSc Thesis WSE-GW, UNESCO-IHE, Delft, *under embargo at the time this report went to press*

GRÖNWALL, J. (2016) *Self-supply and accountability: to govern or not to govern groundwater for the (peri-urban poor in Accra, Ghana)*. Environ. Earth Sci. 75. https://doi.org/10.1007/s12665-016-5978-6

GRÖNWALL, J., MULENGA, M., MCGRANAHAN, G., (2010). *Groundwater, self-supply and poor urban dwellers A review with case studies of Bangalore and Lusaka*, Available at https://pubs.iied.org/pdfs/10584IIED.pdf

HAAG, J (2019) Report on the online course "Professional management *of water well drilling projects and programmes"*, Internal Report prepared for Skat Foundation

LIDDLE, E (2019) A systemic analysis of the factors that affect handpump-borehole yield and water quality in rural sub-Saharan Africa (Doctoral thesis). University of Cambridge, UK.

MILLAR, N.K. WAITE, L AND HARLAN, A. E. (2001) *WATER RESOURCES ASSESSMENT OF JAMAICA,* US Army corps and Topographic Engineering Center, Available at https://www.sam.usace.army.mil/Portals/46/docs/military/engineering/docs/WRA/Jamaica/Jamaica%20WRA%20-%20English.pdf

NGANYANYUKA, K., MARTINEZ, J., WESSELINK, A., LUNGO, J.H., GEORGIADOU, Y., 2014. *Accessing water services in Dar es Salaam: Are we counting what counts?* Habitat Int. 44, 358–366. https://doi.org/10.1016/j.habitatint.2014.07.003

NYARKO, K.B., ODAI, S.N., OWUSU, P.A., QUARTEY, E.K., (2008) *Water supply coping strategies in Accra.* Proc. 33rd WEDC Int. Conf. - Access to Sanit. safe water Glob. partnerships local actions, Accra, Ghana, 2008. 417–420.

SERELE, C (2019) *Professional Management of Water Well Drilling Projects and Programmes – An Overview: Co-facilitation Report*, Internal Report prepared for Skat Foundation

UPTON, K (2019) *Facilitator's Reflection Report,* Internal Report prepared for Skat Foundation

Annexes

Annex 1 Groundwater Use Statistics

One aspect of the course is for participants to reflect on the reliance of the population on groundwater as a source of their drinking water supply. Unfortunately, this data is not comprehensively available. Firstly the source of piped water supplies is rarely documents, and certainly not available in international statistics. Secondly, groundwater may provide a secondary source. In many countries, people residing in urban areas with unreliable piped supplies also invest in their own borehole. Nevertheless, the data within the JMP country files provides information on the primary drinking water supply, and thus a starting point to reflect upon groundwater dependency. The following was shared with the participants though a blog on the RWSN website (https://rwsn.blog/2019/06/25/just-how-much-do-countries-rely-on-groundwater-point-sources-for-their-drinking-water/).

The data presented in the table below has been prepared from the 2019 data published by the Joint Monitoring Programme (JMP) of the World Health Organisation (WHO) and UNICEF (see https://washdata.org/data). Each country has an associated spreadsheet with collated data on Water, Sanitation and Hygiene use. This data is gathered from national censuses as well as household surveys including the Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS) and many others. The country excel spread sheets (and the underlying surveys) contain a wealth of data!

The table below shows the percentage of the population that rely on groundwater point sources as their main source of drinking water for every country and territory for the most recent year for which survey data is available. The data is presented for urban, rural and total populations. Groundwater point sources include **protected** and **unprotected** wells and springs, as well as tube wells and boreholes. Countries may have slightly different nomenclature for the above terms, but these are harmonised in the country tables produced by the JMP.

It is important to note that the data only includes point sources. Water that is bought from vendors, sold in bottles/sachets or transmitted in pipes may also originate from groundwater, but this information is not generally collated by the censuses or surveys and thus cannot be reflected. Consequently, the actual dependency of a particular on groundwater for drinking may be considerably higher. In addition, national governments may also make calculations based on the infrastructure available and assumed number of users per source. Due to the different methods of data collection and calculation, these estimates may differ from that collected by the household survey or census.

Please note that the analysis below has not been peer-reviewed, and so if you are intending to use the data, please do check in the respective JMP country data table. In case you spot any mistakes, please inform the author directly at the email address above.

Table A1 Groundwater point source as main drinking water source (% of the population classified as urban, rural and total)

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Afghanistan	2017	57.3%	2017	71.5%	2017	68.1%
Albania	2012	6.4%	2012	14.7%	2012	10.2%
Algeria	2013	6.6%	2013	19.6%	2013	11.3%
American Samoa					2010	0.5%
Andorra					2005	6.6%
Angola	2016	17.7%	2016	43.0%	2016	26.8%
Anguilla	2009	0.7%			2009	0.7%
Antigua and Barbuda					2011	0.4%
Argentina	2013	9.1%	2010	37.7%	2010	15.0%
Armenia	2016	0.1%	2016	2.6%	2016	1.1%
Aruba					2010	1.3%
Australia	2013	0.1%	2013	1.1%	2013	0.5%
Azerbaijan	2017	0.1%	2017	12.1%	2017	5.4%
Bahamas					2010	2.9%
Bahrain					1995	1.4%
Bangladesh	2016	66.4%	2016	94.7%	2016	84.9%
Barbados			2010	0.1%	2012	0.1%
Belarus	2012	2.7%	2012	32.9%	2012	11.1%
Belize	2016	0.3%	2016	4.1%	2016	2.5%
Benin	2014	39.4%	2014	56.8%	2014	48.9%
Bhutan	2017	0.3%	2017	0.6%	2017	0.5%
Bolivia (Plurinational State of)	2017	5.0%	2017	42.2%	2017	16.5%
Bosnia and Herzegovina	2012	3.6%	2012	11.4%	2012	8.9%
Botswana	2017	0.1%	2017	14.9%	2017	5.3%

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Brazil	2017	0.4%	2017	8.4%	2017	1.6%
British Virgin Islands					2010	1.9%
Brunei Darussalam	2011	0.1%	2011	0.1%	2011	0.1%
Bulgaria	2001	0.4%	2001	2.7%	2001	1.1%
Burkina Faso	2017	17.1%	2017	85.6%	2017	72.9%
Burundi	2017	8.6%	2017	68.1%	2017	61.5%
Cabo Verde	2007	0.1%	2012	15.1%	2012	5.1%
Cambodia	2016	13.5%	2016	47.2%	2016	40.2%
Cameroon	2014	35.5%	2014	74.1%	2017	50.0%
Canada	2011	0.1%	2011	0.7%	2011	0.3%
Caribbean Netherlands					2001	27.3%
Cayman Islands	2010	4.9%		0.0%	2010	4.9%
Central African Republic	2010	49.1%	2010	92.1%	2010	75.4%
Chad	2015	48.0%	2015	82.4%	2015	74.6%
Chile	2017	0.6%	2017	4.0%	2017	2.4%
China	2013	7.4%	2013	43.1%	2016	22.4%
Colombia	2018	0.4%	2018	13.7%	2018	3.3%
Comoros	2012	5.1%	2012	21.3%	2012	16.2%
Congo	2015	24.9%	2015	65.7%	2015	38.3%
Cook Islands					2011	0.0%
Costa Rica	2018	0.0%	2018	0.5%	2018	0.2%
Côte d'Ivoire	2017	33.9%	2017	71.0%	2017	49.5%
Croatia	2003	3.3%	2003	18.0%	2003	20.0%
Cuba	2011	13.5%	2014	41.9%	2011	18.2%
Curaçao					2011	0.9%
Czechia	2003	1.5%	2003	7.1%		
Democratic People's Republic of Korea	2017	17.1%	2017	58.1%	2017	33.1%

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Democratic Republic of the Congo	2014	33.0%	2014	79.4%	2014	63.5%
Djibouti	2017	0.6%	2017	55.5%	2017	10.9%
Dominica	2001	0.6%	2001	6.3%	2009	0.3%
Dominican Republic	2016	0.1%	2016	2.3%	2016	0.7%
Ecuador	2017	1.1%	2017	17.1%	2017	6.1%
Egypt	2017	0.4%	2017	2.1%	2017	1.4%
El Salvador	2017	3.0%	2017	12.3%	2017	6.6%
Equatorial Guinea	2011	44.7%	2011	51.9%	2011	48.4%
Eritrea	2010	3.4%	2010	36.0%	2010	24.6%
Estonia	2010	1.7%	2010	18.8%	2010	6.7%
Eswatini	2014	3.7%	2014	31.5%	2014	24.0%
Ethiopia	2017	5.1%	2017	62.3%	2017	52.0%
Falkland Islands (Malvinas)			2016	43.7%		
Fiji	2014	1.1%	2014	13.6%	2014	7.2%
Finland	1999	1.0%	2005	5.0%	2005	1.0%
French Guiana	1999	5.0%	1999	6.0%	2015	13.5%
Gabon	2013	3.3%	2013	37.8%	2013	8.2%
Gambia	2013	14.4%	2013	60.0%	2013	32.6%
Georgia	2017	4.9%	2017	46.9%	2017	22.2%
Germany	2007	0.8%	2007	0.8%	2007	0.0%
Ghana	2017	11.3%	2017	56.7%	2017	36.0%
Greece	2001	0.2%	2001	3.8%		
Grenada	1999	4.0%	1999	18.0%		
Guadeloupe	2006	0.8%	2006	0.3%	2006	0.8%
Guam					2010	0.1%
Guatemala	2015	5.0%	2015	19.6%	2015	13.4%
Guinea	2016	32.8%	2016	75.3%	2016	59.0%

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Guinea-Bissau	2014	41.0%	2014	78.0%	2014	61.7%
Guyana	2014	1.3%	2014	5.5%	2014	4.4%
Haiti	2017	8.1%	2017	56.5%	2017	37.5%
Honduras	2017	2.0%	2017	4.2%	2017	3.0%
Hungary	1990	5.0%	1990	28.9%		
India	2016	23.8%	2016	63.7%	2016	50.5%
Indonesia	2018	35.2%	2018	66.9%	2018	49.6%
Iran (Islamic Republic of)	2015	1.8%	2015	4.6%	2015	0.8%
Iraq	2018	0.5%	2018	4.6%	2018	1.8%
Ireland	2006	0.0%	2006	0.5%		
Italy					2001	3.9%
Jamaica	2014	0.0%	2014	1.2%	2014	0.6%
Jordan	2016	0.3%	2016	0.7%	2016	0.4%
Kazakhstan	2015	3.2%	2015	21.0%	2015	11.5%
Kenya	2017	21.2%	2017	54.1%	2017	46.2%
Kiribati	2014	0.0%	2014	0.0%	2014	0.0%
Kyrgyzstan	2014	1.1%	2014	11.3%	2014	8.1%
Lao People's Democratic Republic	2017	9.0%	2017	46.0%	2017	34.7%
Latvia	2003	2.4%	2003	12.5%		
Lebanon					2016	10.9%
Lesotho	2015	5.5%	2015	27.8%	2015	21.4%
Liberia	2016	58.7%	2016	74.7%	2016	65.3%
Libya	1995	35.8%	1995	26.9%	2014	19.1%
Madagascar	2016	24.5%	2016	61.6%	2016	57.6%
Malawi	2017	16.3%	2017	86.0%	2017	73.8%
Malaysia	2003	0.8%	2003	6.7%		
Maldives	2014	0.1%	2014	0.2%	2017	0.5%

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Mali	2018	19.5%	2018	72.3%	2018	56.2%
Marshall Islands	2017	0.2%	2017	2.5%	2017	0.6%
Martinique	1999	0.5%			2015	0.4%
Mauritania	2015	6.5%	2015	49.4%	2015	29.1%
Mayotte		0.0%			2013	2.5%
Mexico	2017	0.8%	2017	9.5%	2017	2.8%
Micronesia (Federated States of)	2010	3.6%	2010	10.7%	2010	9.1%
Mongolia	2016	12.8%	2016	52.7%	2016	25.8%
Montenegro	2013	5.1%	2013	29.2%	2013	14.1%
Montserrat	1998	2.0%	1998	100.0%	2001	0.1%
Morocco	2012	1.0%	2012	27.2%	2012	10.2%
Mozambique	2015	21.4%	2015	62.5%	2015	49.6%
Myanmar	2016	34.3%	2016	74.8%	2016	64.0%
Namibia	2016	0.6%	2016	23.4%	2016	11.8%
Nauru	2011	1.6%	2011	0.0%	2011	1.6%
Nepal	2016	41.8%	2016	46.8%	2016	44.4%
New Caledonia					2014	3.1%
Nicaragua	2014	4.4%	2014	59.9%	2016	21.4%
Niger	2017	33.9%	2017	71.0%	2017	49.5%
Nigeria	2018	45.3%	2018	73.1%	2018	60.0%
Niue			1999	20.0%	2010	0.0%
North Macedonia	2011	1.5%	2011	15.1%	2011	7.7%
Northern Mariana Islands	2000	1.3%		0.0%	2010	1.1%
Oman	2014	5.1%	2014	10.0%	2014	6.4%
Pakistan	2016	30.4%	2016	44.0%	2016	39.1%
Panama	2015	0.7%	2015	14.6%	2017	0.0%
Papua New Guinea	2017	2.8%	2017	7.5%	2017	7.1%

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Paraguay	2017	2.1%	2017	9.2%	2017	4.8%
Peru	2017	1.5%	2017	11.1%	2017	3.8%
Philippines	2017	8.4%	2017	37.6%	2017	23.9%
Portugal	2001	0.1%	2001	0.7%		
Puerto Rico					1995	1.8%
Republic of Korea					2015	1.0%
Republic of Moldova	2012	16.9%	2012	65.1%	2012	47.1%
Réunion					2015	0.2%
Romania	1994	11.3%	1994	81.0%		
Russian Federation	2009	3.4%	2009	19.5%	2009	8.6%
Rwanda	2017	17.2%	2017	58.4%	2017	50.4%
Saint Kitts and Nevis	1999	27.0%	1999	27.0%	2007	0.3%
Saint Lucia	2012	0.5%	2012	2.0%	2012	1.6%
Saint Vincent and the Grenadines			1999	20.0%	2012	0.1%
Samoa	2016	2.6%	2016	5.6%	2016	5.0%
Sao Tome and Principe	2010	4.5%	2010	11.7%	2010	6.9%
Saudi Arabia					2017	0.2%
Senegal	2017	7.2%	2017	35.0%	2017	22.5%
Serbia	2014	2.4%	2014	11.7%	2014	6.2%
Sierra Leone	2017	54.7%	2017	68.9%	2017	62.6%
Sint Maarten (Dutch part)					2011	7.4%
Slovakia	2003	2.3%	2003	2.3%	2011	13.1%
Solomon Islands	2015	8.6%	2016	27.6%	2015	17.5%
Somalia	2017	9.5%	2017	60.5%	2017	34.1%
South Africa	2017	0.5%	2017	10.1%	2017	3.8%
South Sudan	2017	66.5%	2017	80.1%	2017	77.3%
Spain	2003	0.6%	2003	0.3%		

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Sri Lanka	2016	17.3%	2016	51.0%	2016	45.3%
Sudan	2014	2.2%	2014	13.2%	2014	9.8%
Suriname	2017	3.1%	2017	5.4%	2017	3.8%
Syrian Arab Republic	2018	4.2%	2018	11.6%	2018	8.4%
Tajikistan	2017	5.2%	2017	18.7%	2017	15.4%
Thailand	2016	1.8%	2016	6.2%	2016	4.2%
Timor-Leste	2016	20.0%	2016	33.6%	2016	29.9%
Togo	2017	36.6%	2017	61.2%	2017	51.8%
Tonga	1999	28.0%	1999	24.0%	1996	1.7%
Trinidad and Tobago	2011	0.9%	2011	1.0%	2011	0.9%
Tunisia	2015	0.5%	2015	10.8%	2015	3.7%
Turkey	2013	5.0%	2013	40.0%	2013	13.0%
Turkmenistan	2016	4.4%	2016	34.3%	2016	22.6%
Turks and Caicos Islands	1999	22.0%	1999	40.0%	2012	1.7%
Tuvalu	2007	1.7%	2007	0.5%	2007	1.1%
Uganda	2017	35.8%	2017	79.6%	2017	71.9%
Ukraine	2018	11.5%	2018	61.2%	2018	27.8%
United Arab Emirates	2003	0.2%			2018	0.1%
United Republic of Tanzania	2017	19.4%	2017	50.5%	2017	41.2%
United States of America	2015	3.0%	2015	45.2%	2015	11.1%
Uruguay	2017	0.0%	2017	3.1%	2017	0.2%
Uzbekistan	2015	6.9%	2015	22.7%	2015	14.2%
Vanuatu	2016	1.6%	2016	4.8%	2016	4.0%
Venezuela (Bolivarian Republic of)	2011	4.3%	2011	25.6%	2011	6.8%
Viet Nam	2016	19.5%	2016	57.2%	2016	45.2%
West Bank and Gaza Strip	2017	1.2%	2017	3.2%	2017	1.5%
Yemen	2013	2.3%	2013	43.1%	2013	31.6%

Country	Urban		Rural		Total	
	Census/ Survey Year	Groundwater point source as main drinking water source (% of the urban population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the rural population)	Census/ Survey Year	Groundwater point source as main drinking water source (% of the total population)
Zambia	2015	26.7%	2015	76.8%	2015	55.8%
Zimbabwe	2017	11.1%	2017	77.5%	2017	57.0%

Annex 2 National Groundwater Database

Table A2 Response to question: *Is there a national groundwater database in your country?*

Country	Existence of database?	Participants clarifications and comments
Azerbaijan	**Yes**	Paper maps where GPS coordinates for a borehole can provide depth for drilling and potential water quality with respect to 3 monitored minerals. There was mention of it being transferred into an electronic format (2019).
Bangladesh	**Yes**	Department of Public Health (DPHE) has a ground water database for all over the country and WDB has few. BWDB has lots of monitoring well throughout the Bangladesh.
Benin	**Yes**	Groundwater database in the national Water Resources Information System (WRIS) (2018) Systeme National d'Information sur l'Eau (http://snieau.bj) (2018)
Afghanistan	**Yes**	There is database for groundwater which is not accurate and nor reliable (2019).
Bangladesh	**Yes/No**	Department of Public Health (DPHE), Government entity is supposed to manage one (2019). Department of Public Health (DPHE) has a ground water database for all over the country and Bangladesh Water Development Board has few (2019). Ground water date base coming from drilling is automatically goes to DPHE not BWDB (2019). Not available at the online platform, but we copies of the databases are available (2019). Department of Public Health Engineering has Aquifer Database Inventory (2019). Database is very general and not updating regularly thus we have to rely our own study, investigation as well (2019). We have borehole log data for the Riverside area but we do not have available data for the coastal area (2019).
Burkina Faso	**Yes**	The establishment of the groundwater resource observation network is relatively recent (1992), although the first piezometer has been installed since 1978 (2019). Since 1996, there have been a national network of about 52 sites with about 94 functional piezometers spread across the country. You will agree with me that this is insufficient to have an exaustive data of groundwater (2019). The existing database is the inventory of drilling, this database is maintained by the Ministry of Water and updated every year. But here too I do not think it is exhaustive because there are still some structures that drill without going through the normal circuit (2019).
Cameroon	**No**	Some sparse groundwater database could exist in institution such as the Ministry of Energy and Water Resources (MINEE) (2019). Current "groundwater databases" are not officially recognized and only cover some regions of Cameroon[9].
Chad	**Yes**	Groundwater database maintained by the ministry in charge of water and is regularly updated, containing 17,000 records (2018)
Côte d'Ivoire	**Yes/No**	Groundwater database is not up to date and data collection is not systematic (2018). No systematic groundwater database (2018).
Democratic Republic of Congo	No	UNICEF has been collecting data with a view to enabling a database to be established (2019). Groundwater database exists from the 1950's and the public company that manages the mines and geographic institute are trying to update hydrogeological maps (2018).
Ethiopia	No	No system to store drilled borehole data (2018). Groundwater mapping efforts (Government and UNICEF) are ongoing (2018). Hard copy records of boreholes drilled for Government in _____region but not well organised and scattered (2018).

[9] Key studies on the groundwater of Cameroon are: 1) Mengnjo et al. (2015) for the Northwest Region, Ngounou Ngatcha et al. (2007, Djoret and Travi(2001) for the Lac Chad Basin, 3) Fouepé et al. (2010) for the Anga'a River, Yaoundé, Fantong et al. (2010) for the Mayo Tsanaga River Basin and Kamtchueng et al. (2016) for the Nyos Catchment.

Country	**Existence of database?**	**Participants clarifications and comments**
		Lack of attention by government to collect, store and collate borehole data & lack of a standard borehole data-reporting format (2018). Efforts to develop a groundwater database are underway. Planned to be managed at the Ministry of Water, Irrigation and Electricity (MIE) (2019). National level database managed by the Ministry of Water, Irrigation, and Electricity (2019).
France		BRGM, a public institution provide access to maps and research outputs through their web portal http://infoterre.brgm.fr/. It's mostly for France and its overseas territories but you can also find information in other countries where BRGM has done research
Ghana	No	Groundwater database is not well developed and needs a careful collection and integration of all data from relevant institution and organisations into one database (2018). There is no proper groundwater database. Water Resource Commission is responsible for managing groundwater data. There have been some specific projects such as the Hydrogeological Assessment of Northern Ghana Project (HAP) but there is still a huge gap in terms of nationwide groundwater database (2019).
Guinea Bissau	Yes	Has an official borehole database (including functionality, location, type of borehole); does not have a well-established system but is being assisted by UNICEF with online system (2018).
Iraq	No	UNDP may support groundwater database (2018).
Kenya	No	Historic database is not comprehensive, particularly of recent decades. There is no central point for storing information and many boreholes lack proper documentation (2018). The Water Resources Authority currently has a groundwater database that is being developed although it is not yet operational (2019). KWIA has pilot project to digitally map boreholes and is trying to obtain funding to scale up (2019).
Lao PDR	No	New established Ministry of Natural Resources and Environment (MoRE) has a mandate to manage the database (2019).
Lebanon	No	Does not have a geological survey. Each project follows its own template for the borehole completion report. There is a groundwater database structure in the Ministry of Energy and Water, but it is almost empty (2018).
Liberia	No	Under development (2018)
Madagascar	No	Groundwater database underdevelopment (2018).
Malawi	**Yes**	Old data in the groundwater database (2018) There is a groundwater database at the Groundwater Division, which uses two software's (WISH and HYDSTRA) (2018).
Mozambique	No	On-going process to establish a national database (data is currently scattered in Excel files in the provinces of boreholes constructed in each district) (2018)
Nicaragua	**Yes**	Efforts to implement a database system since 2012 but with difficulties; data not public (2018).
Nepal	No	Groundwater Resource Development Board (GWRDB) under the Ministry of Irrigation keeps the data for all Terai districts of Nepal. Kathmandu Valley Water Supply Management Board (KVWSMB) under the Ministry of Water Supply and Sanitation keeps the data for the Kathmandu valley. Beside from these institutions, no any institutions/organization keep that kind of data (2019).
Niger	**Yes**	Managed by Public Office IRH/GISNER but it needs a consolidation and updating
Nigeria	**Yes/No**	To the best of my knowledge, there is no groundwater database in Nigeria or any agency responsible for that (2019). Groundwater database managed by the Nigeria Hydrological Services Agency (NIHSA) (2019).

Country	**Existence of database?**	**Participants clarifications and comments**
Pakistan	**No**	Some organisations are collecting some data (depending on need), but there is no systematic sharing and even if data is submitted to the relevant department, the database is not updated on a regular basis (2018).
Saudi Arabia	No	(2018)
Sierra Leone	Yes	Salone groundwater resources database (SALGRID) – http://www.salgrid.org/# (2018)
Somalia	No	No database of groundwater resources (2018).
South Sudan	No	No national groundwater database. There are ten groundwater databases located in ten states, but they are poorly managed, e.g. only 1,642 boreholes recorded in Torit State since 2011 (2018).
Sri Lanka	Yes/No	National Water Supply and Drainage Board (NWSDB) and Water Resources Board (WRB) have groundwater data (2019). The ground water DATA BASE is with NWSDB and WRB. Both are maintain their own history. The DATA are not compiled together.
Sudan	No	Due to lack of institutional and legal mandate, available groundwater data are incomplete, not up to date, un-checked, fragmented in different places/organisations and considered as highly confidential (2018)
Syria	**Yes**	The groundwater information considered as strategic information, and water might be a reason for conflict reason in the future. Ministry of water resources is responsible to study and archive all water sources and hydrologic data in the country. Those studies are not shared publicly. When you plan to drill any borehole organisations must communicate with the respective ministry or water directorate to plan in according to their strategic plan and not harm the existing water aquifer (2019). There is groundwater database but it was not updated during the current wartime.
Tanzania	*No*	
Thailand	**Yes**	Groundwater database maintained by Department of Groundwater Resources contains thousands of drilling records (2018). The Department of Groundwater Resources is managing groundwater database which other organization or private drillers can have access to this database in order to make decision on borehole siting and water management (2019).
Timor Leste	No	(2019)
Trinidad and Tobago	No	No national groundwater database, but persons working within the Water and Sewerage Authority will have their personal databases created for their ease of reference when doing their job. There is reluctant to share data. *"People must understand that the data doesn't belong to them, it belongs to the organisation … for the betterment of Trinidad and Tobago"* (2018).
Uganda	**Yes**	Managed by the Ministry of Water and Environment. Uganda has also developed ground water maps for most districts (2019).
Ukraine	**No**	(2018)
Yemen	**Yes/no**	National Water Resources Authority used to collect groundwater and water level data but stopped due to funding shortages/struggle to collect data; some NGOs as well as private users do not submit data (2018).
Zambia	No	However plans are under way to have the national groundwater data base to be housed under Ministry of Water Development ,Sanitation and Environmental Protection under the auspice of Water Resources Management Authority (WARMA). Information is available at Local Authority level (2019).
Zimbabwe	No	There is, however a water point database (RWIMS), which is a partnership between government and UNICEF.

Annex 3 Adherence to the Four Steps for Better Drilling Contracts

Table A3 Self-assessment by participants of the extent that the four steps for better drilling contracts are followed in their respective organisations for select countries (2019)

Country	Type of Organisation	 Procurement Plan	 Contract Award	 Contract Management	 Monitoring & Reporting	Additional Participant Reflections (in normal font) or *Facilitators Comments (in italics)*
Angola	UN	✓	✓	✓	✗	Contract type at times is not very detailed to suite the actual well drilling contract requirements especially if there are no technical staff to review the draft contracts to be used. Payment schedules are usually aligned to the one year budget system which is sometimes not very workable if implementation starts late in the year. Variations on works are very difficult to include as the contracts are usually fixed contracts with very little or no possibility to adjust the price upwards.
Bangladesh	UN	✓	✓	✓	✗	Limited skilled drillers/drilling company available. Companies do not have hydrologist and skilled engineer.
Ethiopia	Government	✗	✗	✗	✗	*Assignments provide a very good reflection of actual challenges faced, including high staff turnover, challenges of calculating costs, vast workload (including distances) compared to human resource availability in the local government.*
		✗	✗	✗	✗	In most cases, assessment of the companies is not well done and sometimes briefcase contractors get contracts. No prior discussion with potential contractors. Companies most of the time go out without knowing the areas geologic condition and face problems on their company and on beneficiaries. Recently in most of the cases the client geologist/hydrogeologist are not regularly supervising the drilling process creating great loop holes in the quality of the bore hole drilling and construction.
Ghana	Government	✓	✓	✓	✗	The state organisation is usually challenged with the fact that they have to make a follow up to verify the authenticity of the documentation submitted with the tender. It is normally difficult for them because of financial constraints and some the companies not responding to request for verifications.
Lao PDR	UN	✓	✓	✓	**?**	*Monitoring of facility & establishing support to communities for operation and maintenance of the facilities after the handing over was not described.*
Nepal	Government	✓	✓	✓	✓	*Organisation managing the drilling is the same organisation that is using the borehole.*
Nigeria	NGO	✓	✓	✓	✗	Post-construction monitoring is being entrusted to each community to oversee the functionality yield and water quality. Unfortunately, few of those communities has shown enthusiasm about the project once is faulty which most resulted to abandoned projects due to lack of maintenance, financial and human resource management.

Country	Type of Organisation	 Procurement Plan	 Contract Award	 Contract Management	 Monitoring & Reporting	Additional Participant Reflections (in normal font) or *Facilitators Comments (in italics)*
Nigeria	NGO	✓	✓	✓	✓	Not much funding is available and approve to carry out regular follow up.
Nigeria	Private Sector	✓	✓	✓	**?**	*Monitoring of facility & establishing support to communities for operation and maintenance of the facilities after the handing over was not described.*
Nigeria	UN with government	✓	✓	✓	✗	Each of States clusters the borehole locations into lots of minimum 10 boreholes using criteria such as proximity, accessibility and hydrogeological conditions, type of water extraction.
Tanzania	UN	✓	✓	✓	**?**	*Monitoring of facility & establishing support to communities for operation and maintenance of the facilities after the handing over was not described.*
		✓	✓	✓	**?**	*Monitoring of facility & establishing support to communities for operation and maintenance of the facilities after the handing over was not described.*
Uganda	NGO	✓	✓	✓	**?**	*Monitoring of facility & establishing support to communities for operation and maintenance of the facilities after the handing over was not described.*
Uganda	NGO	✓	✓	✓	✓/✗ (60%)[10]	We collaborate with district officials to do a joint monitoring of the constructed/rehabilitated facilities. A report highlighting the challenges faced is always shared with the District water offices, which usually take responsibility of operation and maintenance after the defect period.
USA	Private, reflecting on Government	✓	✓	✓	**?**	Two main well drilling companies are used for large municipal projects. The large municipalities have pre-qualified their drillers. Other drillers are welcome to submit bids, but it is not likely that they will be accepted for the job, due to the reputation of the main two drillers.
Zambia	Government	✓	✓	✓	✓/✗ (70%)[11]	The four steps are imbedded in the guidelines already developed by the Government. Although the fourth step ends at defect liability period. Often than not, there is less post construction support, monitoring and reporting schedule drafted after the defect liability period.

[10] Self-scoring by participant

[11] Participant wrote *"the extent to which monitoring and reporting is followed is roughly 70 %"*, i.e. self-scoring.

Annex 4 Institutional and Legal Framework for 40 Countries– Summary of Responses by Participants

The table below summarises responses to questions on the institutional and legal framework by course participants (2018 and 2019). It covers 40 countries. It is important to note that the responses have not been verified by further literature or a desk review and so reflect the knowledge of the course participants. In cases where there are discrepancies in the responses, these have been noted. Note that in cases where there were differing responses, or the responses are particularly nuanced, the symbol ~ is used.

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Bangladesh		**No**	**Yes**	**No**	**No**	▪ Lots of guidelines or standards for borehole drilling and it is easily, understandable but not widely circulated. In my personal view, there is no organization/institute in frontline to enforce published guideline. ▪ No national association but a few have their small association in district level. ▪ In recent days the major city has done laws not to extract water from ground privately
Benin	**Yes**		**Yes**	**Yes**	**Yes**	▪ No licence, but drillers need to be registered with the Direction General de l'Eau ▪ Drillers association does not seem to be active ▪ DANIDA supported development of guidelines/standards ▪ Permit required if a private company wants to use groundwater for industrial use
Bolivia						▪ Groundwater is considered in national laws and water management plans. New regulatory framework has been created form Supremo Decree No. 2855 (August 2, 2016) which norm the drilling of wells for water supply as an exclusive competence of the Central Government.
Burkina Faso				**Yes**		▪ National Association of Professionals of the Sewerage and Drinking Water Sector of Burkina Faso (ANP-SEBAP), established in 2010, with the support of DANIDA.

[12] for Borehole Drilling & Rehabilitation

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Cameroon[13]	**No**			**No**	**Yes**	▪ Abstraction permit is required to develop groundwater in Cameroon. ▪ Drilling for industrial and commercial purposes need permission of Ministry of Water and Energy added to financial taxes. An exemption of a permission and taxes concerns all types of waters (including drilling) for household's use and family's consumption but within the permitted quantitative & qualitative limits. ▪ Drilling companies should submit drilling data (on quantity water quality) regularly to the Ministry of Energy and Water Resources.
Chad	**~**[14]		**Yes**	**Yes**	**No**	▪ No system of the certification from the ministry of the Water for drilling companies (2019). ▪ National guidelines have been published for borehole drilling and specifically for manual drilling. ▪ Drillers association is active and sometimes involved in training/capacity building. ▪ National Water Fund (new agency under Ministry of Water) working on groundwater abstraction regulations
Côte d'Ivoire	**Yes**		**No**	**No**		▪ Drillers require approval from the National Office for Drinking Water ▪ Regulation of drinking water exists but not widely known and does not actually apply ▪ There is no manual setting out drilling procedures

[13] The law nº 96/12 of August 1996 stipulates that the whole hydrography of sea, surface and ground waters are under the national jurisdiction of Cameroon. There is also the decree nº 2001/165 of May 2001 bearing all modalities on the protection of sea, surface and ground waters of Cameroon against pollution.

[14] Certification is only for manual drilling.

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Democratic Republic of Congo	**Yes**		**No**	**~**[15]		▪ The ministry in charge of water resources is responsible for licensing and regulation of drilling activities. Company needs trade registration no., tax no. & approval from the respective ministry to be able to operate. Drilling companies need prior authorization before any activity. The ministry in charge of water through its decentralized structures such as the SNHCR or the REGIDESO must be contacted by the companies to obtain the authorization to drill. ▪ Water Code (2016) has been promulgated and government has repealed all previous provisions on drilling ▪ Manual drillers association with provincial branches exists-
Ethiopia	**Yes**	**No**	**No**	**~**	**No**	▪ Annual renewal of drillers licences. ▪ Drilling contractors can be members of the National Water Works Contractors Association, but this association is not considered reputable by all, and only few drilling contractors are members. ▪ Drilling permits exist, but are not enforced; abstraction licencing under development
Ghana	**Yes**		**Yes**	**~**	**Yes**	▪ Guidelines for borehole drilling and rehabilitation published but they may not be well-known to practitioners due to insufficient dissemination; guidelines are straightforward to understand; lack of incentives to adhere ▪ There is a drillers association but it one participant state that it is "not effective". ▪ Most unregistered companies able to work for government, NGOs and private users; contractors who do not adhere to them are been punished by not getting approval for certification.
Iraq			**Yes (but old)**			▪ UNICEF building capacity of directorate of underground water in 2018 ▪ The only official document considered as a manual by a (specific) drilling contractor in Iraq is the Bill of Quantity.
Jamaica	**Yes**				**Yes**	▪ The licence to drill is has to be renewed every five years by the Water Resources Authority. ▪ Customers have to get a permit to drill.

[15] Associations for manual drillers.

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Kenya	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	▪ All drillers, hydro-geologists and water sector consultants must be registered and licenced. Drillers are registered and regulated by the Ministry of water and Sanitation of Kenya. The list of licenced drillers and other water professionals (consultants) is published on the Ministry's website, which is updated annually. Unregistered driller cannot obtained a drilling contract from government or NGO. However, annual renewal of registration and licence is normally automatic and in devolved units, some contractors can practice without licence. ▪ National Codes of Practice[16] gazetted in 2013 but not widely known/availed/ adhered to. CoPs under review. ▪ Kenya Water industry Association (KWIA) is active and reputable, promoting good governance and an associative culture; drillers represent 40% of membership ▪ Groundwater authorization is required from Water Resources Authority for borehole drilling; this can be converted to a Groundwater Abstraction Licence.
Lebanon	**Yes**		**No**		**Yes**	▪ Water Code (2018) includes articles on groundwater protection, well drilling licences & gw abstraction ▪ Supposed to have a permit, but there is widespread illegal, unlicensed drilling
Liberia	**No**		**No**	**No**	**No**	▪ Chapter on "Drilled Well" within the Guidelines for Water and Sanitation Services ▪ Discussions regarding abstraction permits are on-going
Madagascar	**Yes**			**No**	**Yes**	▪ Abstraction permits are in the code of water but not put into effect
Malawi			**Yes**	**No**	**Yes**	▪ Drillers need registration when bidding ▪ New drilling guidelines and standards published in 2016 (JICA supported) ▪ Association not necessarily registered ▪ Enforcement of water permits not good

[16] 1. Siting of Boreholes, 2. Borehole Construction; 3 Supervision of Construction of Boreholes and 4. Pumping Test of Boreholes

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Mozambique	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	▪ Regulation according to Public Works ministerial diploma 77/2015. No company can drill boreholes for states without a licence. ▪ Guideline approved by Government (degree law 18/2012 for exploration of groundwater through wells and boreholes, but not widely known beyond government staff. ▪ Government has capacity limitations for enforcement. ▪ Mozambique National Driller Association (APM) has small support from World Bank ▪ Decree 43/2007 & 12/2012 regulates water abstractions. Permits required for commercial & industrial use; irrigation of area more than 1 hectare and piped water
Nepal	**Yes**	**No**	**~**	**~**		▪ Drillers have to obtain licences. Unregistered drilling contractor ca not obtain work from Government. ▪ There is regulation of groundwater consultants but only for Kathmandu Valley i.e. in Capital of Nepal and it is followed by Kathmandu Valley Water Supply Management Board but there is not any regulation outside. ▪ Opinion differences regarding guidelines o No national guidelines or standards for borehole drilling and rehabilitation. o The government has prescribed guidelines for methods and technologies to be followed in drilling. Specific lithologies are listed with acceptable drilling methods and how to list unit rates in BOQs. These are standardized and followed by certain actors such as INGOs but enforced, only available in print form and the private sector along with smaller NGOs may contract drillers who do not follow the guidelines. o Department of Water Supply and Sewerage has own guidelines which helps for drilling. ▪ Different opinions: National drillers association of Nepal is not so active; there is no national association.
Nicaragua				**No**		▪ Norms exist but are not well known by the public

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Nigeria	**No**	**No**	**Yes**	**Yes**	**No**	▪ Drilling companies only have to register as corporate organisations. Federal Government through the NIGERIA Integrated Water Resources Management Commission (NIWRMC) regulates drillers - this was contested by a trainer. Consultants must register with the Corporate Affairs Commission (CAC) but this is not groundwater specific. Practicing geologists and geoscientists are registered by the Council of Mining Engineers and Geoscientists (COMEG) but the body has some in-house issues in the past few years and has have not been effective. ▪ Code of Practice for Water Well construction issued in 2010 is comprehensive but little known, even among professionals. Not all rules are well followed due to lack of enforcement from Government and penalty for organization that deviate; adherence to the regulations and enforcement weak; no enforcement of the standards and there are no incentives to adhere to the guidelines. ▪ There are two drillers associations that operate nationally - BODAN and AWDROP
Pakistan		**~**	**No**	**No**		▪ The regulation of groundwater consultants are there but an active regulation body is not available, plus that is not the case all over the country, its only limited to certain parts of the country, mostly to big cities ▪ Guidelines / standards for borehole drilling are available with departments at the provincial level tuned to their context, but not published at the national level at regular intervals. They are not in the form of set regulations. Private drilling companies, involved in non-government projects do not follow them appropriately.
Saudi Arabia	**Yes**		**No**	**No**	**Yes**	▪ General procedures about borehole drilling available when drillers get their licence ▪ Study underway to better monitor and manage drilling contractors ▪ New Water Law

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Sierra Leone	**No**	**No**	**Yes**	**No**	**No**	▪ Currently, there are no regulations for contractors and hydrologist for boreholes in the country. It seems anybody who has a drilling machine can construct a borehole. ▪ In future, the Water Resources Management Agency will have to regulate the boreholes drilling processes. New National Water Resources Management Act 2017 will regulate companies /consultants and abstraction ▪ Principles of Borehole Drilling and rehabilitation published ▪ There are standards in Sierra Leone for borehole drilling and construction but problem we have in the country is the reinforcement of those guidelines and code.
South Sudan	**No**		**Yes**	**No**	**No**	▪ Guideline on drilling association is being worked on. ▪ Hand dug well water association newly initiated by government with UNICEF support. ▪ Issuing of permits & regulating abstraction has not been clearly streamlined to states.
Somalia	**No**	**No**	**No**	**No**	**No**	▪ Due to prolonged civil war in Somalia, there is no national drilling association in Somalia ▪ There is no any regulation of drillers and s no licenses
Spain	**Yes**				**Yes**	▪ It is common to have illegal drilling. Some studies talk about 500,000 to 1 million illegal boreholes operating in the country, mostly for irrigation. ▪ When a drilling fails, minimizing costs is at stake and they tend to be left poorly protected or filled
Sri Lanka				**No**		▪ The local drillers in local Government as small enterprises registration
Sudan	**No**			**No**	**No**	
Syria	**Yes**	**No**	**Yes**	**No**		▪ There are guidelines and standards for borehole drilling but are not well published,also unfortunately not all of the guidelines are well followed due to lack of site supervision or potential bribery. ▪ Drillers are licenced and controlled by ministry of water and they cannot can drill without obtaining a licence for each borehole in name specifying the exact location, depth, etc.

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Tanzania	**Yes**	**Yes**	**Yes**	**No**	**Yes**	▪ One has to acquire a drilling permit prior to undertaking drilling. This is being regulated by the relevant government bodies i.e. water basin boards. It is not that effective, as some contractors tend to drill without having the permit when mostly doing the drilling for private sectors. No unregistered contractor or contractor can obtain work for government. ▪ Groundwater consultants are regulated by the Engineers Registration Board (ERB). Unregistered consultant/contractor cannot obtain work for government, but NGO or private user can offer them work. ▪ Guidelines on procedures for groundwater exploration in Tanzania mainland; Government regulations and guidelines on groundwater exploration in Tanzania mainland and Government specifications and regulations applicable to water well drilling and installation in Tanzania mainland. Unfortunately these are are not widely known, with no incentives to adhere and no enforcement. ▪ The regulation of water use is in place where one has to pay for water abstraction annually but not very effective, as it is not known by everyone. In 2019, the government has removed it or made the use underground water by private sectors free.
Timor Leste	**No**	**No**	**No**	**No**	**No**	▪ Government is currently engaged in undertaking a countrywide groundwater study which would serve as a knowledge base for regulations, licensing
Trinidad and Tobago	**Yes**		**No**	**No**	**Yes**	▪ To become approved (pre-qualify) by the Water and Sewerage Authority (WASA), drillers are required to have their rig inspected and approved for the use specified. ▪ National Energy Skills Center's Drilling Academy trains upcoming drillers and sets out standards and procedures for them to follow ▪ Although there is no national guideline of standard for borehole drilling in Trinidad and Tobago, there are two pieces of legislation that are applied to all borehole drilling and rehabilitation contracts (chapter8).

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Thailand	**Yes**	**No**	**Yes**	**Yes**	**Yes**	▪ Drillers without certificates cannot obtain work for government, NGOs or private ▪ Groundwater Act B.E 2520 and notifications /regulations under the act specify that for groundwater drilling, a geologist or engineer has to be responsible for supervision. They have to be certified, which involved passing training. The certificate is valid for 5 years. However, the act does not specify any standards of practices for supervisors. ▪ Guidelines not widely known nor so easy to understand; Incentives to adhere to guidelines lacking, as is enforcement ▪ Drillers association is active and reputable ▪ All types of drilling and abstraction operations require licences
Ukraine	**Yes**				**Yes**	▪ Permission for a borehole is needed if daily consumption is bigger than $5m^3$ or water to be used for farming
Uganda	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	▪ Drillers **and consultants** licences issued on an annual basis; list on Ministry of Water & Environment website ▪ Policies, regulation, guidelines, standards in place but enforcement is a challenge ▪ Borehole numbering system in place ▪ Permits required for motorised boreholes ▪ Ugandan government has guidelines for drilling and rehabilitation and well known with practitioners; it's a mandate for all practitioners to know and practice them ▪ Have a drillers association (started about 2 years ago and so far it is reputable. ▪ Drillers are licenced and controlled by Ministry of Water and Environment and no driller can get a job for government or NGO without being registered.

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
USA (Florida State)	**Yes**	**Yes**				▪ Drillers must be licensed through the State of Florida and must be continually active in the drilling profession to maintain their license. For all public, federal, and most private wells, the driller must be certified through their State. Only in some cases will private wells be drilled without a licensed driller. ▪ Groundwater consultant must be a licensed professional geologist in their State. Similar to drillers, hydrogeologists must show that they are working in their field, and must take 30 "continuing education" credits every 2 years. No person can sign/seal for well drilling projects without a P.G. license. Courses are offered online, e.g. buy a 30-credit package that once they review the material and pass the quizzes, they show certificate to State Board and they are approved. Credits are also obtained from attending conferences related to hydrogeology
Yemen	**Yes**		**No**			▪ Drilling permission paper exercise only/ standards & regulations not strictly enforced ▪ Standards need to be updated ▪ SWSLC has established a department to supervise drillers ▪ National Water Resources Authority used to collect groundwater and water level data but stopped due to funding shortages/struggle to collect data and some NGOs as well as private users do not submit data ▪ Young professionals prefer to seek opportunities with NGOs other than government

Country	Does the following exist in the country?					Notes: These are comments by the participants and trainers as shared in the discussion forums and through assignments. It should be noted that these comments have not been verified.
	Licence/registration /permit/certificate		National guidelines[12] & standards	National drillers association	Abstraction permit/ licence	
	Drillers	Consult -ants				
Zambia	**Yes**			**Yes**	**Yes**	▪ National drillers association that focuses on self-regulation of drillers, registration of members and fostering the voice of drilling companies with the regulator Water Resources Management Authority (WARMA) ▪ Statutory Instruments No. !8-20 were introduced in 2018 require all drillers and consultants to be registered with WARMA. it provides for licensing of drillers, registration of equipment etc. ▪ With the Statutory Instrument recently introduced, it obliges that all boreholes drilled have to be fully cased to the bottom. If this is not followed,Drillers risk their licenses being revoked. ▪ The Zambian regulation provide now for abstraction permits for both surface and ground water. Drilling a single borehole requires a one payment of $23 and any user abstracting more than 10,000 litres per day is expecting to be paying for the water. ▪ Zambia is in the process of populating the groundwater data base and shall be housed by Water Resources Management Authority (WARMA) in the Ministry of Water Developments, Sanitation and Environmental Protection
Zimbabwe				**No**	**Yes**	▪ Groundwater abstraction and use is regulated by the Water Act chapter 20;24 of 1998: a borehole can only be drilled after obtaining authority from the Catchment Council (CC) and the authority will lapse after 12 months. Information such as property name, location of existing boreholes, the number and location of potential sites to be drilled, water use and abstraction volumes shall be submitted to the catchment council (CC) on prescribed forms whether or not the borehole is to be used for primary or commercial purposes. It is also mandatory to submit the drilling and construction, pumping test, pump installation and water quality data to the CC on the appropriate forms provided by the CC. However most drillers do not submit the data.

Annex 5 Actions Proposed to Raise Drilling Professionalism (2018)

The table below summaries the topics discussed and actions proposed by participants to raise drilling professionalism in assignment module 5.

			Stakeholders Interviewed/Surveyed									
			Govt.		Not G.		Private			Other		
Organisation	**Country**	Topic(s) Discussed	National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	**Ideas for action**
Government	Benin	Groundwater database and groundwater monitoring network	✓									Noted that monitoring is financed by donors rather than government.
UN	Cameroon	Key actions required	✓			✓		✓				Elaboration of a construction code/technical guideline; Training of borehole drilling companies Improved planning at council level; Audit of borehole drilling companies
UN	Chad	Manual drilling association (issues, technical capability, expectation and plans)						✓				Survey on the quality of the upper aquifer that underlies N'Djamena; Raise awareness of positioning wells to avoid contamination in the urban setting; Train new members of the association, on drilling techniques and bidding
UN	Côte d'Ivoire	Delays in execution of works, Procurement and supervision, Data	✓					✓			✓	Set up data collection tools. Recover VAT
UN	DRC	Manual drilling professionalization (company registration, associations, govt. dialogue)				✓						Support the establishment of a drillers association

			Stakeholders Interviewed/Surveyed									
			Govt.		Not G.		Private			Other		
Organisation	**Country**	Topic(s) Discussed	National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	**Ideas for action**
UN	DRC	Manual drilling (institutional framework, providers, donors); Mapping of areas favourable for manual drilling; Obstacles to use of hydrogeologists to site and supervise		✓		✓						Include supervision by an experienced hydrogeologists in all tenders
UN	Ethiopia	Drilling Supervision (availability, capacity, qualifications, delays, milestones, in-house vs. outsourcing)		✓	✓			✓				Study to better understand economic value of drilling supervision. Develop code of conduct/code of practice Support groundwater legislation
UN	Ethiopia	Groundwater information Project design, implementation & monitoring: Human resources capacity in local government (experience, equipment, turnover)		✓								Expand detailed hydrogeological studies involving remote sensing and overlay analysis, field studies and drilling test wells. Support and lobby for improved data collection, including sharing best practice. Provide on-job and practical training to professionals
UN	Ghana	Value for money, procurement, professional expertise	✓				✓					Have a central point at national level for data collation. See how many reports by different stakeholders can be routinely shared.

Organisation	Country	Topic(s) Discussed	Stakeholders Interviewed/Surveyed									Ideas for action
			Govt.		Not G.		Private			Other		
			National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	
UN	Ghana	Mechanisms for professionalism, borehole drilling management, data	✓									Hold discussions with CWSA on the workflow and steps to improve on professionalism. Ensure measures are in place to improve data collection. Will validate all sites selected by consultants before construction takes place. Carry out a nation-wide capacity building and refresher training on professionalism within borehole drilling.
UN	Iraq	Selection of borehole location						✓			✓	Mapping water aquifers. Enhance capacity in Directorate of Underground Water. Update/ activate technical guidelines for water including boreholes
UN	Iraq	Authorisation to drill, drilling professionalism, improvements	✓	✓	✓							Share knowledge learned. Explore how to establish better information management system for boreholes
UN	Jordan	Lack of drilling contractors, maintenance of completed borehole, oversight	✓									Technical training. Conduct feasibility studies for planned projects. Differentiate between development and emergency projects
UN	Kenya	Major challenges, community engagement and procurement		✓		✓						Support capacity building of county team to build drilling supervision capacity through workshops and on-job training.
UN	Lebanon	Siting, permits	✓									Will include a hydrogeologist for site selection, follow-up during drilling and documentation of results. Engage in dialogue to reach a proper coordination and data sharing, plus harmonized data recording.

Organisation	Country	Topic(s) Discussed	Stakeholders Interviewed/Surveyed									Ideas for action
			Govt.		Not G.		Private			Other		
			National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	
UN	Madagascar	Private sector perspective						✓				Try to enable drillers to be paid their first instalment after receiving materials to support small drilling companies. Map areas with groundwater potential (project underway).
UN	Madagascar	Reduce negative boreholes, sustainability of boreholes and control office						✓				Several solutions proposed (improve siting and database, and set up monitoring chain)
Government	Malawi	On-site practical issues (contract document, equipment, safety and security)						✓				Hold site meetings so that all parties involved can meet and discuss pertinent issues of the contract and check equipment.
Government	Nicaragua	Familiarity with procedures, obstacles								✓		Develop a training program to reproduce knowledge learned during the course. Implement a system to register contractors that demonstrate capacity to provide the services.
UN	Nigeria	Code of Practice, supervising capacity, payment for dry boreholes and roles.					✓					Strengthen adherence to Nigerian Code of Practice
UN	Nigeria	Borehole failure, non-adherence to specifications, quality control		✓			✓					Organise on-job field training programme for contractors to demonstrate key stages such as test pumping and platform construction. Technical training of government for supervision and 3rd party monitoring

			Stakeholders Interviewed/Surveyed									
			Govt.		Not G.		Private			Other		
Organisation	Country	Topic(s) Discussed	National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	Ideas for action
NGO	Pakistan	Bidding, siting, coordination, post-construction monitoring				✓		✓				I can share resistivity test data for areas where the chances of dry boreholes are high with the relevant government line department. Pay for dry boreholes in areas where chances are high.
Government	Saudi Arabia	Siting - use of geophysical methods, maps and hydrogeological reports before drilling; licencing; costing; quality; dry boreholes										Strengthen capacity. Training on costing. Borehole database. Guidelines
UN	Sierra Leone	Drilling process including contract award, supervision, regulation, groundwater database and operation and maintenance	✓									Try to scale up SALWACO Sustainability Plans across the country.
UN	Somalia	Borehole lifespan, reasons for failure, professional siting and construction						✓				Will advocate with the water department to include drilling sector stakeholder conference in the 2018 work plan.
UN	South Sudan	Procurement, supervision and monitoring of borehole drilling							✓			Improve professional skills of drilling supervision On job training for newly recruited drillers Closer collaboration between agencies for procurement
Government	Thailand	Problems of borehole drilling, challenges and solutions						✓				Noted that the lack of deeds of ownership of land where drilling is to take place causes problems for drillers. Provide budget to enhance drilling capacity.

			Stakeholders Interviewed/Surveyed									
			Govt.		Not G.		Private			Other		
Organisation	**Country**	Topic(s) Discussed	National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	**Ideas for action**
Government	Trinidad and Tobago	Groundwater information	✓									Put all data available into one national water database
Government	Trinidad and Tobago	Groundwater database, data sharing, drillers association; human capacity: licences;	✓					✓				Establish a national database. Educate the public about the benefits of water well drilling. Engage Ministry of Planning in siting process. Share plans with other relevant ministries.
UN	Uganda	Difficulties and how to address them						✓				Discuss clustering drilling works for a number of districts with the government
UN	Uganda	Hydrogeological information and borehole records				✓						Advocate for inclusion of supervision in borehole procurement, ensuring budget provision and experienced and skilled person is assigned to supervise. Efforts to improve borehole record keeping by drillers and sharing with government
NGO	Yemen	Equipment, challenges, siting, driller orientation								✓		Share what has been learnt. Organisation to set a good example.
NGO	Yemen	Technical drilling challenges		✓								Follow systematic steps for borehole project

Annex 6 Actions Proposed to Raise Drilling Professionalism (2019)

The table below summaries the topics discussed and actions proposed by participants to raise drilling professionalism in assignment module 5.

			Stakeholders Interviewed/Surveyed									Ideas for action
			Govt.-		Non G		Private			Other		
Organisation	Country	Topic(s) Discussed	National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	
NGO	Bangladesh	Drilling project improvement				✓		✓				Provide training, prepare guidelines and establish database of drilling companies.
UN	Bangladesh	Procurement and contract management process	✓			✓						Raise skills of partner organisations.
UN	Bangladesh	Borehole planning, design, construction and supervision				✓						Engage someone for full time supervision.
NGO	Bangladesh	Procurement						✓				Organise a training workshop for partners and drilling companies
UN	Bangladesh	Water quality of tube wells and contamination.				✓						Develop guideline on hygiene during well development to share with partners.
UN	Bangladesh	Siting, selection of contractors, supervision & pump test	✓									Develop clear guidelines for procurement, contract management, monitoring, supervision, data recording and reporting for the organisation.
NGO	Burkina Faso	Understanding project operations	✓									Avoid front companies. Hold pre-bid meeting. Integrate payment for dry boreholes.
NGO	Cameroon	Situation analysis		✓								Raise awareness of siting, construction and utilisation aspects among water resource managers, planners and policy makers.
UN	Chad	Contract management	✓									Revised and aligned key elements of this course, specially procurement and dialogue and action

Organisation	Country	Topic(s) Discussed	Stakeholders Interviewed/Surveyed									Ideas for action
			Govt.-		Non G		Private			Other		
			National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	
												in my organisation. I will improve the supervising of the project flowing all aspect in this course.
UN	Chad	Drilling professionalism	✓									Restitution of the key elements of this course (the five modules) to all the stakeholders in boreholes drilling, especially colleagues, logistic, and Government supervisors.
UN	DRC	Realities of drilling in the province		✓								Work to improve many aspects of borehole drilling professionalism.
UN	Ethiopia	Dry boreholes, regulations, challenges	✓									Support drillers association. Provide equipment and training on use of equipment to government bureaus.
Government	Ghana	Post-construction monitoring, water quality, procurement and contract management.	✓			✓						Share knowledge from course and advocate for capacity building
Private	Ghana	Procurement & monitoring challenges	✓			✓						Send blind sample to water quality testing labs
UN	Ghana	Drilling capacity, accountability and incentives for professionalism	✓									Engage more with the government to translate interest or desire for quality boreholes into deliverables. Explore the provision of better guidelines.
Private	Jamaica	Staff retention, clientele, monitoring					✓	✓				
UN	Kenya	Viability, water quality, local government, challenges.		✓								Support capacity building of county water department.

Organisation	Country	Topic(s) Discussed	Stakeholders Interviewed/Surveyed									Ideas for action
			Govt.-		Non G		Private			Other		
			National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	
UN	Kenya	Professionalism in the drilling sector	✓									Develop simple and clear ToR's for siting and supervision. Ensure proper procurement steps are followed and that borehole completion reports are submitted. Raise awareness of problems with no water no pay contracts.
UN	Madagascar	Realities of drilling						✓				Improve drilling capacity and payment modalities.
NGO	Madagascar	Drilling situation & professionalism									✓	Coach drillers and build their capacity on siting.
UN	Malawi	Regulation of borehole drilling and construction	✓									Inform my organisation of the registration requirements of the National Water Resources Authority (NWRA). Engage with NWRA on other compliance aspects.
NGO	Nepal	Institutional strengthening, siting , construction quality					✓	✓			✓	Strengthen the institutional framework.
NGO	Nepal	Post-construction monitoring, functionality, private sector capacity.	✓									Give reasonable contract terms for the drilling of dry boreholes and communicate these terms to bidding drillers. Consider giving more weight to the technical aspects of proposals.
UN	Niger	Understanding of specific project & capacities				✓						Facilitate training.
Private	Nigeria	Quality and contract award		✓								Training government staff on professional management of drilling projects. Advise my organisation to ensure invoices are paid on time and push invoices personally to the finance team.

Organisation	Country	Topic(s) Discussed	Stakeholders Interviewed/Surveyed									Ideas for action
			Govt.-		Non G		Private			Other		
			National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	
UN	Nigeria	Cost-effective boreholes in Nigeria				✓		✓				Support the Government for comprehensive registration of all drilling companies.
Private	Nigeria	Borehole quality, staff capacity, selection, payment	✓									Training the government staff on professional management of drilling projects.
Private	Nigeria	Borehole failure, costing & pricing; integrity						✓				Design training programme for geoscientists and professionals with relevant associations. Inform the public on the importance of effective drilling professionalism.
NGO	Pakistan	Drilling quality						✓				Note the importance of siting before initiation a project and allocate a contingency budget.
UN	Somalia	Private sector realities						✓				Ensure hydrogeological studies prior to drilling. Establish a national drilling and groundwater database.
UN	South Sudan	The drilling industry						✓				Advocate to the government for tax exemption for an item related to boreholes spare parts. Provide support for the training of local professionals in Business management.
UN	South Sudan	Drilling professionalism					✓	✓				Establish a groundwater database, form a drillers association and provide training in supervision.
UN	Syria	Main challenges facing businesses	✓			✓	✓			✓		Broad range of areas require attention.
UN	Tanzania	Adherence to principles for cost-effective borehole drilling.				✓						Adhere to the principles of cost-effective drilling and enhance cooperation with others.
UN	Timor Leste	Groundwater as a resource and groundwater usage	✓		✓	✓						Continue stakeholder consultation and compiling scattered knowledge.

Organisation	Country	Topic(s) Discussed	Stakeholders Interviewed/Surveyed									Ideas for action
			Govt.-		Non G		Private			Other		
			National	Region/ Province/ Local	UNICEF/ UNHCR	NGO/CBO	Siting/ supervision	Drilling	Support	Donor	Civil society/ research	
NGO	Uganda	Drilling realities		✓				✓	✓		✓	Ensure real-time supervision. Find ways of paying towards dry boreholes in water-stressed belts/areas.
Government	Uganda	Experiences of borehole drilling		✓								Training
Government	Zambia	Procurement				✓						All drilling companies should send one or two officers for training on technical aspects. Train government staff involved in siting and operating drilling rigs.
WFP	Zimbabwe	Professionalism, challenges, improvements to drilling				✓						Improve procedures within the organisation. Provide advice to private farmers on drilling. Support the establishment of a drilling association.
Private	Zimbabwe	Regulation and licencing								✓		Advocacy on hiring professionals. Make better use of groundwater data within the organisation.