

Professional Drilling Management Online Course

Training Report 2022



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This document reports on the online course entitled Professional Drilling Management that took place in 2022. The course was financed by Federal Institute for Geosciences and Natural Resources (BGR), Germany. This is the second of two documents – the first reports on the online course Groundwater Resources Management. Both reports can be downloaded from www.rural-water-supply.net, <http://agw-net.org/> and <https://ask-for-water.ch>

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The first edition of the course in 2018 was developed within a Project Collaboration Agreement (PCA) between UNICEF and Skat Foundation, while the second edition of the course was made possible thanks to collaboration, financial and in-kind support from Skat Foundation, Lotteriefonds St. Gallen, United Nations High Commission for Refugees (UNHCR), WaterAid UK, Oxfam UK, the Water Integrity Network (WIN), the British Geological Survey (BGS), UNICEF and the Africa Groundwater Network (AGW-Net).

Partnership

The 2022 Online Groundwater Courses benefitted from the establishment of an advisory group, which brought together about 40 key stakeholders from the water and higher education sectors. The advisory group provided expertise to improve the content and methodology of the course, raised awareness of the initiative and joined hands to see how to continue to stimulate interest and fund professional capacity development in the future. The courses were reviewed, co-facilitated and supported by partner organisations as shown in the logos below. Annex 1 provides the list of course managers, plus the volunteer reviewers and co-facilitators of the course.



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Summary

Drilled water wells are vital to achieving universal clean drinking water, providing safe, affordable, reliable and available water sources. To ensure that the water wells or boreholes are built to last, they must be drilled, developed and completed in a professional manner. Key elements of a professional drilling sector are robust procurement, contract management, siting, borehole design, construction, and supervision. Furthermore, the management of the groundwater resources must also be considered and support provided to long-term maintenance if services are to last. Unfortunately, in many countries it is difficult to develop skills in these areas due to a lack of training and mentoring opportunities. Thanks to funding from the Federal Institute for Geosciences and Natural Resources (BGR) in Germany, 2022 two online courses (i) Groundwater Resources Management and (ii) Professional Drilling Management each targeting 250 participants were held.

The Professional Drilling Management Course ran over a four-month period from July to October 2022. It was implemented for water professionals, with guidance and support from about 40 partner organisations from the water, groundwater and higher education sectors.

The 2022 online course on Professional Drilling Management provided participants with a comprehensive overview of the different aspects of drilling management, specifically (i) groundwater data and siting; (ii) procurement and contract management (including costing and pricing); (iii) borehole drilling and supervision and (iv) legal and institutional frameworks. In the last of five modules, participants were encouraged to reflect upon and share actions that they as individuals and as organisations could take to raise drilling professionalism in the context in which they work.

From the 781 people who applied for the course, 314 were selected, of which 209 were active participants. A total of 162, equivalent to 78% of the active participants passed the course. This is significantly higher than the current Cap-Net average completion rate of 53%, and 15% for Massive Open Online Courses (MOOCs). To pass, they had to pass a series of quizzes, which tested their knowledge of each module. Of the active participants, 40% were women – a major achievement in such a traditionally male-dominated sector. Further, 86% of participants were from African member states, reflecting the intentional geographic focus of the course, and partnership with the African Ministers Council on Water (AMCOW).

The course evaluation survey shows that participants appreciated the course and the knowledge they gained, as well and that their expectation has been met. Of those (146) who completed the participant feedback survey, 97% stated that the course was very beneficial, and 73% found it to be extremely relevant for their work.

This 2022 Online Course on Professional Drilling Management, and its sister course, Groundwater Resources Management, should not be the end of this type of training. The participants responses in terms of satisfaction, alongside the type of actions that they would like to take as a result of the knowledge gained, indicate that the course is meeting a need in the sector. The high pass rate, alongside the responses of the participants in the discussion forum, and drilling sector survey, indicates high motivation among the participants, alongside a well-structured and pedagogically robust course.

The large interest in this course, with less than half of applicants invited, illustrates that there is high demand for this type of learning. Of the over 750 people who applied, that remain, a large number of male applicants from NGOs and the UN who were not invited to take this edition due to the agreed emphasis on women and government staff in particular.

Participants of the course were keen to see that others are trained, and capacity built further, with many expressing an interest in training that is more in-depth, and also field training. Previous online

courses have required participants to also pass assignments, thus applying their knowledge, and receiving more feedback from facilitators. It is very important to recognise that while the latter provide more depth, they are more costly, and given the extremely limited, and to date ad hoc funding, that there will always be a trade-off between participant numbers and depth.

The topics raised in the discussion forums illustrated the multifaceted nature and complexity of the drilling sector in many countries. While training alone is unlikely to be able to solve all of the challenges, it does place professionals in a much stronger position, armed with information and knowledge to challenge the status quo and improve not only practices but also the wider legal and institutional framework which affects how projects operate.

The online course discussions and survey not only raise skills, but the compilation and analysis of the data shared provides insights into the opportunities and challenges of the drilling sector across the world. As this report shows, many challenges, such as lack of groundwater data, corruption, coupled with gaps in skills and a distinct lack of training opportunities are undermining the sector, and thus the attainment of the Sustainable Development Goals for Drinking Water - all over the world.

As this report goes to press, the organisers have not secured funding for this course to be run again. Discussions with SADC GMI, ECOWAS and 2iE showed a keen interest in rolling out, and even adapting the Groundwater Resources Management course the two Southern and West African Regions in the future.

Fundraising efforts to enable this course to continue, need to continue. Looking into the future, the advisory group that was established for the two Groundwater Courses in 2022 is striving to enable these courses to be rolled out in different languages, and ultimately managed by African Institutions.

It is recommended that this course is run again, ideally on an annual basis. The organisations that are actively involved in fundraising for future courses are all encouraged to continue with their efforts to raise funds to make this possible. In addition, regional organisations, such as SADC-GMI and 2iE are encouraged to embed this course within their own training programmes.

Looking ahead, regional courses, with facilitators covering all regions within the country could enable participants to sharpen their knowledge on the specific issues, guidelines, policies and practices within their specific countries.

More effort is needed at national, and potentially regional, and international level to sensitise stakeholders about what borehole drilling guidelines or standards, and groundwater regulations have been issued.

Inspired by the courses, an entry on Groundwater Databases has been developed as part of the African Groundwater Atlas ¹ by the British Geological Survey (BGS). In order to boost knowledge about groundwater databases in future courses, a short video with two or three examples of groundwater databases, including their update and mechanisms for access should be prepared based on countries with particularly good practice.

These specific challenges are important to consider in future courses which may have a specific geographical (regional) focus. Incorporating course contents and bringing in co-facilitators to address these issues would add value to the courses.

¹ <https://www.bgs.ac.uk/geology-projects/africa-groundwater-atlas/>

For those potential participants who are interested in taking such a course, or who applied for the courses in 2022, but were not successful, the courses will hopefully be available once again.

And for funding agencies in the sector, who are keen to build capacity, it is hoped that this report will inspire you to invest in training, whether face-to-face or online, or to bring these issues into existing certificate or degree programmes, so that the professionalism of the borehole drilling sector can go from strength to strength and support the attainment of Sustainable Development Goal (SDG) 6.1 in particular.

Introduction

An estimated 50% of the global and 75% of the African population rely on groundwater for their drinking water supplies. This is likely to increase in the future, in the face of growing demands and climate change, particularly given that groundwater resources are often less affected than surface water by climate change impacts.

Drilled water wells are vital to achieving universal clean drinking water, providing safe, affordable, reliable and available water sources. To ensure that the water wells or boreholes are built to last, they must be drilled, developed and completed in a professional manner. Key elements of a professional drilling sector are robust procurement, contract management, siting, borehole design, construction, and supervision. Furthermore, the management of the groundwater resources must also be considered and support provided to long-term maintenance if services are to last. Unfortunately, in many countries it is difficult to develop skills in these areas due to a lack of training and mentoring opportunities,

Thanks to funding from the Federal Institute for Geosciences and Natural Resources (BGR) in Germany, 2022 saw two online courses on groundwater, targeting about 500 participants in total. The courses, entitled Groundwater Resources Management and Professional Drilling Management were hosted by Cap-Net UNDP ² and managed by the African Groundwater Network (AGW-Net) and Ask for Water GmbH. The courses were specifically developed for professionals working on groundwater resources management and the management of water well drilling projects, as well as those responsible for decision making. They each ran over a four-month period, and were offered free of charge to all participants, with the aim of building the capacity of government, NGO, and private sector staff, as well as academia in African member states and beyond.

While Professional Drilling Management online course is no substitute for face-to-face training and mentoring, it does provide a relatively low-cost way to introduce a large number of professionals with a thirst for knowledge, to the main aspects of professional drilling management.

This document reports on the 2022 **Professional Drilling Management** online course. It provides information on the participants, and their perceptions of the course, as well as reflections from the facilitators. The report also summarises what was shared by the participants on the discussion forums and through a participant survey. The latter provides insights into professional drilling management from around the world, the challenges that still need to be overcome. This combination of process and content reporting is intended to provide food for thought and inspiration for future capacity building initiatives, whether online or face to face, whether global, regional or national. An accompanying course manual and course materials are also available for download.³

² <https://cap-net.org/pdm/>

³ Danert, K. Brentführer, R. and Diene, M. 2023. 'Professional Drilling Management Online Course - a Training Manual (2022)' Ask for Water GmbH, Africa Groundwater Network (AGW-Net), Federal Institute for Geosciences and Natural Resources (BGR), African Ministers Council on Water (AMCOW), UNDP Cap-Net & Partenariat National de l'Eau du Sénégal (PNES). <https://doi.org/10.13140/RG.2.2.16659.14888>

1 Course content and learning methods

The 2022 online course on professional drilling management provided participants with an introduction on how to professionally manage water well drilling projects and programmes. It set out to equip participants with knowledge on: groundwater data, siting, costing and pricing, procurement and contract management, borehole drilling and supervision and how professional water well drilling is affected by the wider legal and institutional environment. The five course modules are summarised in Box 1.

Box 1 Professional Drilling Management online course - overview of the five training modules

Module 1- Introduction, Groundwater Data and Siting provides participants with:

- an appreciation of the importance of groundwater for drinking water supplies in their own country
- an understanding of select key groundwater terms
- recognition of the value of groundwater data
- a basic understanding of what constitutes good borehole siting and how the siting process depends on the hydrogeological environment.

Module 2: Procurement and Contract Management of Borehole Drilling. Upon completion, participants have a better appreciation of the financial risks of borehole drilling and know that there are different cost components to consider. They are thus able to reflect on the borehole drilling procurement and contract management processes within their own organisation.

Module 3: Borehole Drilling and Supervision enables participants understand some of the key technical reasons for immediate and long-term borehole failure and to appreciate the skills and equipment required to ensure that boreholes are drilled to a high quality. Participants appreciate the importance of drilling supervision; know the responsibilities of the drilling supervisor and the actions to be carried out at each stage to ensure that the driller delivers the borehole as specified in the contract.

Module 4: Legal and Institutional Considerations introduces participants to the key elements of the legal and institutional framework (at national or state level) that supports borehole drilling professionalism. These include driller licensing; borehole permits and national (or state level) associations.

Module 5: Actions to Raise Drilling Professionalism equips participants with a wider perspective of the groundwater development sector in the country in which they work. Participants will have opportunities to draw upon and integrate the knowledge developed through the previous modules, and engage in dialogue with others. The final quiz will focus on potential actions that could be taken to improve borehole drilling professionalism in the context in which they work.

The course was hosted on the virtual campus of Cap Net UNDP, using software provided by edX⁴. The virtual campus enables participants to scroll through text, watch embedded videos and read embedded texts, all of which can also be downloaded. As set out in the course manual³, each module includes text setting out a short introduction, goal, learning objectives and orientation video. The modules also include mandatory videos and reading materials. In order to be able to progress from one module to the next, participants have to score at least 60% in a multiple choice quiz comprising ten questions for the first four modules. Participants could take each quiz three times. Additional recommended videos, reading and websites were also provided, but the mandatory materials provide all the information needed to pass each quiz.

⁴ <https://www.edx.org>

Participants were also encouraged to respond to questions in a discussion forum, which is where the course managers and co-facilitators (Annex 1) were able to respond and interact with the participants.

The course was self-paced and participant-led with no live sessions. This meant that they could progress entirely at their own pace and at times when it suited them. Registration and module commenced in late June 2022, and following an initial two week period for participants to settle in, modules 2 to 5 were each opened one week after the other. The course remained open for four months in total, and so participants were able to progress at their own pace once all of the modules were open.

Participants did not have to undertake any assignments to pass the course. While this did limit the interaction with the facilitators, particularly to provide additional guidance, it meant that more participants could take the course. Marking of assignments by facilitators takes time and comes at a financial cost.

Engagement between the participants and co-facilitators was possible in the discussion forum. Co-facilitators, working on a voluntary basis provided one to two hours per week to review and respond to the comments in the discussion forum.

2 Applicants, participants and engagement

The course was designed for professionals who are already engaged in the management of water well drilling projects or programmes with an emphasis on low- and middle-income countries. They should have either be already involved in drilling management or expect to undertake work in this area within one to three years. Target participants include government, NGO, UN and donor organisation staff, as well as those working in the private sector. Target participants may be working in development or humanitarian aid/emergency contexts.

The call for course applicants was launched on the 6th May and remained open to 15th June. It was widely promoted through social media (LinkedIn and Twitter), as well as directly to mailing lists, websites and through the networks of the course partner organisations.

A total 860 applications were made, of which 79 were duplicates, meaning that 781 people applied for the course. This figure includes nominations from member states that were made through AMCOW. Of the applications, 15% were female, and 87% were from Africa. The selection criteria set gave priority to female participants with a target of 30% and with at least 150 out of the target 250 (60%) participants to be based in Africa/nationals of African member states. Priority was also given to government staff⁵. Combining these criteria proved to be a challenge, particularly given the high proportion of applicants that were male (84%) and relatively low proportion that were government staff (32%). The outcome was that that male, NGO applicants had a low chance of being selected.

Finally, 314 people were invited to participate in the course ⁶, of which 45% were government staff, 85% were from Africa, and 36% were women. A total of 209 of invited participants were active. Table 1 provides an overview of the types of invited and active participants.

⁵ Government staff included applicants stating government, water utility, river basin organisation or water regulatory commission in their application.

⁶ The number of selected participants was raised to over 300, rather than 250 due to experience of drop out from the Groundwater Resources Management Course, which was launched two months earlier.

Table 1 Breakdown of participant types

TYPE	DETAILS	INVITED		ACTIVE	
		No.	%	No.	%
GENDER	Man	189	63%	126	60%
	Woman	123	36%	83	40%
	Rather not say/other/don't know	2	1%	0	0%
REGION	Africa	264	85%	180	86%
	Non-Africa	50	15%	29	14%
INSTITUTION	Government/ Water Utility Entity/ River Basin Organisation	142	45%	95	45%
	Non-Governmental Organisation/Civil Society	55	18%	41	20%
	Academia/Research/Education	40	13%	27	13%
	Private Sector	47	15%	37	18%
	UN/Inter-Governmental Organisation/Humanitarian Organisation	14	4%	5	2%
	Independent Professional/Community Member	9	3%	3	1%
	No data	7	2%	1	0%
TOTAL		314	100%	209	100%

The active participants came from 54 countries (Figure 1 and Annex 2).

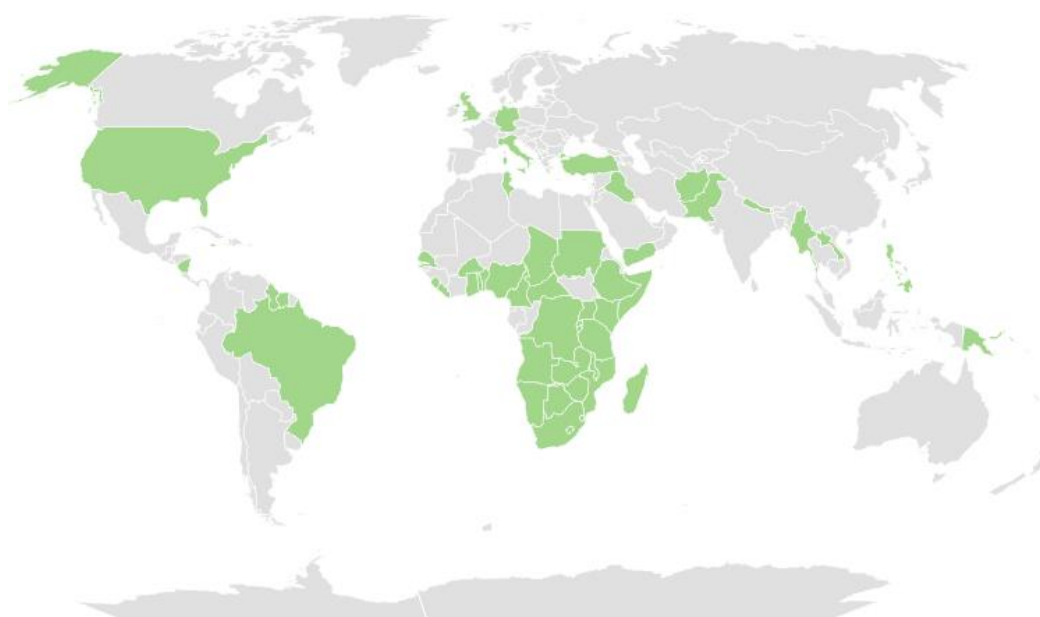


Figure 1 Map showing countries of residence of active participants

A total of 162 participants completed the course and generated their certificate, corresponding to 78% of the active participants. This completion rate is significantly higher than the current average completion rate for Massive Open Online Courses, (MOOCs) which is approximately 15%.⁷ The average completion rate for Cap-Net Courses is 53%⁸

⁷ "Massive Open Online Courses (MOOCs) have the potential to enable free university-level education on an enormous scale. A concern often raised about MOOCs is that although thousands enrol for courses, a very small proportion actually complete the course". <http://www.katyjordan.com/MOOCproject.html> (accessed 28 Sep 2022)

⁸ <https://cap-net.org/the-network/online-courses/> (accessed 12 Dec 2022)

3 Course surveys and feedback

Participant feedback

Of the 162 participants that completed the course, 146 also completed the participant survey to evaluate Cap-Net's virtual campus and the online course itself. Key data presented below shows a positive experience of the virtual campus (Figure 2) and that the participants found the course beneficial and relevant (Figure 3).

Annex 3 provides the full list of additional comments from the participants. Most of the comments were very positive, while specific challenges related to the discussion forum postings, the sound quality of some of the additional recorded material (taken from other sources).

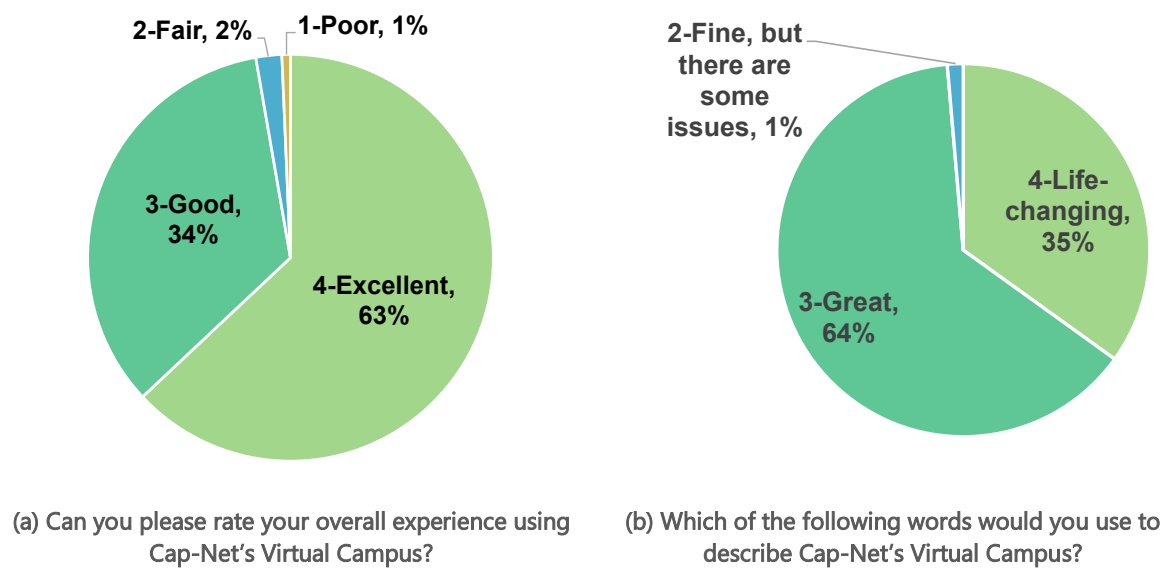


Figure 2 Participant feedback with respect to the virtual campus

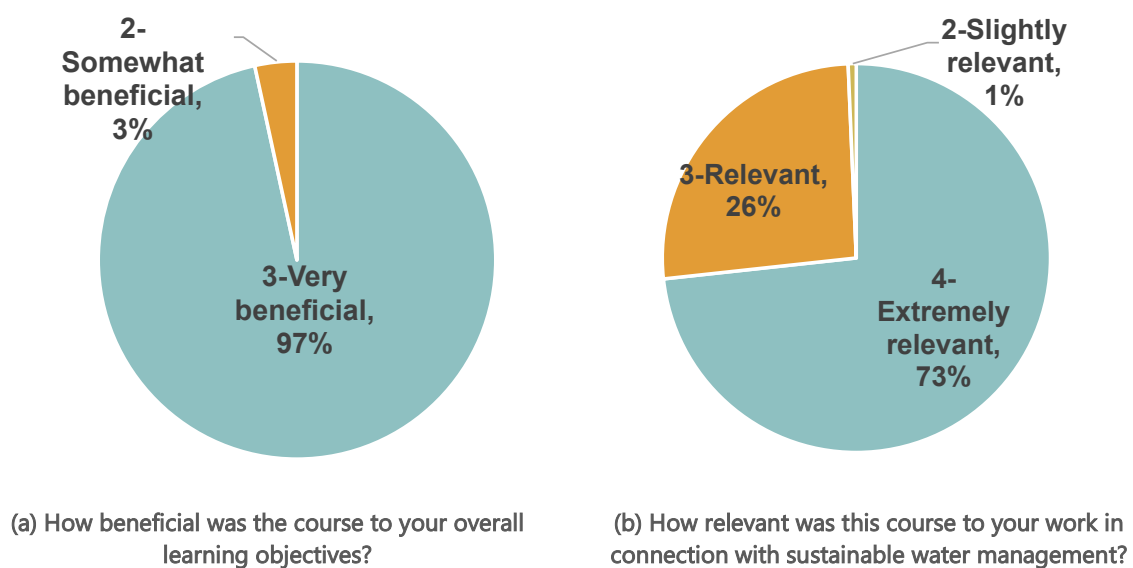


Figure 3 Participant feedback with respect course benefits and relevance

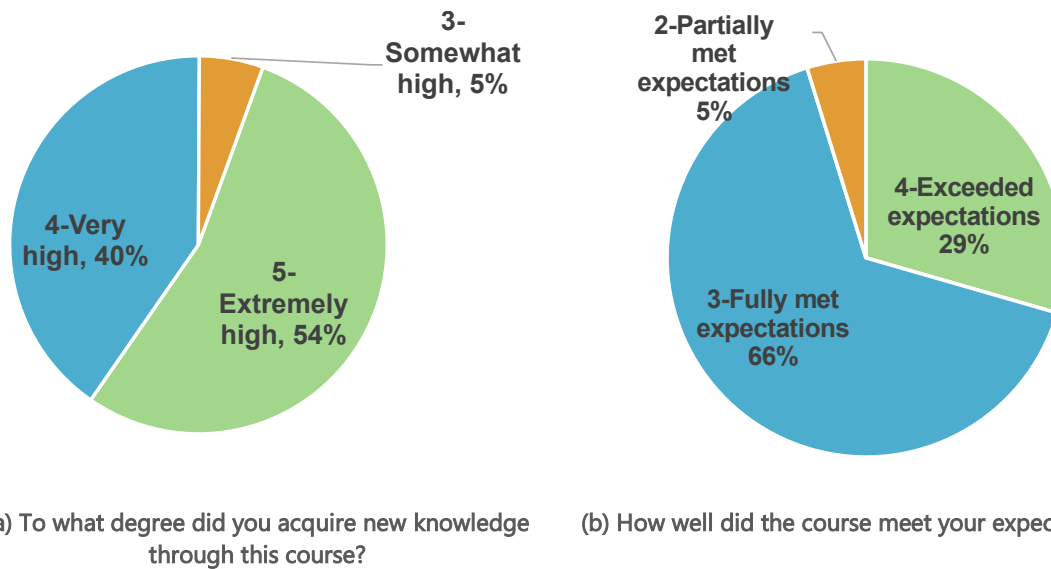


Figure 4 Participant feedback with respect to knowledge and expectations

In addition, 71% of the surveyed participants were highly likely, and 27% somewhat likely to be interested in interacting with other course participants. One course participant wrote asking for the establishment of a WhatsApp group. All participants were invited to join the existing RWSN online community on Sustainable Groundwater Development⁹.

Participants were asked "What was the most valuable concept or resource introduced in this course to you?"¹⁰ Analysis of the free text responses indicates a wide spread across different topics, as summarised in Figure 5, with supervision, contract management, drilling and procurement the top four responses.

Six specific enlightening and inspiring extracts from participants are:

- "Borehole drilling and supervision has been an eye opener to me while at site. On addition to this, I learnt more about legal and institutional considerations which I didn't know before".
- "The Procurement and contract management module was more educative as it helped us to appreciate how the drilling industry operates and the risks associated with it. It also helped us to understand the financial implications that come along with the decisions that we make and finally how to come up with a cost for drilling a borehole".
- "I do find all the materials quite resourceful, however costing and pricing was an opener for me".
- "Supervision check list and the proper gravel pack material. Most drillers in are using wrong materials for gravel packing".
- "The practical nature of videos, with more resources for further understanding was very helpful. Paying for ALL boreholes, dry or wet, as best practice, is really a challenging learning".
- "Having the content in the publication form was very useful for me. The course had solidified my on the job training. The most valuable concepts were Supervising Water Well Drilling and Procurement and Contract Management. The most valuable course introduced to me was Costing and Pricing from the perspective of the Well Driller."

⁹ https://dgroups.org/rwsn/groundwater_rwsn

¹⁰ Participants were able to provide more than one answer.

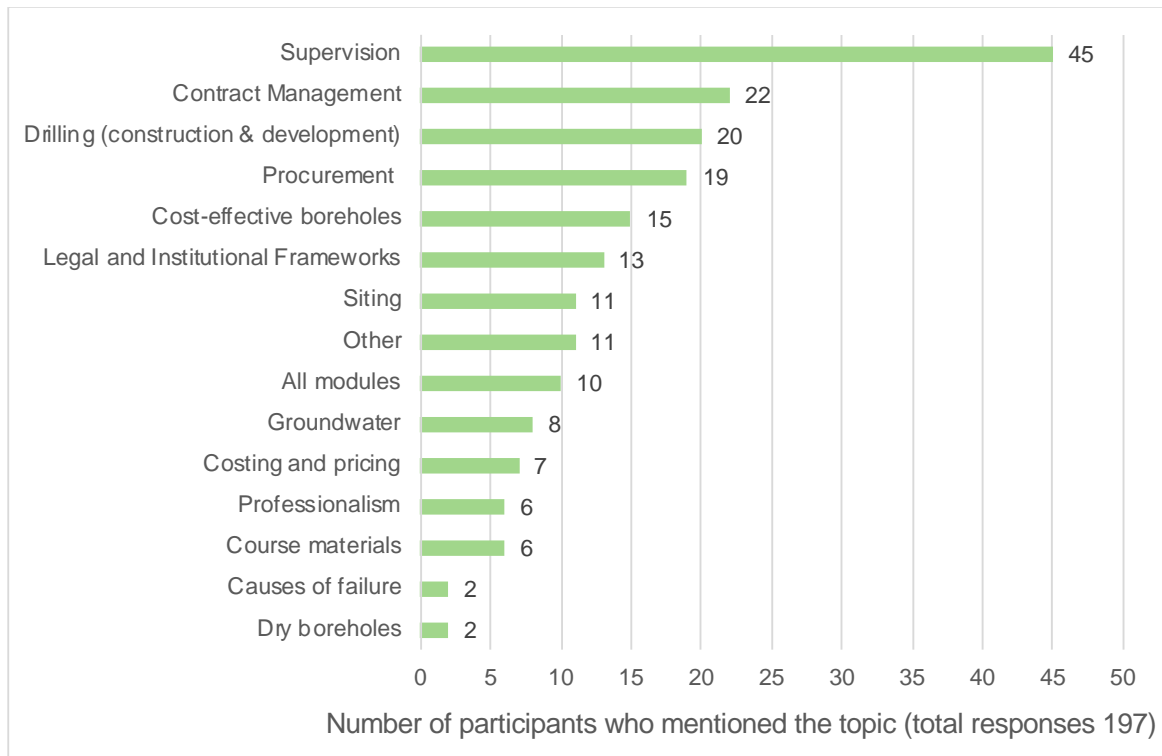


Figure 5 Participant feedback on most valuable concept or resource introduced in this course

Participants were also asked “What topic(s), if any, do you wish the course would have covered in greater depth?”. Figure 6 shows that siting was the most common response, followed by none, indicating overall satisfaction. A total of 23 participants mentioned drilling processes, technologies, and or management, and borehole design. While this topic (in depth) was deliberately not part of the course, the responses illustrate demand for more knowledge in this regard, something which other courses could provide.¹¹

The fact that three of the top five responses to the question regarding more depth were core topics for the course, raises the question of the need for follow-up specific courses. Some of the requests would be difficult to incorporate without significantly lengthening the course. However, some of the comments provide ideas for the groundwater community in terms of demand for learning materials.¹² The desire for more in-depth knowledge also raises a re-consideration of graded assignments to enable the participants to engage more deeply with the topics. As stated in the introduction, this course deliberately did not include assignments in order to try to bring down training costs and enable more participants to take place. Other comments included the need for actual in person practical trainings.

¹¹ Responses included: the drilling process, I wished it compared different geological formations and caving experienced during drilling, which sometimes make drillers avoid drilling deeper

¹² Response examples: siting: “We wish the course would have covered in greater depth for ground water data and siting by making a video of different locations like mountain area, gravel zone area, good borehole site areas and poor drill areas in more details”. Drilling: “We think we need more deep knowledge with a good quality video of construction of good bore hole in different zones of country like hilly area, sand area, gravel areas etc.” Legal and institutional frameworks: “legal and institutional frameworks in particular drillers and consultants’ capacity assessment to support private sector engagement in the water sector. What should be the minimum standard/requirements regulation and licensing to different contexts.” Drilling: “pumping test and step drawdown test should have been covered in greater depth.”

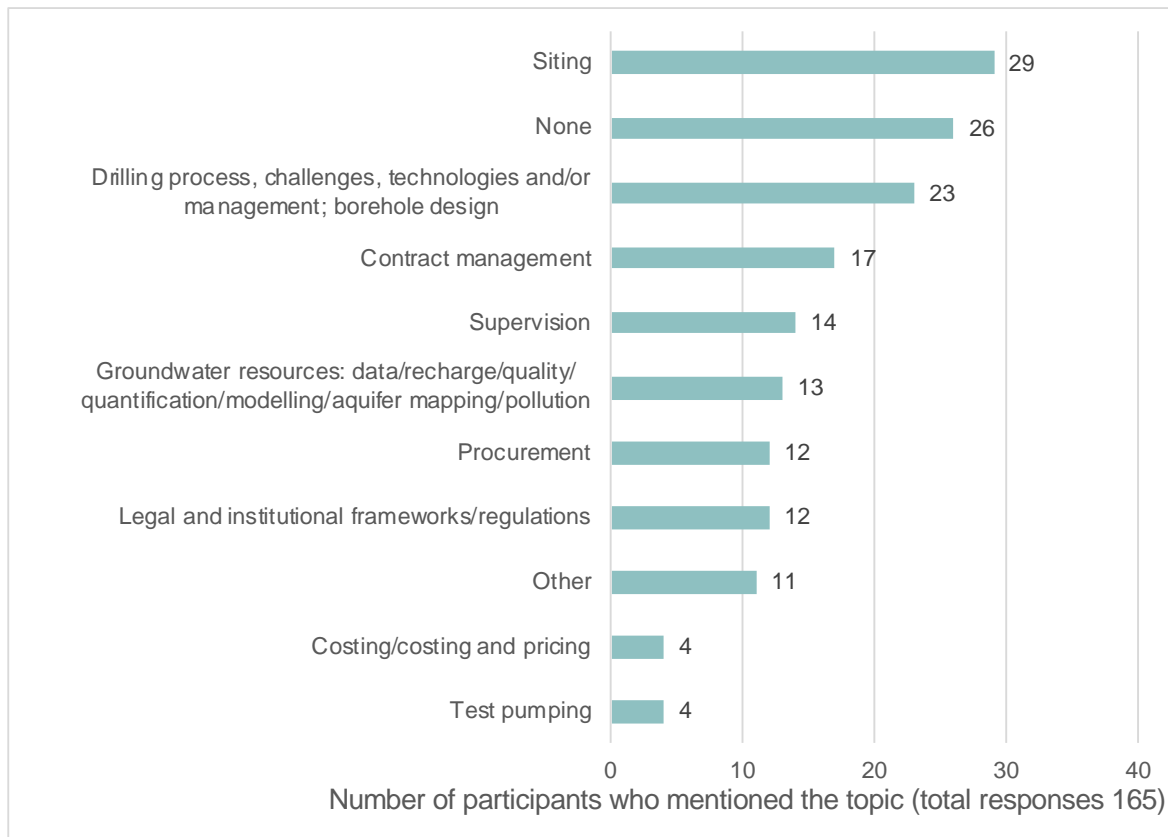


Figure 6 Participant feedback on topic(s), they wish the course would have covered in greater depth?

Participants were asked which of the following statements best describes how you intend to apply the knowledge gained from this activity? Responses are presented in Figure 7.

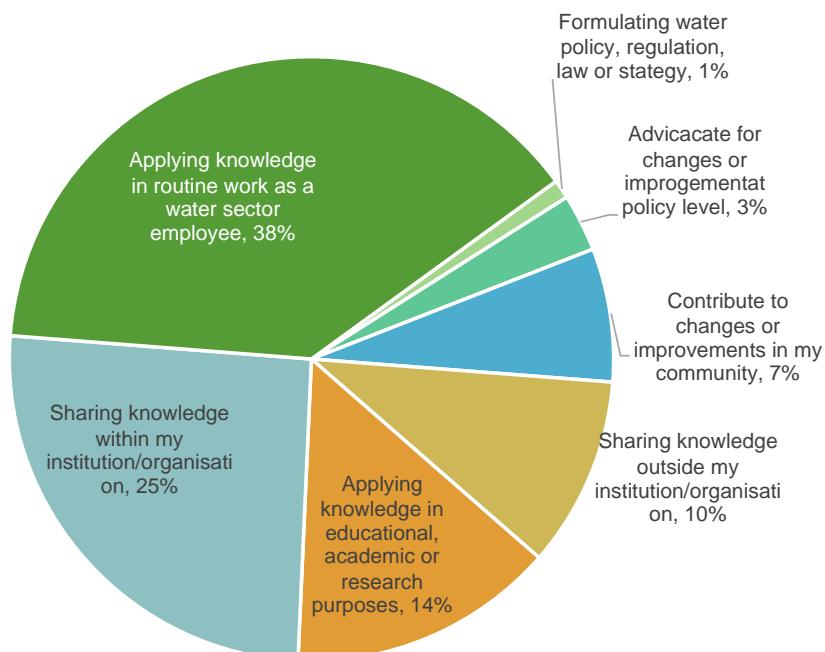


Figure 7 Participant feedback on how they intend to apply the knowledge gained from the course (% responses).

Further details on participant actions are provided in chapter 4 (Module 5 - survey responses on the drilling sector and participant actions).

Finally, participants were provided the opportunity to give additional feedback. Ideas included a text book summarising the content, more details on specific topics, including second level courses that provide more details (noted also in Figure 6), more interaction with the facilitators and the need for physical meetings and face-to-face, practical training. While the latter is beyond the scope of the online training, it illustrates the demand for knowledge in the topics covered by the course. In response to the comments about not being able to download videos, following the course closure, participants were subsequently informed about how they can do this, and advised that the course remains available to all active participants as an archive on the Cap-Net UNDP Virtual Campus.

Co-facilitator feedback

As well as the two course managers, and the Cap-Net UNDP team, an additional 18 professionals volunteered to review the training materials and/or co-facilitate the discussion forums (Table 2 and Annex 1). The reviews improved the module content and materials.

Table 2 Overview of reviewers and co-facilitators for each module

Module	Voluntary reviewer/co-facilitator
1. Introduction, Groundwater Data and Siting	Kassahun Aweke, Fenta Nigate, Mahamadou Koita, Daina Mudimbu, Johannes Münch, Moshood N. Tijani
2. Procurement and Contract Management of Borehole Drilling	Tara Bartnik
3. Borehole Drilling and Supervision	Bentje Brauns, Iazalde Tayobe, Sampson Aheleh Tettey, Kawawa Banda, Beyenne,
4. Legal and Institutional Frameworks	Jenny Grönwall, Adedotun Adelike, Jorge Alvarez-Sala, Levy Museteka, Tsnet Tsegay
5. Actions to Raise Drilling Professionalism	Brighid Ó Dochartaigh, Moustapha Diene, Adedotun Adelike

All co-facilitators were asked which modules they were interested in, and the weeks that they would be available. They were subsequently assigned to modules and time slots through the four month duration, and were provided instructions and guidance for their participation in the discussion forums through email.

As anticipated, not all volunteers were able to provide the time and inputs that they may have envisaged at the start, but those who could, actively participated by responding to participants in the discussion forums.

Six co-facilitators completed the survey to learn about their experiences, with responses as follows:

- The facilitators were active across the full spectrum of time involvement from 2 weeks up to more than six weeks. In terms of time inputs per week, two spent less than 30 minutes, two spent 30 minutes to one hour and two spent one to two hours.
- Half of the facilitators were satisfied and half highly satisfied with the orientation that they received.
- In terms of improvements, it was recommended to make finding the right cohort discussion page fool-proof, and to have a quick pre-meeting to discuss the facilitation.

- The learning from undertaking the co-facilitation was:
 - A lot of insights regarding the collection of groundwater data and well siting in different African countries.
 - More about the concerns, interests & practical experience of practitioners around the world related to borehole drilling.
 - That participants eager to discuss seemed to have finished the entire course early; by the time I began facilitating there was barely any need any longer.
 - I learned more about procedure made in place in different countries concerning data management.
 - From the discussion forum, the course provides information about drilling practices and challenges in different countries. The challenges are similar in many respects and participants as well as facilitators will realise the issues are not peculiar to their country. This makes it easier to carefully look for solutions to the challenges.
- The main challenges faced were by the facilitators related to the interaction with the participants, i.e.:
 - Sometimes a lack of responses and discussion from the participants
 - Limited interactivity of the discussion between facilitators & participants, and between participants. ... this could be due to the 'clunkiness' of the online forum, but also possibly that facilitators were not sufficiently visible to participants and/or participants not known to each other.
 - The main challenge is the reaction of learners (to the facilitators). They do not interact enough.
 - I came in towards the end of the course on this one and the group was not very active anymore at that stage

Notably, the set-up of the platform was such that participants were not automatically informed if there had been a response to their discussion forum inputs. In order to try and boost the response of the participants to responses by facilitators, a general message was sent to encourage them to go back and look for these. This seems to have helped to a limited extent, but in most cases, as the replies came the co-facilitators who had raised questions were no longer scheduled to engage with the course, and so others, or the course managers responded. It was also noted that many participants may not feel secure using the English language in writing, which reduces their willingness to discuss. In the future, more use could be made of freely available translation software, although this would have an additional time requirement.

The co-facilitators were asked, assuming that the course was to remain the same length, in terms of five modules, what changes would they recommend be made to the course, and also what recommendations do they have? Responses were:

- Include more video material, record sessions regarding specific topics and make them available for the participants.
- Add a review of techniques adopted for boreholes siting in geological contexts.
- Consider introducing live sessions, WhatsApp discussion groups or other mechanisms to enhance communication between participants, facilitators and course providers.
- If possible, add voice discussion online.
- Improve the question design and platform to foster more active participant discussion.
- I would wish, as in the two previous courses, that participants are given assignments and facilitators provide feed backs on the evaluation of the assignments. This helps to reinforce the understanding of the course materials by participants and to correct wrong notions or impressions of the materials. Overall, it will make for a more robust course and the

participants will get the feeling of having achieved a challenging task and the certificate is well earned.

The latter comment relates to participant feedback for more depth on certain topics (See Figure 6 and below).

Half of the co-facilitators who filled in the survey plan to use the course materials in their work Four out of the six would be prepared to undertake a similar amount of time as a co-facilitator once again, while one indicated that they would like to be involved on a paid basis.

All six survey respondents think that the course should be offered on a regular basis in the future.

4 Participant perspectives from around the world

Module 1 Groundwater data and siting

Groundwater database

In the opening module of the course, participants were asked the following *1) Is there a groundwater database in your country, and if so, which institution manages it? How is it used, and do you have experience of accessing the information?* While participants from most countries responded that there is one (Annex 4), there were cases where there was a lack of consensus among participants from the same country (e.g., Nigeria, Ethiopia, Ghana and Zambia). There were also cases where multiple institutions were mentioned as managing databases. Further, some participants cited water point inventories, rather than databases suggesting that not all participants understood the difference between a groundwater and water point database.

Where national groundwater databases were mentioned as existing, participants shared problems including that the data were old, not comprehensive, required cleaning and was not easily accessible. The challenges of a lack of groundwater data were also voiced in Module 3, where a lack of information about the geology and hydrogeology was among the reasons given for premature borehole failure. One participant (from Ethiopia) stated *“the lack of groundwater data creates lots of problems ... for example, there are not enough research and scholarly outputs concerning to groundwater (its quality, quantity, and its sustainable management)”*.

Looking into the future, in order to boost the knowledge about groundwater databases in future courses, a short video with a few examples of groundwater databases, including their update and mechanisms for access should be prepared, based on countries with particularly good practice. Based on the 2022 course responses, countries that may be worth following up for such a video include Togo, Jamaica, Uganda, Malawi, Zambia and Lesotho.

Siting

Participants responded to the question on borehole siting that it is undertaken by government agencies, consultant hydrogeologists and at in some cases, by the drilling contractor themselves.

While many of the participants stated that a logical process to siting was being followed, as set out in the course materials, some noted that this is not always the case and that siting is not always systematic. The use of trained and experienced hydrogeologists was discussed frequently, and, in the case of Uganda and Kenya, registered hydrogeologists were mentioned. In some countries, geologists, engineers and hydrologists undertake the siting, with some participants noting the need for specific training on groundwater and borehole siting.

Module 2 Procurement and contract management

Discussion

Private sector challenges and solutions

First set of questions: *1) To run a successful borehole drilling business, there is need for the enterprise to have a business plan, sufficient cash flow and competent staff and to understand the market. Tell us what other challenges you think that a private sector drilling businesses may face and how you think that these challenges could be overcome?*

Participants responded with specific challenges that they have encountered or observed:

- **No water no pay contracts**, where the risk of a dry borehole is transferred entirely to the driller (Kenya, Liberia, Uganda, Somalia¹³, Zimbabwe).

¹³ Among some NGOs

- **Financial:** ever changing costs of drilling, prices of fuel and consumables/market price variations (Kenya, Uganda, Zimbabwe). Difficulty for private sector drilling firms to access funding/difficult to access finance/lack of loans from banks (Nigeria, Zimbabwe). Economic instability (Nigeria). Payment delays from client (Nigeria, Uganda). High foreign exchange rates (Jamaica). High costs of equipment, materials and fuel (Ethiopia, Nigeria). Lack of funds for full time supervision (Zambia).
- **Equipment and materials:** Lack of technical equipment, including for pumping test (Malawi). Difficulties in bringing in spare parts to rural areas when the machines fail (Ethiopia). Importing spare parts, which causes delays if machinery needs to be fixed (Sierra Leone). Having the right material and tools can be difficult (Mozambique). Inadequate maintenance of equipment (Ghana).
- **Staffing:** Poor staff retention (Kenya). Retention of qualified staff, when they have no ongoing contracts (Kenya). Employment of incompetent family members as staff (Zimbabwe). Not employing competent staff (Ghana).
- **Skills and practices:** Personnel with poor technical knowledge. Lack of technical staff (Zambia). Low capacity of local companies, most of which do not have trained engineers, geologists and geotechnical expert surveyor (Somalia). Not enough skilled geophysicists and hydrologists (Nigeria). "... many quacks and unqualified personnel working in the industry leading to many failed holes and a bad name for the industry (Nigeria). Difficulty in ensuring human resources quality and know how (Mozambique).
- **Competition:** very high competition among drillers, leading to the submission of lower price bids (Ethiopia). Stiff competition from government institutions, making it difficult for the private sector (Kenya).
- **Regulation:** - see also Module 4. Lack of proper regulation and/or implementation of regulatory policies leading to a drilling industry that is free for all (Nigeria). Inconsistent application of drillers licencing regulations (Ghana). Mushrooming of private drilling companies, especially for private drilling for farmers coupled with a lack of national standards for the drilling companies, however the Water Law is under revision, which will address this issue (Botswana).
- **Corruption** (see next section of module 2 for more details)
- **Planning and logistics:** difficulties in getting rigs to site in the rainy season (Rwanda)
- **Security:** risk to professionals operating in areas with security threats (Burkina Faso).
- **Groundwater resources and technical issues:** Highly corrosive groundwater, mud cake formation, hole collapse, loss of circulation.

Private drillers deal with overlapping challenges, as stated by one participant from Uganda: "Here in my country, contractors face a challenge of misuse of lumpsum contracts, difficulties in payment recovery, and low prices of the work to be done, all merged make the entire procurement processes a bit hard and unfair." However, on a positive note (also from Uganda) another participant stated that "[high] costs are normally factored into the bids and normally ..., the government contracts are not awarded to just the low priced bids but also your track record in drilling performance and the proposed implementation plan from the contractor".

Solutions shared to overcome these challenges, and improve the situation are summarised below:

- **Training** in order to build the capacity of policy makers to advocate for change (e.g. regarding no water no pay contracts). Intensive training on siting, geotechnical surveys, data analysis and good drilling practices. Universities should also adopt drilling curriculum into their teachings while at the university. "With this training and in my government position, the participant will help to develop a standard Procurement Contract for a driller".

- **Finance:** Loans (from government) for private drilling enterprises to finance water projects. Government can support by ensuring that staff working in these companies are certified and banks lend money to the enterprises at fair rates. Expose players to project finance institutions so that they can be exposed into the finance sector and be able to procure their machinery.
- **Raise awareness** on some of the scenarios that could happen due to breached steps and methodologies.
- **Improve practices:** Proper siting and approval of the siting by the consulting company and the client. Conduct market assessments early on and map out specific suppliers and the length of time needed for procurement.
- **Staffing:** In order for staff to stay and deliver well, they need a good pay package (since their work is hard and risky) and sufficient staff should be on site for the task to run smoothly and avoid fatigue.

Four steps to better drilling contracts

The second set of questions asked participants: *2) How are each of the four steps¹⁴ to better drilling contracts in the film and RWSN publication, followed (or not) within your organisation (or for another organisation with which you are familiar), and what could be improved?* As well as responses where participants were generally satisfied that the steps were being followed in their respective organisations, some shared aps and reflections on ways of improving the status quo, as illustrated by the following extracts:

- **Procurement planning and procurement law:**
 - "In our organization, not all steps are followed especially ... preparation of procurement plan and ... monitoring. Even all other steps are not comprehensively followed so this course is really an eye opener and it will assist in professionalizing the whole process in our organization".
 - "The first step of procurement/preparation plan prior to this course was not followed by our organisation ... we only concentrated on contract award and monitoring and evaluation, having known all of these information, we will apply these vital four steps going forward".
 - "In preparation for a good procurement plan I think in most cases the clients give work to the lowest bidder instead of looking at the track record of the contractor".
 - "In most of time and in accordance with the law governing public procurement, the tender is given the bidder with the lowest price who is not necessary the best bidder. In addition, since the evaluation is done automatically through the system, sometimes it is difficult, even impossible to modify or adjust the contract, depending on the complexity of work, which sometimes affect the quality of winning bidder"
- **Payment and monitoring:** "In our institution the last two stages present more difficulties. ... payment is made by the general affairs department, which deals with the finances and ... is not always involved at the start of the process. The last step on monitoring also poses a problem, ... new works are not systematically declared. which causes the database to update slowly"
- **Corruption and conflict of interest:**
 - "These four steps have been very challenging in to overcome because of bribery and corruption. this has ... affect[ed] the tender and bidding processes in my

¹⁴ In brief, these four steps are (i) preparing a procurement plan, (ii) a systematic contract award process, (iii) professional contract management, including regular communication, supervision and timely payment and (iv) monitoring and reporting after construction.

country. My firm ... bid ... and the company was well equipped with equipment and professional with competent drillers but having seen the cost and price of the borehole, the offer was later turn down and the contract was given to another company that has little experience and professional coupled with epileptic equipment. The borehole was reported to later failed ... bribery and corruption that has eaten deep into the fabrics of the borehole and water institutions in my country".

- "The four steps are difficult to follow mainly as a result of conflicts of interest in the procurement process, hence compromising effective supervision and monitoring."
- "Most of the steps followed but aspects of corruption before awarding a contract is common ... In such a case less supervision of work [and] at the end it lacks it standards."
- "... some contractors connive with superiors or even the funders implementing authority and breach some of the critical steps".
- **Communication:** "professional contract management, regular communication is not actually done in most cases ...contractors avoid much communication so the thy can cut corners."
- **Contract document:** "The only aspect that I think could be improved are the incorporation of a clause in the contract ... in the case of multiple borehole drilling contracts. Each contract should be separated from the other in terms of implementation. Such that if one borehole drilling faces a challenge it will not affect the other borehole drillings, this saves time and drilling can go on as planned for the others."
- **Supervision:**
 - "...supervision, monitoring and evaluation are not taken as very important because sometimes ... the job done by the drilling companies are not in line with the specifications ... in the contract document. I am sure if the supervision is to be taken seriously the problem of poor workmanship could be history this training has helped the good understanding of the importance of ... supervision".
 - "Support for junior supervisors especially those in the regulating agency is lacking and a review of the policy in the granting of permits for well drilling should include provision for this to be mandatory to improve the quality of management."
- **Overall:** "... practices are sometimes out dated and methodologies questionable. It is therefore very useful for me to bring some of this material to our partners in the government to promote their understanding of the issue first. The same is being done with the private sector so to have everybody on the same page".

Module 3 Borehole drilling and supervision

Poor borehole performance

Participants were invited to reflect on the question: *1) Based on your experience, or that of your colleagues, what are the main reasons for low yielding boreholes, poor quality water or mechanical failure just a few months after construction?*

Taken together, responses covered most of the problematic areas, with some participants focusing fairly comprehensive responses and others focusing on a few key areas. Themes shared are presented below:

- **Knowledge and data gaps:** lack of understanding of the geology, lack of geological and hydrogeological information, inadequate data, lack of long-term groundwater data.
- **Aquifer** capacity low; low transmissivity; low density and poor connectivity of fractures; aquifer thickness; tapping perched aquifers.
- **Siting:** Poor site selection, poor borehole siting procedures, poor interpretation of geophysical surveys, not following siting reports properly, not involving the community properly in siting; contractor paying little/to no attention on carrying out desktop studies and baseline survey but rather want to start drilling.
- **Drilling skills:** Lack of drilling knowledge, low level of trained personnel by the driller.
- **Supervision:** Inexperienced supervision, limited supervision (sometimes perceived as an unnecessary cost), lack of supervision, test pumping without supervision; lack of communication between the supervisor and driller.
- **Corruption:** Collusion¹⁵ between supervisor and driller to outwit the client; community boreholes sited at points not because there are the most viable in the area in terms of potential productivity and water quality, but because they are close to the houses of influential persons in the community.
- **Technical issues:** Not properly following the entire process of drilling, completion and development; poor development and poor gravel pack quality; drilling too shallow; wrong size of gravel pack; not allowing enough time for development; poor borehole design and installation; not aligning the screens properly with the aquifer, boreholes not properly sealed, lack of grouting; not installing the bottom cap properly, leading to siltation; rupture of screen, siltation of borehole; poor quality casings; sub-standard products; drillers stopping at first water strike rather than drilling to depth.
- **Pumps:** Poor quality/inferior pump/pump materials, pump failure, poor pump installation.
- **Water quality:** pollution affecting water quality, sources of contamination near the well (e.g. if borehole is close to a landfill, abattoir, canals, cemetery or the chemical industry. Lack of water quality testing
- **Financial and contractual:** Poor payment management by the client; lack of separation of the contract between siting and drilling; turnkey contracts combined with drillers stopping at the first water strike to compensate for other dry wells that have not been paid for; inaccurate pricing at the tendering stage.
- **Post-construction:** Poor well maintenance; overuse of pump; inadequate attention to maintenance of the water supply system.

One participant shared a recent story – “23 wells ... were built at the end of last year to be used in irrigation The data ... indicated that the wells were in perfect condition, however, a few months ... the wells are pumping a lot of sediment. Investigating ... the step test data (well efficiency) were

¹⁵ Collusion means secret or illegal cooperation or conspiracy in order to deceive others. Example, "the armed forces were working in collusion with drug traffickers"

all collected in the wrong way ...the screens used were not from the factory, the PVC casing was manually cut without adequate control to become a screen”.

Further, specific concerns in relation to a number of countries were also shared:

- Poor siting and borehole design practices alongside limited groundwater availability (Zimbabwe).
- Markets flooded with materials whose quality is highly compromised, such as a driller with casing dimensions are far less than the normal dimensions, or poor slot distribution along the casing (Kenya)
- Vandalism and theft after construction and installation (South Africa).
- Poor knowledge of the drillers, coped with unclear guidelines from part of the government and the underlying corruption brings boreholes to perform generally below expectations and often break down. Main identified problems are: wrong depth of the borehole (no link to previous geophysical survey), wrong positioning of the screens (little understanding of lithology and groundwater flow), wrong data on boreholes (pump tests are sometimes just airlift best guess), lack or poorly installed gravel packing (Mozambique).
- Most of the boreholes are drilled without supervision from the government and as a result, a lot of substandard work is done (Liberia).
- Drillers stopping at first water strike rather than drilling to depth (Zambia).
- Supervisors relying on contractors for transport and food. This then dilutes the whole essence of borehole supervision as it allows poor workmanship. Since the supervisor is compromised the result is poor siting, excessive use of drilling pastes/fluids, poor quality gravel filter pack, use of sub-standard materials and inadequate development (Malawi).
- Most reasons are construction capacity and lack of supervision (water level, log and camera), as well as the use of only one design for borehole construction (Somalia).
- Nature of the aquifers, which are low-yielding and poor quality water, including highly acidic water (Northern Kenya).

Borehole Camera

The second question was *2) How could a borehole camera be used to ensure drilling quality?*

Participants explained that a borehole camera can be used for verification in case there is any doubt about the borehole completion, or to audit drilling works. It can enable us to see the drilling depth, the types of casing used, the depth of the borehole casing, casing damage and collapse and screen position as well as sedimentation.

Specific responses included:

- “Borehole camera makes us « see » hidden details underground. In case there’s a fault underground, the camera can reveal it for proper action”.
- “Just showing the contractor that you have a borehole camera improves the results as he knows you'll check the borehole ;-) Once the borehole has been completed, we can check screwing of the casings, screen quality, alignment, etc.”

For a number of participants, this was the first time that they had heard about a borehole camera.

Module 4 Legal and institutional frameworks

Guidelines and Standards

In the module 4 discussion forum, participants were invited to discuss: *1. Has the government in your country published national guidelines or standards for borehole drilling and rehabilitation? If so, are they widely known? Are they easy to understand? Are there incentives to adhere to the guidelines, or is there any enforcement of standards?* In addition, knowledge of guidelines and standards was also part of the participant survey undertaken in Module 5. Reflections from the discussion forum from specific countries are presented below, while Annex 5 tabulates data from the survey.

- **Brazil** has the ABNT (Brazilian Association of Technical Standards), a National Standards Forum. All NBR (Brazilian technical standard) were created by this association. Key NBR include:
 - NBR 12212-Well project for water collection underground;
 - NBR 12244-Construction of a well to capture underground water.They are easy to understand, but are not free. Older versions are available on the internet but new ones must be bought. ABNT does not receive government funds to do the important role of National Normalization Forum, therefore, sales of ABNT's technical standards correspond to an important source of fundraising. However, these standards are not widely known, and unfortunately there are no incentives to adhere to them.
- **Malawi** has standards, which are also well known (through national workshops), are clear and enforced (through penalties). There is a borehole construction technical manual with guidelines for borehole drilling, pumping test, civil works and pump installation activities. One participant stated "though some drilling companies seem not to follow these guidelines. ...a good number of drilling companies are doing a recommendable work. This means that those drillers which have the technical manual are able to understand what have been laid out in the manual".
- A participant explained that in **Mozambique**, drilling laws and regulations are quite extensive and well prepared (with the help of the international community to align with best practices and standards), but their enforcement is poor. Corruption and lack of understanding of laws and regulatory frameworks objectives were cited as the most common causes for this. Further, it was noted that although data on drilling boreholes should be handed over to the government by law, this is does not generally happen.
- In **Kenya**, although the standards are in place and widely known, there are no incentives to adhere to them, apart from through supervision.
- Similarly, is the case of **Zambia**, where the government has guidelines, which are not widely known. The physical presence of the responsible institution and lack of network in many parts of the country were cited as two reasons for this situation.
- In **Nigeria**, only some participants were aware of the Code of Practice for Water Well Construction. The lack of legal backing for this from the National Assembly was noted as one of the obstacles in nationwide implementation.
- "In **Ghana**, the Water Resources Commission is responsible for the issuance of Drilling Licence but ... regularising these private drillers is a hard nut to crack because most tenders and bidding may not always require a drilling licence. Either it is ... ignored as a requirement or simply not known. ... the few complying drillers issued with licence ... have to compete with ... unlicensed drillers to bid contracts"¹⁶.

¹⁶ Point raised in Module 2

- In the case of **Ethiopia**, one participant noted that while the government has a national guideline, it is mostly the regional offices that are responsible for its implementations, adding that the guideline is not actually used. Another participant from Ethiopia stated that there is no published national guidelines and standards for borehole drilling and rehabilitation”, This suggest that if a guideline does exist, it is not widely known about.
- In **Somalia** water well drilling guidelines were established in 2019 through a Technical Working Group of government, WASH cluster partners and national consultant hydrogeologists.
- “In **South Sudan**, Guidelines and Standards are not in place but we are using a UN tool called GLAAS (UN-Global Analysis and Assessment on Sanitation).¹⁷ ... South Sudan is still struggling with economic recovery and other national challenges so when we settle these issues, we will have a room to create Associations that will take charge of water resources and technologies on drilling and abstraction.”
- The **Rwandan** government “has not yet published national guidelines or standards for borehole drilling and rehabilitation”.

Drillers and consultants

The set of questions in relation to drillers and consultants were posed¹⁸. Regulatory aspects are combined with permitting in 2Drilling, consulting and water use regulations” below.

Drillers associations

The participant responses in the discussion shine light on the fact that drillers associations are exist in some countries, but even when established, they were not always widely known about (e.g. Ghana, Kenya, Nigeria), as indicated by the range of responses from different countries. Annex 6 provides synthesises the survey responses concerning drillers associations, with some highlights from the discussion forum presented below:

- While there are state and national drillers associations in **Nigeria**, these have not been established in all states. The three associations named were Association of Well Driller Owners and Practitioners (AWDROP), Borehole Drilling Association of Nigeria (BORDAN) and (Association of Groundwater Explorations (AGE). They are all recognised and have all undertaken sensitisations workshops.
- **Kenya** has the Kenya Drillers Network Association, which a participant explained is a very active body where drillers raise issues affecting to the government.
- Participants in **Malawi, Rwanda, Jamaica and Sierra Leone** all stated that there were no associations in these countries. This is echoed in the Module 5 survey (Annex 6), which also indicates that these do not exist in many other countries.

¹⁷ This tool has 14 technical guidelines in which one of them emphasis much on safe drinking water initiative and drilling technology,

¹⁸ Question 2. Is there a national (or state drillers association, and if so, is it active? What has it done? Is it reputable? Is there any regulation of drillers, e.g. through licencing? Who regulates, and how effective is it? Can an unregistered drilling contractor obtain work from government, an NGO or a private user? Is there any regulation of groundwater consultants, e.g. through licencing? Who regulates, and how effective is it? Can an unregistered consultant/contractor obtain work from government, an NGO or a private user?

Drilling, consulting and water use regulations

Insights with respect to the licencing of drillers (and consultants) are summarised in Table 3 in combination with responses with respect to water use licencing¹⁹.

Table 3 Participant views on water use regulation

Country	Statement
Brazil	Water is a good of the Union (necessary to the community and its use must be available to all citizens). Therefore, except for low-flow abstractions, the use of water for any activity requires the granting the right of use. The abstraction of surface water is supervised and regulated by ANA (National Water and Basic Sanitation Agency) and by the environmental agencies of the states. Groundwater abstraction is supervised and regulated by state environmental agencies. In situations predefined in Law n° 9,433, of January 8, 1997, any grant may be suspended at any time (totally or partially, definitively or temporarily).
Ethiopia	There is a regulation in abstraction permission in some of the areas of the country like the capital city Addis Ababa and some parts of the nation for all kind of groundwater. There is regulation of drillers controlled by Ethiopian ministry of water and energy. unregistered drilling contractor cannot get work from the government or NGO.
Ghana	Water Resources Commission in Ghana issues drilling licenses and abstraction permits. However, most private drilling companies are without the drilling license drill a lot of boreholes. There are regulations in Ghana, but they are not implemented. There are regulations on drilling contractors and consultant but these are never adhered to as most drilling contractors are drilling for private people and at times NGO's or politicians especially during election year.
Jamaica	"There is a Water Resources Act and Regulation (1995), under which, a permit is required to sink, enlarge or alter an existing well. A permit is required for exploratory drilling. A license is required to abstract and use water from a well. The Water Resources Act requires drillers to be licensed and required to comply with National Contracts Commission (NCC) procurement procedures when bidding for contracts. There is no regulation of groundwater consultants, however, they have to obtain clearance from the NCC to be eligible for government contracts.
Kenya	Kenya Engineering board and Water Resources Authority are the government bodies responsible for issuing and approving licences for drillers, thus regulating drillers. The Water Resources Authority is mandated to authorize a client to drill after application, attaching a siting report by a registered hydrologist. After successful drilling, an abstraction permit will be sought by the client. Any water use (diversion, abstraction or obstruction of water sources calls for permits and one has to adhere to the amount of water permitted to abstract/obstruct/divert within a given period. The government licenses drillers through the Ministry of Water, Sanitation and Irrigation and the list is handed over to Water Resource Authority to supervise the water use. The regulation is not entirely effective since there are delays in updating

¹⁹ *Is there any regulation of water use, such as abstraction permits? What type of groundwater abstraction requires a permit? Are there any challenges with these?*

	<p>annual records. Unregistered contractor can not obtain work from Government. The above also hold for the consultants.</p>
Lesotho	<p>Lack of regulation and licencing, particularly in relation to drilling, with the result that borehole monitoring is lacking.</p>
Malawi	<p>"..., the National Water Resources Authority (NWRA) in accordance with the Water Resources Act is mandated to provide strategic leadership in the overall management and development of the country's water resources in terms of regulation, assessment, planning, conservation, development, allocation, coordination, protection and delivery for use by all sectors that depend on it. Underfunding is their major challenge."</p> <p>National Water Resources authority has been given a mandate to issue water abstraction permit. Water permits are given to the water abstractions for irrigation, water supply in semi urban and townships.</p> <p>The Ministry of water and sanitation only gives licences to those who want to start drilling boreholes. Further, no unregistered company get a job from government or private sector, unless otherwise agreed, but basically, this is not allowed.</p> <p>On the groundwater consultancies, only registered consultants are allowed to execute the consultancies on groundwater.</p>
Nigeria	<p>The Integrated Water Resources Management Commission has developed Water Use Regulation for ground and surface water resources since 2014. There are specific water use licences for various water uses.</p> <p>Some states require abstraction permits for boreholes, such as the one-off fee in Kaduna state.</p> <p>Contrasting views: (a) an unregistered drilling contractor cannot obtain work from government or NGOs but can do that from a private user. (b) u drillers do still drill for NGOs, Government and private users</p> <p>There is regulation of groundwater consultants especially from NMGS and Nigeria Association of Hydrogeologist in conjunction with the federal ministry of water resources e.g. through licencing.</p> <p>... even when drillers undertake a shoddy job, there are a lack of consequences.</p>
Sierra Leone	<p>The groundwater development and protection regulation passed into law in August 2022. The National Water Resources Management Agency (NWRMA) regulates. prior to the enactment of the regulations drilling companies have applying for licence to drill. However, the agency was not effective in enforcing the drilling companies due to the lack of the regulations. The regulations has penalties for defaulters which the agency hope to take advantage of to enable the drilling companies to comply. Prior to the establishment of the agency, any driller contractors can bid for any contract either from the government, private or NGO without a licence or permit. With formation of the agency, it is pre-requisite for any drilling contractors to possess a licence in order to apply for any drilling contracts. This to a very large extent seem to be working. at the moment. There is no regulation of groundwater consultant and they can be hired.</p>
South Africa	<p>A participant stated that they were aware of regulations, standards and licensing, but had no idea of the details or if enforcement, adding that "following the interesting prompting in this course, I will certainly reach out to [the reputable hydrologists who know all the rules & regulations] to become better informed". Another participant stated that although the country does have regulations in</p>

	place, direct measures to ensure that companies comply to water use licenses conditions is a problem
Zambia	<p>A permit is required to abstract any form of ground water by anyone but one participant has observed that boreholes that are drilled by Government directly are not always registered and permits not given, whereas in contrast, those drilled for Government through private drilling companies are registered.</p> <p>WARMA is mandated to regulate drillers through licencing and its very effective though they lack human resource in some parts of the country. For unlicensed drillers, getting a job from government and NGO is difficult but they do get jobs from private clients due to many factors, including the cost.</p>

In the participant survey, participants from the following countries reported an absence of borehole drilling licencing: Lesotho, Madagascar, Mozambique, Nigeria, Rwanda, Senegal and Somalia.

Module 5 Actions to raise drilling professionalism

Discussion

Unrealistic pricing

Participants were asked to reflection the situation *whereby a client tries to squeeze the driller for a low (and unrealistic) price, and a driller takes on a job, knowing that the conditions are not ideal.*

Overall, the responses provided well-articulated examples of the type of problems that occur in such a scenario, including compromised quality and the rationing of materials. One participant stated that this scenario has become the normal trend in the **Nigerian** borehole drilling sector, with the caveat that this leads to the manoeuvre of drillers that are not well trained and ultimately a "messed up" drilling project. It was stated that the aforementioned situation is rife in **Ghana**, noting that "probity and accountability is just a slogan than an act", with the driller tending to do shoddy work. In the Ghana example, the employment of unskilled personnel was also cited as an outcome, alongside drilling contractors running out of funds, and even ending up in court.

One participant candidly stated that, in such a scenario, "the client has probably no interest in the long term success of the borehole, hence is ready to engage in a win-lose situation", while another stated "you pay for what you get. if you pay low and all you expect from the driller is substandard job".

Non-payment for dry boreholes

The second scenario in this discussion for participant reflection was: *the donor or client is not willing to offer direct financial compensation for drilling dry boreholes, even though some will be drilled in high risk area.* The lack of professionalism of such an approach, misuse of the rights of the donor/client, and the effect that it has on inhibiting drillers from working in areas with a risk of drilling dry boreholes were among the issue mentioned by participants. The importance of good siting, as well as agreeable and conducive contracts were also both noted, with one participant stating, that at least, an agreement is needed between the client and driller for a percentage payment and another potential site in the case of a dry borehole. Specific experiences mentioned include:

- A participant from **Zimbabwe** stated that "This is standard practice in our country. ...and most of the drilling is done in high risk areas, as they have the most need. Due to this reason a lot of shortcuts are being done to ensure 'wet' holes. Less than 6 months later, most of these are non-functional. There is need for a policy change to share the risk between the client and the contractor if we are to have professionalism in the drilling sector".

- In the case of **Sierra Leone**, it was noted that “though contract are offered based on BOQ'S, ... it is unacceptable to accept dry boreholes. ... most contract are awarded with ... the drilling contractor is expected to do the sitting and drilling as well, hence he is responsible if he drills dry wells. Mostly, no independent consultancy is sort for sitting. I have once witness an NGO) having borehole sitting done by an independent international consultant and drilling done by a drilling contractor. The sitting by the international consultant was also aimed at training staff of the ministry on borehole sitting”.
- “Most times in [**Nigeria**]... the client is not willing most times offer direct financial compensation for dry boreholes even though the drilling is in highly risked areas”. In another example from **Nigeria**: “we encounter such an incidence with ... [the] client ... threatening to sue the organization should [it] refuse to refund back the half payment he made before the drilling operation start.” The (successful) defence was that the organisation has surveyed the site provided the client with a report including the risk involved and that they would not be penalised if the borehole was. be dry. Another participant from Nigeria explained that drillers cut corners with respect to the casing by not installing it for the full length of the borehole, adding that this may be done with, or without the knowledge of the client.
- The issue of non-payment for dry borehole was stated as an issue that has also frustrated drillers in **Malawi**, with some drillers quitting the industry due to a lack of financial resources to remain in it.
- In western **Zambia**, it was noted that a lot of drillers refused to engage in cases of contracts that do not pay for dry boreholes due the sandy conditions there, which require a lot of fuel and lubricants (making it expensive and risky).
- In contrast, a participant from **Chad**, shared their experience that negative drilling (payment for dry boreholes) is based on the equipment used and time spent.
- “In **Jamaica**, the drilling companies are paid for dry boreholes. The occurrence of drilling dry boreholes is not frequent. Consultants are usually hired to site wells”.

Statement - Ghana “I will advocate for a strong professional body of drilling Companies and drilling supervisors/Geoscientist with a strong legal regime or framework backed by state institutions so as to eliminate such clients who may want to go outside ... to have their way”

Module 5 - survey responses on the drilling sector and participant action

In order to gain insights into the situation with respect to professional drilling management around the world a short survey (using Google Forms) was included in Module 5. This section provides a summary of the perspectives shared by the 120 participants who completed the survey.

National guidelines and standards

Participants were asked whether the government has published national guidelines of standards for borehole drilling and rehabilitation. The responses, sorted by country are presented in Annex 5. While all but one respondent in Malawi stated that these do exist, for most other countries with multiple responses, there was a mix of opinions, and/or respondents did not know. What seems to be the exemplary case of Malawi may be due to the national workshops for sensitisation which have been conducted by relevant authorities, as explained by a participant in the discussion forum of Module 4. In general, the responses indicate the difficulty in finding such information, and, that in the countries where such guidelines or standards are in place, more awareness-raising is be required to ensure that they are widely known.

Contract award

A total of 39% of respondents stated that government project and programmes sometimes award drilling contracts to experiences and qualified drilling contractors, while 49% stated that this is sometimes the case (Figure 8). It is important to note that perceptions varied within the same countries.

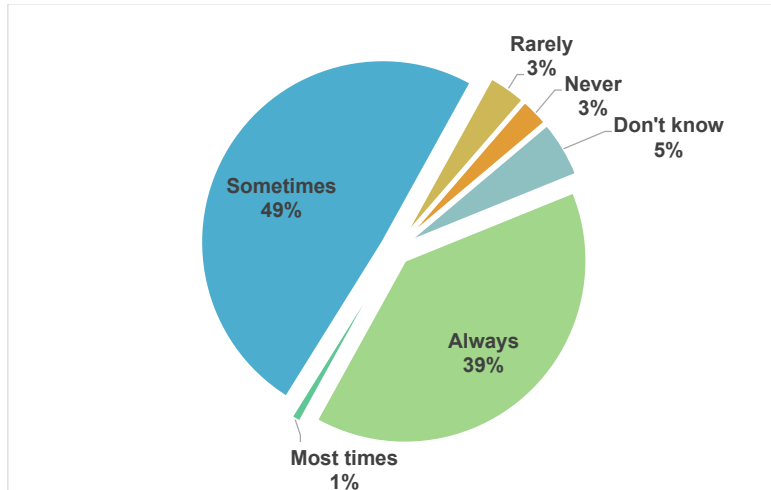


Figure 8 Do government projects and programmes award drilling contracts to experienced & qualified drilling contractors?

(Percentage of response) – 120 responses

Supervision

In response to the question on government supervision, only 22% of respondents stated that the government always ensure that independent supervision of the borehole construction & completion takes place. 48% of respondents stated that this was sometimes the case, with 25% stating that this rarely, or never occurs. As with the previous questions, there were differing views among participants from the same country.

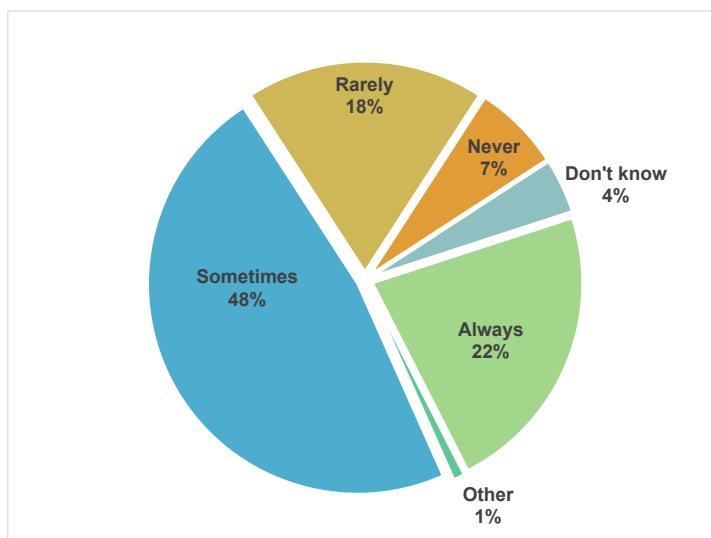


Figure 9 Does the government ensure that independent supervision of the borehole construction & completion takes place?

(Percentage of response) – 120 responses

Skills, knowledge and experience

Table 4 shows that less than half of the respondents are confident of that the skills, knowledge and experience within the country for the drilling sector are sufficient to meet the SDGs by 2030.

Table 4 Do you believe that there are sufficient skills, knowledge and experience of siting, supervision or drilling professionals in the country to meet the needs of access to drinking water for all by 2030?

Response	Number	Percentage
Yes	55	46%
No	62	52%
Don't know	3	3%
Total	120	

On a positive note, in some of the countries where it was believed that capacity is insufficient, there are examples of initiatives taking place to raise skills, e.g.:

- Comoros – Projet de gouvernance du secteur de l'eau (PROGEAU).
- Lesotho – Leretholi Polytechnic Institution trains technicians in Water and Environmental Engineering and they do the module Groundwater Hydrology.
- Mozambique – Pronasar, a national initiative supported by donors like SDC, and SDC itself that is trying to bring in exactly the same knowledge discussed in this course through secondments to UNICEF, trainings in groundwater development, etc.
- Somalia – Government, private sector and National WASH cluster partner team platform/workshops. Some training by academic institutions.
- Tanzania – The Ministry of Water through the Water Resources Institute is preparing technicians to carry out the groundwater issues. Sometimes Technicians are attached to experienced professionals to gain knowledge on groundwater issues.
- Uganda – Establishment of the Water Resources Institute. Capacity building of drillers by Ministry of Water and Environment.
- Zambia – Initiatives by SADC-GMI, World Vision, TRALAD and BGR. University of Zambia in collaboration with the Water Management Authority. Introduction to Hydrology. University of Zambia, department of mines. Groundwater management support project.²⁰

In countries where participants believed that sufficient capacity of drilling professionals is in place initiatives cited were:

- Ghana – Water Aid, Academia such as Kwame Nkrumah University of Science and Technology and University of Mines and Technology organized short courses for professionals, but most courses come with participation fee and the private companies who do most the drilling hardly attend such organized short courses.
- Malawi – The Ministry of water and Sanitation through the National Water Resources Authority is responsible for engaging the registered borehole drilling companies in various trainings on groundwater management.
- Nigeria – Introduction of drillers license after the completion of training course at National Water Resources Institute

²⁰ Notably, in the case of Zambia, which provides an example of face-to-face training within the course itself, a participant stated "it's a 50-50 chance because currently, Engineers have graduated and deployed for work in different Districts and the challenges are that these are not well equipped to handle. Supervision of Borehole Drilling, ... which took place in 2018, I believe it has not been effective because a lot of us Engineers, we haven't had any Trainings concerning Drilling and we had to rely on the Contractors as they did their works and from there we could gain/get some knowledge as the works progresses".

- Rwanda – GAIA Survey and PRD rigs which are providing trainings regarding ground water
- South Sudan – Capacity Building Initiative and it had been initiated by the government (Ministry of Water Resources and Irrigation) this is done by sending staff abroad for studies.
- Sudan – Sometimes the institution raises the efficiency of engineers by conducting training courses and workshops (Drinking water and sanitation units).

There were also expressions of hope for training, e.g., for Sierra Leone, alongside many participants to stated that nothing was available, despite the needs. Details of the different responses from each country, showing different perceptions are presented in Annex 7.

Challenging geological environments

The participants were asked whether there are any areas with particularly challenging groundwater for development, such as high risk of dry hole, salinity, iron/manganese, low pH), and about groundwater hotspots (e.g., concern about falling water tables or pollution).

In total, 96% of the participants provided examples of all of the above challenges for 34 countries, as detailed in Annex 8. The types of challenges affect the borehole drilling sector in different ways, and need to be considered when planning, costing and managing drilling programmes. Such issues could be considered more in-depth by national, or regional courses in the future, whether online, or face-to-face.

Potential actions by participants and for their organisations

The questionnaire contained within Module 5, asked participants to provide at least one action that they would like to undertake to improve drilling professionalism, and an action which the organisation for which they work should take. This question echoes the question posed in the closing survey (Figure 7), but provides more details. Full responses are presented in Annex 9.

Further analysis shows that in the case of individual actions, putting new knowledge into practice was the most frequent response, followed by training/capacity building, and awareness-raising. Practices to be improved covered the entire spectrum of the course. Actions that participants mentioned included developing borehole databases, using better equipment and higher quality materials and groundwater research. Examples of responses include:

- I would like to establish a database of all boreholes that the organisation has drilled within the last 10 years. Thereafter, I would want to advocate for a follow up of these borehole and consistent monitoring of the water points ... It would be great to even publish the findings of the study.
- Put in place stringent penalties for defaulting individuals or companies.
- Deregistering of non-compliant drillers.
- Save some fund to organise for us extra capacity building on drilling supervision and professional and sponsor female engineers to take up the course on drilling supervision and professional.
- There is need to improve on supervision during the drilling process. Many times, during drilling, contractors are not frequently supervised and some of the key steps like borehole development sometimes are done when there is no supervisor on ground.
- I really need to put my finger print on groundwater data and resource management by producing a research output concerning to all the issues about groundwater hydrology.

Conclusions

These 2022 Online Course on Professional Drilling Management, and its sister course, Groundwater Resources Management should not be the end of this type of training. The participants responses in terms of satisfaction, alongside the type of actions that they would like to take as a result of the knowledge gained, indicate that the course is meeting a need in the sector. The high pass rate, of 78%, alongside the responses of the participants in the discussion forum, and drilling sector survey, indicates high motivation among the participants, alongside a well-structured and a pedagogically robust course.

The large interest in this course, with less than half of applicants invited, illustrates that there is high demand for this type of learning. The 2022 course gave priority given to applicants that were women, from Africa and working for government, and has meant that of the over 750 people who applied, that remain, a large number of male applicants from NGOs and the UN who were not able to take this edition.

Participants of the course were keen to see that others are trained, and capacity is built further, with many expressing an interest in training that is more in-depth, and also field training. Previous online courses have required participants to also pass assignments, thus applying their knowledge, and receiving more feedback from facilitators. It is very important to recognise that while the latter provide more depth, they are more costly, and given the extremely limited, and to date ad hoc funding, that there will always be a trade-off between participant numbers and depth.

The topics raised in the discussion forums illustrated the multifaceted nature and complexity of the drilling sector in many countries. While training alone is unlikely to be able to solve all of the challenges, it does place professionals in a much stronger position, armed with information and knowledge to challenge the status quo and improve not only practices but also the wider legal and institutional framework which affects how projects operate.

The online course discussions, and survey not only raise skills, but the compilation and analysis of the data shared provides insights into the opportunities and challenges of the drilling sector across the world. As this report shows, many challenges, such as lack of groundwater data, corruption, coupled with gaps in skills and a distinct lack of training opportunities are undermining the sector, and thus the attainment of the SDGs, all over the world.

As this report goes to press, the organisers have not secured funding for this course to be run again. Discussions with SADC GMI, ECOWAS and 2iE showed a keen interest in rolling out, and even adapting the Groundwater Resources Management course for the two Southern and West African Regions in the future.

Fundraising efforts to enable this course to continue, need to continue. Looking into the future, the advisory group that was established for the two Groundwater Courses in 2022 is striving to enable these courses to be rolled out in different languages, and ultimately managed by African Institutions.

For the potential participants who are interested in such training, or who applied for the courses in 2022, but were not successful, they will hopefully be available once again.

And for the funding agencies in the sector, keen to build capacity, it is hoped that this report will inspire you to invest in training, whether face-to-face or online, so that the professionalism of the borehole drilling sector can go from strength to strength.

Recommendations

Training, professional development, degrees and certificates

It is recommended that this course is run again, ideally on a cyclical, annual basis. The organisations that are actively involved in fundraising for future courses are all encouraged to continue with their efforts to raise funds to make this possible.

The course manual and core training materials are available online and can be copied and adapted (see inside cover of this report for Creative Commons Licence and hosting of materials). Efforts should be undertaken to raise awareness of these materials.

Universities as well centres for Technical and Vocation Education and Training (TVET) offering relevant degree or certificate programmes are encouraged to incorporate and adapt the materials that have been consolidated for this online course.

Regional organisations, such as SADC-GMI and 2iE, which have expressed an interest in continuing with this, or the “sister” course on Groundwater Resources Management are encouraged to embed these courses within their own training programmes. Regional courses, facilitated by trainers that can cover all countries within the region could further enable participants to sharpen their knowledge on the specific issues, policies, guidelines and good practices within their specific contexts. Incorporating course contents and bringing in co-facilitators to address local issues could add value to the courses.

In-country, regional and international organisations are encouraged to explore how to cover training topics that participants would have liked to have in more depth. i.e., borehole siting, drilling processes, technologies, drilling management and borehole design. Future online courses could also consider adding more in-depth modules on these topics, as well as adding additional reference materials that cover these topics in more detail.

Awareness-raising and knowledge sharing

More effort is needed at national, and potentially regional, and international level to sensitise stakeholders on the borehole drilling guidelines or standards, and groundwater regulations have been issued.

Inspired by the courses, an entry on Groundwater Databases has been developed as part of the African Groundwater Atlas ²¹ by the British Geological Survey (BGS). In order to boost knowledge about groundwater databases in future courses, a short video with examples of groundwater databases, including their update and mechanisms for access should be prepared based on countries with particularly good practice.

The Rural Water Supply Network (RWSN), as a global knowledge network and its members/partners in-country should consider mechanisms such as workshops, webinars or training to discuss and share solutions for the numerous challenges faced in the planning, costing and management of borehole drilling programmes.

²¹ <https://www.bgs.ac.uk/geology-projects/africa-groundwater-atlas/>

Annex 1 Managers, course co-facilitators and peer reviewers

Dr. Kerstin Danert



Course Manager, responsible for developing the course, leading its facilitation, reporting and the supervision of co-facilitators.

Kerstin Danert is a water specialist, researcher and facilitator with over 20 years of experience, and who has worked in over 15 countries in sub-Saharan Africa. Her passion is water supply and groundwater resources in sub-Saharan Africa. She has spent a decade and a half of trying to improve the quality of boreholes in the sub-continent, and more recently has been examining problems with handpump component selection, quality and supply chains.

Dr. Moustapha Diene



Course Manager, responsible for developing the course, leading its facilitation, reporting and the supervision of co-facilitators.

Moustapha Diene is hydrogeologist, Senior Assistant Professor at University Cheikh Anta Diop, Dakar – Senegal. He earned water engineering degree in Technical University of Gdansk (Poland) and doctorate degree in hydrogeology and hydrochemistry at Cheikh Anta Diop University in Dakar (Senegal). He gained a long experience in groundwater management, water supply and sanitation, through research and national/international projects. He is the former Network Manager of the Africa Groundwater Network (AGW-Net), and currently member of the Steering Committee; he has implemented and facilitated many training courses on integrated groundwater management in Africa.

Adedotun Adelike



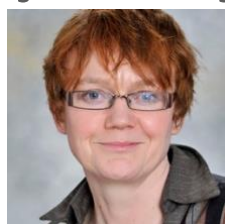
Adedotun Adekile is a hydrogeologist based in Nigeria. He has over forty years' experience providing consultancy services to governments and development agencies across Africa. He has for several years been involved in training of WASH personnel including two sessions of the on-line Professional Management of Water well Drilling Projects and Programmes.

Dr Bentje Brauns



Bentje is a hydrogeologist at the British Geological Survey with 10 years' experience in groundwater monitoring and design of small-scale monitoring networks. Her research interests include water resources in Africa and Asia (recharge, water quality, impacts from agricultural activities) and groundwater-surface water interactions.

Brigid Ó Dochartaigh



Brigid is a UK-based hydrogeologist with 25 years of experience, particularly in groundwater resource assessment and management in challenging (e.g. low permeability, dryland, arctic or urban) and data-scarce hydrogeological environments; groundwater mapping; and communicating hydrogeological information. She has worked across the UK and in countries across Africa, in Asia, the Middle East, and South America; and is a recognised expert on groundwater resources in Scotland.

Dr. Callist Tindimugaya



Dr Callist Tindimugaya has been working with the Ministry of Water and Environment in Uganda for 32 years and is currently, Head of the Water Resources Planning and Regulation Department. He holds a PhD in groundwater resources management, University of London, 2008. He has been very key in establishing groundwater resources management and development frameworks in Uganda and was a Regional Vice President for the International Association of Hydrogeologists (IAH) in charge of Sub-Saharan Africa from 2012 to 2020. He is also a Steering Committee Member of the African Groundwater Network (AGW-NET) and has represented Uganda on various regional and international organizations such as the Nile Basin Initiative (NBI), Inter Government Authority on Development and UNESCO's Intergovernmental Hydrological Program.

Daina Mudimbu



Ms Dee holds an MSc in Remote Sensing and GIS from the University of Greenwich and a first degree is a BSc General in Geology and Biological Science also from the University of Zimbabwe. She is an earth and spatial scientist with interests in environmental geochemistry, medical geology and hydrogeology. In a professional career of over 24 years, she has used a combination of skills in multi-disciplinary research teams and development projects, in environmental and groundwater monitoring and management, land use planning and environmental impact assessments. She is currently in the final year of DPhil studies in Medical Geology at the University of Zimbabwe (UZ).

Fenta Nigate



Fenta Nigate obtained his BSc degree in Applied Geology from Mekelle University (Ethiopia) in 2001. He has got his MSc degree in Water Science and Engineering, specialized in Hydrology and Water Resources from UNESCO-IHE (The Netherlands) in 2007. In his professional career, he has been working in different governmental and non-governmental organizations (Dec 2001-September 2005 and May 2007-September 2009) in the position of hydrogeologist. From October 2009 onward, Fenta is a lecturer and researcher at Bahir Dar University, Ethiopia. Fenta did get his PhD from Ghent University in 2019 and now working as assistant professor in Bahir Dar University. He has participated in international conferences and presented his research findings.

Iazalde Tayobe



Iazalde Tayobe, Mozambican, 42 years old. Graduated Civil Engineer by Eduardo Mondlane University and master's degree at IHE Delft, Netherland; 16 years working in Water Sector.

Worked for Salomon, Lda (consulting company); FIPAG (Investment Fund and Water Supply Asset Holder) as Head of Project Department; UNICEF as WASH Officer and Current working with WaterAid Mozambique as Water Supply Advisor and lecturer at Eduardo Mondlane University, Mozambique.

Dr. Jenny Grönwall



Jenny Grönwall is an Advisor on Water Policy and Rights with the Stockholm International Water Institute, and the organisation's human rights focal point. With a background in law, Jenny has an interdisciplinary PhD in water management and more than 20 years of experience in the field, focusing on groundwater governance and self-supply in India and sub-Saharan Africa. Her research also involves sustainable textiles manufacturing and zero liquid discharge methods.

Johannes Münch



Johannes Münch is a Hydrogeologist working as a Policy Advisor at the German Federal Institute for Geosciences and Natural Resources (BGR). He gained his M.Sc. in Hydrogeology at the University of Tübingen. In course of his professional career he gained experiences in the field of groundwater research and exploration, groundwater monitoring and groundwater modelling.

Jorge Alvarez-Sala



Jorge Alvarez-Sala, works at UNICEF in New York HQ, as WASH Specialist leading the water supply portfolio, which includes water access, quality and sustainability. He is in charge of a UNICEF initiative of professionalization of WASH services, which included the development -together with RWSN/Skat Foundation- of a toolkit on professional drilling operations. Jorge has 20 years of experience in the WASH sector, most of them at field positions in a variety of countries including humanitarian, transitional and development contexts in Europe, South America, Middle East, Africa and South East Asia. His previous job was with UNICEF in Ethiopia, where he was the manager of both the WASH Sector Coordination and the Emergency WASH pillars. In the particular field of groundwater, he has experience in the expansion of groundwater exploitation for a bottling company in Spain, drilling emergency boreholes in Darfur (Sudan), or using state of the art remote sensing to identify deep groundwater aquifers in the Somali region of Ethiopia (600m deep); and also advocating for the standardization of water point monitoring systems in Ethiopia as part of the second phase of the OWNPN.

Kassahun Aweke



Kassahun Aweke, has a BSc Geology (with very great distinction) from Woldiya University (Ethiopia) in 2018. Employed by Dire Dawa University he contributed to the establishment of Geology department. Currently he is doing his Hydrogeology MSc thesis entitled as “Estimation of Groundwater Storage using GRACE satellite data, the case of Ethiopia” in Addis Ababa University. Kassahun has been studying the hydrogeology of Ethiopia. He also has software skills in GIS. He wishes to become a problem-solving collaborative international researcher on global groundwater issues.

Dr Kawawa Banda



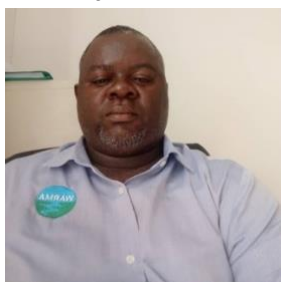
Dr. Kawawa Banda is a Senior Lecturer in Hydrogeology and Remote Sensing in the Department of Geology in the School of Mines at the academic at the University of Zambia in Zambia. He holds a PhD degree in Environmental Engineering (strong focus on groundwater hydrology), from the Technical University of Denmark (DTU) in Copenhagen. He holds a Master's degree in Integrated Water Resources Management and a Bachelor's degree in Geology from the University of Zambia. Currently, he is the Network Manager for the Africa Groundwater Network supporting knowledge dissemination on groundwater in Africa. He is also a technical committee member for the technical Committee for development of groundwater regulations for Zambia coordinated by Water Resources Management Authority (WARMA).

Dr KOITA Mahamadou



KOITA Mahamadou (PhD) is senior lecturer in Hydrogeology at International Institute for Water and Environmental Engineering in Burkina Faso since 2011. He works on hydrogeological characterization and modelling. He is involved as a lead investigator in various international projects on the integration of new scientific knowledge of aquifer characterisation, testing of new groundwater planning tools.

Levy Museteka



Levy Museteka has worked in the water sector in Zambia for the last fifteen years with progressive professional experience in hydrochemistry and hydrogeology. He has been involved in a number of groundwater research studies in Zamia. He also possesses experience in conception, development and implementation of groundwater regulations.

Dr. Moshood N. TIJANI



Moshood N. TIJANI is presently the Groundwater Desk Officer and Climate Lead at the African Ministers' Council on Water (AMCOW), Abuja, Nigeria. He holds a doctorate degree in Hydrogeology and Hydrochemistry from the University of Muenster, Germany as well as a Post-graduate Certificate in Hydrogeology from University of Tuebingen, Germany. He was, before now, a Professor of Hydrogeology and Environmental Geology at the Department of Geology, University of Ibadan, Nigeria His areas of professional competence include groundwater resources assessments with reference to groundwater exploration, aquifer characterization and groundwater quality and environmental contamination issues.

Sampson Aheleh Tettey



Sampson is the Interim Senior Regional Technical Advisor with WaterAid West Africa and provides technical and advisory support, capacity development, quality assurance, monitoring and evaluation, learning, innovation and knowledge management support. Previously, Sampson was the Senior Hydrogeologist and Head of Water Supply at the World Vision Ghana Integrated-WASH Project with a focus on groundwater assessment and development. He has over 21 years of experience and is a member of the Ghana Institute of Engineers, and holds a BSc in Geological Engineering and MSc in Water Resources Engineering and Management from Kwame Nkrumah University of Science and Technology.

Tara Bartnik



Tara Bartnik, works for WaterAid UK as Programme Support Advisor for Water, supporting WaterAid country programmes teams on water supply, climate resilience, gender inclusion, systems strengthening and construction quality. Recently led an internal review on processes for procurement of mechanical drilling services, and is passionate about professionalisation of the sector. Tara has a background in civil engineering, and has previously worked in Australia, Norway and Timor-Leste.

Tsnat Tsegay



Tsnat Tsegay has a BSc in Geology from Mekelle University (Ethiopia). Employed by Mizan-Tepi University, she contributed to the establishment of the Geology department and curriculum formulation in the university. She has an MSc in Hydrogeology (geological engineering) from Addis Ababa University with the thesis title of "comparative study of nitrate levels in groundwaters of Addis Ababa and Dire Dawa cities" in 2017. Currently, Tsnat is a PhD student at Addis Ababa University undertaking research on groundwater vulnerability and groundwater quality assessment of Upper Awash (central Ethiopia).

Annex 2 Further information about participants

Table A2.1 Countries of residence of active participants

Afghanistan	Iraq	Rwanda
Angola	Italy	Senegal
Benin	Jamaica	Sierra Leone
Botswana	Kenya	Somalia
Brazil	Laos	South Africa
Burkina Faso	Lebanon	Sudan
Burma	Lesotho	Suriname
Burundi	Liberia	Swaziland
Cameroon	Madagascar	Tanzania
Central African Republic	Malawi	Togo
Chad	Mozambique	Tunisia
Comoros	Namibia	Turkey
Democratic Republic of the Congo	Nepal	Uganda
Ethiopia	Nicaragua	United Kingdom
Fiji	Nigeria	United States
Germany	Pakistan	Yemen
Ghana	Papua New Guinea	Zambia
Guyana	Philippines	Zimbabwe

Table A2.2 Nationalities of active participants

Afghanistan	Iraq	Rwanda
Angola	Italy	Senegal
Benin	Jamaica	Sierra Leone
Botswana	Kenya	Somalia
Brazil	Lesotho	Sudan
Burkina Faso	Liberia	Suriname
Burma	Madagascar	Swaziland
Burundi	Malawi	Switzerland
Cameroon	Mozambique	Tanzania
Chad	Namibia	Togo
Comoros	Nepal	Tunisia
Democratic Republic of the Congo	Netherlands	Uganda
Ethiopia	New Caledonia	United Kingdom
Fiji	Nicaragua	United States
Gaza Strip	Niger	Zambia
Germany	Nigeria	Zimbabwe
Ghana	Pakistan	
Guyana	Papua New Guinea	
	Philippines	

Annex 3 Detailed responses to participant survey

Table A3.1 Can you please rate your overall experience using Cap-Net's Virtual Campus? –Comments

Comment
It has been easy to follow and do whatever posted.
Haven't had any problems
The mix of videos, webinar recordings, course material and website links is all very helpful
The course has been made easily understandable and the site is user friendly.
Excellent, the mandatory videos were of great assistance in explaining complex concept in a simple way
We have only have difficulty in clear listening to the recorded online discussion of the discussion providers
C'est une très bonne formation. Merci beaucoup aux organisateurs
It was so knowledgeable
very educative
We experienced using Cap-Net' Virtual Campus as an excellent platform for learning such online courses very friendly and we loved the extra website links for more study on the course topic. Thank you
Easier to use and its user friendly
Content was well organized and easy to understand and where necessary clear examples was used.
it was user friendly
LEARNT ALOT. IM NOT LEAVING THE SAME WAY I WAS BEFORE I TOOK PART IN THIS VERY IMPORNTANT TRAINING PROGRAM
Some of the transcripts of the video were not related to the video
I faced challenges in submitting posts on the discussion forum. Sometimes they would disappear after submitting.
It was well structured and contained relevant information
None
We enjoyed using Cap-Net's Virtual Campus as a good source of knowledge for professional drilling management in very effective way. Thank you.
It has been an amazing journey learning this course online with all these features.
It is user friendly
The discussions are very good, wondering if there could be a way to track comments from the facilitators or other participants on one has answered.
One is give 3 trials which is so fair enough for some one
Except for videos that are sometimes difficult to watch as their audio is of poor quality (better microphones could help)
very easy to navigate and straightforward
It was very thoughtful for the moderators to allow students to participate in the course in their own free time.
As long as you have access to internet, you can acquire all the necessary information needed from the campus
The content was good, the only issue is that the platform does not allow the attendee to track his progress.
Next time to design a way the participant can track the progress
Very simple and user friendly.
Les vidéos et documents sont très importants, et facile à utiliser
The feature are user friendly
User friendly and easy to navigate the site for content.
good experience
The materials were on point.
I got experience and knowledge about problem solving solution in drilling management process.
It would have been ideal if videos could be downloaded for future reference
At first it was difficult to sign on but after it was resolved by the support team it was working fine and easy to navigate
I learnt a lot in each module and I got to understand more about drilling a successful borehole
excellent because of the way courses are prepared .
My experience has been user friendly
the whole package was good including videos, text and quizzes
the course was well prepared that I was always excited to learn about the next module and I learned more about it

Table A3.2 Additional Feedback

Comment
It will be good to add module in Borehole siting, protection of groundwater resources
A small text book summarizing the training materials can be handy!
Am grateful that I was given an opportunity to learn in this course
As suggested earlier, the course should as much as possible use examples of newer/recent techniques in the different areas of borehole siting, drilling and other areas within the scope of the course.
Beneficial and broadened my understanding of contract management
Cap-Net's Virtual Campus is a very good initiative and would recommended more of the similar course.
DETAILED ON SITING TOPIC
Excellent course. It really broadened my understanding and knowledge. I've downloaded all resources for further study, and even further docs that I found on the websites shared. Thank you to all who contributed!
Excellent opportunity and hug appreciation to the organizers and facilitators. I am so grateful for the opportunity. Keep up and Million thanks again.
For me the course was good and provided me with so much knowledge.
Great piece
Great works.
I am delight to be part of this exceptional training course. I am indeed grateful for that, my sincere gratitude to all the organizers, colleague and partners in this movement, thanks once again.
I am pleased with the course. I have been looking for material that is applicable to my region. Training at this level is not available within my region (Caribbean). The course material was easy to use and very interesting. Concerning the Quiz; the correct answers could be displayed after the 3rd attempt at the questions.
I do appreciate the efforts and Several reminders to learn and accomplish the course
I highly appreciate from all of the supporter of this course.
I thoroughly enjoyed the course. Thank you for gathering very informative reading material.
I would be pleased to organise such a training like the one organised in Namibia with our partners in the north of Mozambique (supervisors, government counterparts and private sector alike). Please contact me if this is possible.
I would like to have further studies in hydrogeology
I would like to have more of these type of trainings if they are to be given every year. Let me say again thank you very much for the great presentation from more experienced/skilled facilitators as you are.
I would love to review my notes on the platform even after the course deadline has passed
I would suggest to have more questions in the quizzes.
I'm ready to take up any other training if given an opportunity. Time given for the course was sufficient
In future spicy the courses with physical meetings so that participants can obtained detailed knowledge and certificates say diplomas, degrees, MSc and PhDs
It was my pleasure to attend this course. I thank you very much for scheduling this capacity development exercise
It was not only theoretical but also practical course so a course containing field work to learn regarding drilling in field should be conducted...!
May be Part 2 of this course can be organised so we go into details of some of the models
Merci pour ce cours, J'espère par la suite si possible, des cours en Alimentation en eau gravitaire (source)
N/A
Overall a great course to undertake for capacity building in Africa and looking forward for more such courses.
The course has to be planned in such a way that Lecturers and students can meet somewhere for field demonstrations
The course is very informative
The course modules has been so interesting and in line with my career.
The course offers practical knowledge and skill that has increased my understanding on Borehole Drilling Management
The course should have allowed virtual interaction with course tutors
The course was good and I will be happy to participate in similar courses in the near future. Thank you.
The course was great and i have definitely gained more knowledge about professional drilling management which i intend to use in my day to day work as a water sector employee

The course was very educating. I have been helped a lot in the area of drilling supervision and procurement and estimation in drilling works.

The course was very educative, beneficial and will help in my line of work in the water sector.

The course was very useful, I gained many information that will help me in my career in WASH sector as an engineer.

The courses are really supportive to exercise in my working area. I recommend to keep providing such useful courses in future too.

The duration of the course is quite flexible as it allows time for all participants to fully benefit from the course despite setbacks of busy schedules. Thank you for quite an informative course.

The overall course was very interesting.

There was no opportunity for us the participants to download the videos (both mandatory and recommended). Many of my colleagues would like to partake in the training, How do you give them invitation?

This course is a life changer for me as it came at the right time for me and now we would be able to execute our projects in providing access to water in a professional way to last for a long time

This course was great and I enjoyed it very much. Thank you

This course was really amazing and fruitful for sure we have learned a lot however if possible think about the practice, it will be fruitful to meet and share different ways of doing our work

This course was very helpful to the growth of my understanding towards ground water therefore i recommend this course to be given to all head drillers so that it can better their understanding. in addition, a hydrology short course should be introduced to the drillers.

This is a very good course and if any new knowledge comes up i would be very eager to apply for the new course

Tous les cours sont clairs mais je pense que l'ajout de simulation de cas pratique pourrait être efficace.

Very helpful content

approfondir les connaissances techniques en matière de forages pétrolier /prévoir des sessions de formation pour des modules qui se rapportent étroitement au forage d'eau: diagraphies, prospections électrique et électromagnétique....

good

i am very grateful to have been one of the participants to increase on my knowledge pertaining to professional Drilling which will be valuable to my career going forward. the course is well presented but if we can include a lot of practical work as in more practical videos it would really help.

it is very interesting; it would be better also to show how to fix failed boreholes and pumps.

je souhaiterais que le cours intègre un module sur la qualité de l'eau, sa gestion et son suivi. Merci

more text and videos on the pumping test.

my suggestion to organize online workshop with facilitators to ensure that the objective of the course is achieved or not

over all, it was very nice. it i would be better to add a webinar at the end of each course or in the course closure. Finally, i would like to apologize the facilitators and all the teams for not taking my responsibility as a co-facilitator since i have got unexpected responsibility by organization at that time. Thank you very much.

thank you for allowing me to learn from you, i will use knowledge and skills acquired to contribute to my community

the course videos cannot be downloaded for future reference reading

we need a field experience next time.

Annex 4 Groundwater database

The table below is based on the responses to the discussion questions with respect to Groundwater Databases in Module 1. It should be noted that the responses have not been verified. However, given the lack of comprehensive, and readily available data on this, it is shared in this document.

Country	Groundwater database ²²	Database Host(s)/Managers(s)	Summary of responses
Angola	Yes		Stored and managed by the department of water who are also the regulating agency for drilling licences in urban places. However, there is slackness in terms of reinforcing drilling companies to submit drilling data.
Brazil	Yes – but of monitoring wells rather than construction and lithological records.	Geological Survey of Brazil (SGB - CPRM).	There is the Geological Survey of Brazil (SGB - CPRM). Hydrogeological surveys have been carried out since 2010 and the Integrated Groundwater Monitoring Network - RIMAS is maintained. With more than 400 dedicated wells, RIMAS carries out qualitative and quantitative monitoring in the main free aquifers in Brazil, such as: Guarani, Alter do Chão and Urucuia. Where RHN does not have coverage, RIMAS also installs and operates automatic hydrometeorological collection stations, the data used are for forecasting aquifer recharge. Mato Grosso – BR doesn't have much data or monitoring wells for the SGB but the state has large sedimentary basins with aquifers of great potential that are little known. However, government most likely does not have good records of their construction and lithological description. The Brazilian geological service project focuses on qualitative and quantitative monitoring of groundwater.
Burkina Faso	Yes		Ministry of Water and Sanitation, and others who ensure decentralised management of surface and groundwater data (e.g. Comoe Water Agency, Mohoun Water Agency, and Nakambe Water Agency) Data can be accessed but it is a long process
Cameroon	Yes	Ministry of Water and Energy (water information system unit)	Based on boreholes and drinking water supply carried out in the country. It is a decision support tool and is accessible to the general public. to improve the updating of data There are problems updating the data - collection sheets have been developed and made available to the technicians who drill the boreholes but they are not always filled in, and even when they are, the transcription into the machine is not always done. Further, there is the problem of internet connection in remote areas.
Comoros	Yes	Direction Générale de l'Energie, des Mines et des Ressources en Eau	

²² Responses to question: Is there a groundwater database in your country?

Ethiopia	Yes & No	<p>Different responses</p> <ul style="list-style-type: none"> Water Resource Commission (WRC) and Community Water and Sanitation Agency (CWSA). Ministry of Water Resources and Metrological Office Minister of Water, Irrigation, and Energy Region and zone water offices 	<p>Contradictory responses:</p> <ul style="list-style-type: none"> The WRC are responsible for issues licenses for any water abstraction and one is required to submit data on drilling or any use of groundwater to this institution before a new license is issued. The data base is accessible to Hydrogeologist or others working in the water industry to help them improve on their groundwater search. More work is yet to be done to make this available database comprehensive much more accessible online. Data are usually in the hands of individuals and not easily accessible. To my knowledge no official ground water database, but ground water mapping and data's were provided by ministry of Water and Energy. Bore holes data (water level, water quality and hydrogeological maps) are provided when they requested formally. <p>More recently the Ministry is trying to establish a groundwater database with Acacia Water.</p> <p>World Vision also has a database of shallow and deep wells.</p>
Fiji	Yes	Department of Mineral Resources and the Secretariate of the Pacific Community.	<p>The data are mostly used for research purposes, extraction for bottled artisan water and community based water supply services.</p> <p>Accessing the groundwater data in Fiji requires approval from the Department of Mineral Resources.</p>
Ghana	Yes & No	<p>Different responses:</p> <ul style="list-style-type: none"> Water Research Institute of CSIR Water Resources Commission 	As part of the mandate of the commission, drilling companies must submit drilling logs to the commission annually and the commission issues drilling license to the drilling companies.
Guyana	Yes/No		Should be the Hydrometeorological Service but it the groundwater database is limited and not fully operational. Public supplier also had a groundwater database but this is not shared without request.
Jamaica	Yes	Water Resources Authority of Jamaica	The information is accessed from the Authority's website as a "Water Information System"
Kenya	Yes	Ministry of Water & Sanitation and Irrigation and Water Resources Authority	<p>Issue is updating. Often drillers do not submit borehole completion reports, especially on dry wells.</p> <p>County Government of Turkana has designed its own database for functionality of boreholes and not ground details.</p> <p>In Kenya, borehole data is maintained by WRA (formerly WRMA) and can be accessed by geologists at a fee of approx. Kshs.2,500/- (last time the participant checked).</p>
Lesotho	Yes	Water Affairs	
Libera	No		
Madagascar	No		

Malawi	Yes	Different responses: <ul style="list-style-type: none"> ▪ Water Resources Department ▪ National Water Resources Authority ▪ Department of water under the ministry of water and sanitation 	National Water Resources Authority is requesting data so that it can produce a comprehensive GW database to complement that of the ministry of water Data is available when requested
Namibia	Yes	Ministry of Agriculture, Water, and Land Reform.	Data is available upon request
Nepal	Yes	Groundwater Resources Development Board under the Ministry of Energy, Water Resources and Irrigation,	
Nigeria	Yes and No	Different responses: <ul style="list-style-type: none"> ▪ Nigerian Hydrological services agency, ▪ Nigerian association of Hydro-geologist, ▪ Nigerian Mining and Geoscience society ▪ State water cooperation of the state 	There is a vast groundwater database where professionals, on-professionals can have access to in solving various groundwater problems. The data are significantly used by various users especially the professionals in the water and environmental industry. Accessing the groundwater data in my country has been very friendly in terms of prompt access and usage.
Pakistan	No		
Rwanda	Yes and not sure	Ministry of National Resource	There is a Water Resources database. The Water Resources Board (WRB) is responsible. I am not sure the extent of existing groundwater data, but groundwater levels on pre-selected boreholes (8) is regularly monitored. Also water quality data exist since they are also monitored
Sierra Leone	Yes		
Somalia	No & Yes (partial - regional)		In Somalia , there are information managements centres located in Garowe and Hargeisa and Moqdisho and they have a groundwater database (Water points, hydrogeological, geological datasets) but all datasets are at regional scale while the local datasets can available through the private consultants working on the field more than the government and FOA-SAWLIM program who also collecting groundwater and land resource datasets. database with scale is accessible but the datasets at local hydrogeology and geology are not accessible for me

South Africa	Partial & yes	Department of Water and Sanitation	<p>Different responses:</p> <ul style="list-style-type: none"> ▪ Outdated Groundwater Resource Information Project (GRIP) for Limpopo Province ▪ National Groundwater Archive ▪ National groundwater database (NGDB)
South Africa	Yes		Anyone can register and access the data
South Sudan		Ministry of Water Resources and Irrigation	Yes we do have a Database for Groundwater (Boreholds) and it is managed by the Ministry of Water Resources and Irrigation plus some data managed by UNICEF- South Sudan.
Suriname	Yes and no		<p>Actually, there is no central database on groundwater data in Suriname. But there are intuitions, such as the University, the Water Company and the ministry of Natural Resources that have data. But it is not freely accessible to everyone, and data is scattered.</p> <p>There is a database for water data at the Suriname Water company which has their own drilling department.</p>
Tanzania	Yes	Ministry of Water and Irrigation and the Directorate of Water Resources	<p>Data are not comprehensive</p> <p>Need to write a letter to the Director of Water Resources</p>
Togo	Yes	Regional directorates of the Ministry of Water	The regional directorates feed the database, and the data are centralized at the level of the Integrated Water Information System (IWIS) division.
United States	Yes	United States Geological Service (USGS)	The United States has 850,000 records of wells, springs, boreholes, and other water supply systems. USGS also has a national waterboard which captures data from 13, 500 water stations. USGG uses the data to measure water quantity, quality, distribution, and flow direction. This gets transmitted to public and private utilities, relevant federal agencies, and the general public who manages or monitors water resources.
Uganda	Yes	Ministry of Water and Environment	Data are available for use
Zambia	Yes	<p>Different responses:</p> <ul style="list-style-type: none"> ▪ Water Resources Management Authority (WARMA) ▪ Ministry of Water Development 	<p>Database is called GEODIN</p> <p>It provides Borehole logs, Pump test graphs, Chemistry data table, water quality report, Borehole completion form, and Groundwater monitoring table. The database is used to make informed decisions regarding Ground Water Resources Management.</p> <p>Data is available upon request</p>

Zimbabwe	Yes	<p>Different responses:</p> <ul style="list-style-type: none"> ▪ Databases managed by catchment councils ▪ Zimbabwe National Water Authority 	<p>The catchment councils collect information, that is, siting reports and drilling reports and these are submitted to Zimbabwe National Water Authority. However, the information is sketchy and not easily accessible to the public.</p> <p>To obtain a drilling permit, an individual, organization or driller need to submit siting reports and eventually drilling reports. The reach of the respective catchment councils is not extensive and some drillers get away with drilling without the permits. It is therefore not entirely known how many boreholes are in the country.</p> <p>In Zimbabwe, we do have a government affiliated organisation which is responsible for groundwater database management, Zimbabwe National Water Authority. However I am not aware of how to access this database.</p>
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Annex 5 National guidelines or standards

Table 4.1 Responses to question - Has the government published national guidelines or standards for borehole drilling and rehabilitation?

Country	Responses
Afghanistan	Yes
Benin	Yes
Botswana	No
Brazil	Yes
Burkina Faso	Yes, no
Chad	Don't know
Comoros	No
Ethiopia	Yes, No, Don't know
Fiji	No
Germany	Yes
Ghana	Yes, No, Don't know
Iraq	Yes
Jamaica	No
Kenya	Yes, Don't know, There are agreed upon borehole drilling procedures but unfortunately not properly captured in policy and implementation.
Kenya	Yes
Lesotho	No
Madagascar	No
Malawi	Yes, Don't know
Mozambique	Yes
Namibia	Don't know
Nigeria	Yes, No, Don't know
Rwanda	Yes, No
Senegal	No
Sierra Leone	Yes
Somalia	Yes, No
South Africa	Yes, No, Don't know
South Sudan	No
Sudan	Yes
Suriname	No
Tanzania	Yes
Togo	Yes
Tunisia	Yes
Uganda	Yes, No, Don't know
UK	Don't know
Zambia	Yes, No,
Zimbabwe	Yes, No,

Annex 6 Drillers Associations

The table below summarises the information from participant survey to provide an overview of drilling associations around the world, i.e. Question 5. Does a national drilling association exist, or are there state level drillers associations in the country? If there is a driller association(s), tell us the name, and if it is currently active.

Country	Participant response: is there a drillers association?	Participant response: Name of association
Benin	No	
Brazil	Yes	Brazilian Association of Underground Waters (ABAS) promotes the National Meetings of Well Drillers
Burkina Faso	No	
Comoros	No	
Ethiopia	Yes & No	
Fiji	No	
Ghana	Yes, No & Don't know	Ghana Association of Drillers
Iraq	No	
Jamaica	Not applicable ²³	
Kenya	Yes, No & Don't know	KENYA DRILLERS NETWORK ASSOCIATION ²⁴ , Kenya water Industry Association (KWIA)
Lesotho	No	
Madagascar	No	
Malawi	No	
Mozambique	No ²⁵	
Namibia	Don't know	
Nigeria	Yes, No & Don't know	Borehole Drilling Association of Nigeria (BORDAN) ²⁴ , Association of groundwater explorationists (AGE) ²⁴ , Association of Water Well Drilling Rig Owners and Practitioners (AWDROP) ²⁴
Rwanda	No	
Senegal	No	
Sierra Leone	No	
Somalia	No & don't know	
South Africa	Yes & don't know	Borehole Water Association of Southern Africa
South Sudan	No	
Sudan	No	
Suriname	No	
Tanzania	No	
Togo	Yes	Association of drilling contractors of Togo
Tunisia	Yes	
Uganda	Yes, No & Don't know	Uganda Drilling Contractors Association (UDCA) ²⁴ active.

²³ Two companies are on the island that drill for water

²⁴ Active

²⁵ PLAMA is an association of water practitioners and some are private companies

United Kingdom	Yes	BDA ²⁴
Zambia	Yes, No & Don't know	Drillers Association of Zambia (DAZ) ²⁶
Zimbabwe	Yes, No & Don't know	

²⁶ Needs to be capacitated

Annex 7 Skills, knowledge and experience

The survey in module 5 asked participants whether they believed that the skills, knowledge and experience of siting, supervision or drilling professionals are sufficient to meet the needs of access to drinking water for all by 2030, as well as about ongoing initiatives to improve them. The table below presents the responses.

Country	Sufficient skills, knowledge & experience ²⁷	Initiatives ²⁸	Details of any initiatives mentioned ²⁹
Afghanistan	No	No	
Benin	No	Don't know	
Botswana	No	No	
Burkina Faso	Yes	Yes	<ul style="list-style-type: none"> ▪ Ongoing thesis on how to reduce negative boreholes in the basement areas of Burkina Faso. ▪ On-going project -RESOB (Water Resources in the Basement of Burkina Faso) to rethink the way borehole are sited. Part of it another program to the WASH sector.
Ethiopia	Yes & no	Yes	<ul style="list-style-type: none"> ▪ Since the technology and pattern of works are variant throughout the time, there should be training and skill development issued for the technical as well as for being creating a valuable company to the country. ▪ University
Fiji	No	No	
Germany	Yes	Yes	<ul style="list-style-type: none"> ▪ Technical guidelines, national and international norms, etc., accreditation of samplers by DAkkS, certification of drillers by DVGW Deutscher Verein des Gas- und Wasserfaches e. V.
Ghana	Yes		<ul style="list-style-type: none"> ▪ Water Resources Commission is one such entity that often organizes workshops for drilling companies
Ghana	Yes	Don't know	
Jamaica	No	Don't know	
Kenya	Yes & no		<ul style="list-style-type: none"> ▪ PRD Rigs Kenya provides annual trainings for drillers ▪ Only hydrogeological reports from qualified and registered geologists are permissible by Water Resources Authority to authorize drilling.

²⁷ Question 8. Do you believe that there are sufficient skills, knowledge and experience of siting, supervision or drilling professionals in the country to meet the needs of access to drinking water for all by 2030?

²⁸ Question 9a. Are there any initiatives taking place in the country to raise the skills, knowledge and experience of siting, supervision or drilling professionals?

²⁹ Question 9b If there are initiatives to raise the skills, knowledge and experience of siting, supervision or drilling professionals, please describe them, or provide the title of the project and names of the organisations running them.

Country	Sufficient skills, knowledge & experience ²⁷	Initiatives ²⁸	Details of any initiatives mentioned ²⁹
Lesotho	No		<ul style="list-style-type: none"> ▪ Lerotholi Polytechnic Institution trains Technicians in Water and Environmental engineering and they do the module Groundwater Hydrology
Madagascar	Yes	No	
Malawi	Yes & no		<ul style="list-style-type: none"> ▪ The Ministry of water and Sanitation through the National Water Resources Authority is responsible for engaging the registered borehole drilling companies in various trainings on groundwater management³⁰.
Mozambique	No		<ul style="list-style-type: none"> ▪ Pronasar, a national initiative supported by donors is trying to bring in exactly the same knowledge discussed in this course through secondments to UNICEF, trainings in groundwater development, etc.
Namibia	No	Don't know	
Nigeria	Yes & no		<ul style="list-style-type: none"> ▪ Introduction of drillers license after the completion of training course at National Water Resources Institute
Rwanda	Yes & No ³¹	Planned	
Senegal	Yes	No	
Sierra Leone	No		<ul style="list-style-type: none"> ▪ The NWRMA has initiate to train staff of the agency and drilling companies but lacks resources ▪ There is no project but in order for the Agency to ensure effective compliance is hoping to training staff of drilling companies to adhere to the borehole guidelines
Somalia	Yes	Yes	<ul style="list-style-type: none"> ▪ Groundwater exploration, by PWDA ▪ So far, in our country there is initiatives or ongoing project to develop skills and knowledge for supervision and drilling professionals except some training or capacity building made by academic institutions and department of groundwater ministry of energy and water resource federal government Somalia.
South Africa	Yes & Don't know	Don't know ³²	<ul style="list-style-type: none"> ▪ There are many online conferences on groundwater related matters. The main (in-person) conference I'm aware of for SADC will be in Namibia in November 2022.

³⁰ Response was not specific about initiatives rather indicating responsibility.

³¹ Apparently, we have like 3 private drilling companies and one NGO which are doing drilling work so I really doubt the skills and experience of the 3private company only this NGO is meeting the quality

³² The National Groundwater Strategy was issued by Department of Water & Sanitation in 2017. It's a very ambitious strategy, but I don't know how implementation / enforcement is progressing.

Country	Sufficient skills, knowledge & experience ²⁷	Initiatives ²⁸	Details of any initiatives mentioned ²⁹
South Sudan	Yes		<ul style="list-style-type: none"> Capacity Building Initiative and it had been initiated by the government (Ministry of Water Resources and Irrigation) this is done by sending staff abroad for studies.
Sudan	Yes		<ul style="list-style-type: none"> Sometimes the institution raises the efficiency of engineers by conducting training courses and workshops (Drinking water and sanitation units)
Suriname	Yes	No	
Togo	Yes	No	
Uganda	Yes & No		<ul style="list-style-type: none"> Establishment of the Water Resources Institute, in Entebbe Yes, WE-Consult conducts these trainings to all new staff
UK	Yes	Don't know	
Zambia	Yes & No & Don't know	Yes	<ul style="list-style-type: none"> Groundwater Management Support Project/ SADC- GMI, world vision, TRALAD, BGR University of Zambia in collaboration with the Water Management Authority Borehole drilling supervision and we'll development Short trainings on borehole siting and drilling. Currently, i believe we only have (this) Online Training Course - Skat foundation on Professional Water Well Drilling Management which is in collaboration with Cap-Net.
Zimbabwe	No	No	

Annex 8 Challenging geological environments

A total of 96% of 120 participants provided examples of challenging geological environments³³ in their particular contexts covering 33 countries, as summarised in Table A8.1. These specific challenges are important to consider in future courses which may have a specific geographical focus. Incorporating course contents and brining in co-facilitators to address these issues would add value to the courses.

Table A8.1 Responses to the question: If there are any areas with particularly challenging groundwater for development (e.g. high risk of dry hole, salinity, iron/manganese, low pH) or groundwater hotspots (e.g. concern about falling water tables or pollution), please describe them.

Country	Descriptions of challenging geological environments
Afghanistan	<ul style="list-style-type: none"> ▪ Dry hole and groundwater pollution
Benin	<ul style="list-style-type: none"> ▪ There is for example the saline intrusion in the aquifer located in the municipality of Abomey-Calavi (coastal area)
Botswana	<ul style="list-style-type: none"> ▪ Areas around Gaborone, which is underlain by extensive granite with very low groundwater potential
Brazil	<ul style="list-style-type: none"> ▪ Brazil is huge, with all kinds of challenges, from confined aquifers that are being drained losing pressure, salinity in coastal regions due to the saline wedge, overexploitation, huge number of clandestine wells (it is estimated that in Brazil there are more than 2.5 million wells and 90% of them are clandestine).
Burkina Faso	<ul style="list-style-type: none"> ▪ In basement areas of Burkina, 40% of drilled boreholes are negatives. ▪ Yes in Burkina faso there many ores, which are extracted (gold, iron, manganese). And those extraction pollute the quality of the groundwater.
Chad	<ul style="list-style-type: none"> ▪ Due to drilling on shallow aquifer, in the coming years I expect great pollution in NDjamena city.
Comoros	<ul style="list-style-type: none"> ▪ The main groundwater resource of Grand Comore, exploited by the national water company for capital and by some piped networks from wells made at the end of the 80's. The exploitable flows are very important because of the very high transmissivity of the volcanic formations (drawdowns of the order of cm per m³ pumped). ▪ The main problem is related to the chemical quality of the pumped water –very high permeabilities also lead to a significant contamination of the water table by sea water (problem of salinity)".
Ethiopia	<ul style="list-style-type: none"> ▪ Groundwater pollution, risk of dry hole and salinity ▪ Low lands, arid and semi-arid deserted places of Ethiopia ▪ In our country, there are many challenges specially for salinity problems in North eastern Ethiopia, Afar Region, dry hole in Eastern Ethiopia, in Metamorphic terrain. ▪ Salinity and fluoride problem
Fiji	<ul style="list-style-type: none"> ▪ Falling water tables
Germany	<ul style="list-style-type: none"> ▪ In coastal areas salinity of deeper groundwater is a problem. Lots of agricultural use, industrial areas / brown fields. Exhaustive industrial groundwater use. Recently: lowering groundwater tables due to drier seasons.
Ghana	<ul style="list-style-type: none"> ▪ The success rate for the Tolon Kumbungu area in the Northern Region is about 25%. ▪ Some level of dry holes in the Northern part of Ghana. ▪ There is risk of dry hole at Atebubu and Kwame Danso. ▪ Salinity issues at Prang in the Bono East Region of Ghana. ▪ Areas with high risk of dry hole such as Agotime Ziope District, East Gonja District and many other districts

³³ Question10a. In the country, are there any areas with particularly challenging groundwater for development (e.g. high risk of dry hole, salinity, iron/manganese, low pH) or groundwater hotspots (e.g. concern about falling water tables or pollution)?

Country	Descriptions of challenging geological environments
	<ul style="list-style-type: none"> Areas with high concentrations with iron/manganese, there are areas with high concentration of fluoride above the WHO guideline value.
Iraq	<ul style="list-style-type: none"> A lot of areas with challenges of groundwater for development especially in west of Ninvah governorate (Sinjar district). depth of groundwater due to low range of rainfall in the last 3 years, low PH and high salinity.
Jamaica	<ul style="list-style-type: none"> Saline intrusion and saline upcoming along coast in limestone and alluvium wells, manganese in alluvium aquifer, high risk of dry hole in non-karstic low permeability limestone (poor siting), groundwater hotspots (high sodium and pH due to contamination from bauxite/alumina operations in limestone aquifers; high nitrate contamination of alluvium aquifers from historic disposal of sewage through soak away pits)
Kenya	<ul style="list-style-type: none"> Tana river, Lamu experience saltwater intrusions while Samburu is an area with very low groundwater potential Areas particularly in the arid and semi-arid areas have low ground water potential and if any suffer from high salinity same as areas near the lake. Leaving residents to rely on areas near rivers to sink wells with portable water. In northern Kenya the area is very dry to the extent that no single boreholes has ever succeeded. In some areas also a flammable gas are discovered during drilling making it risky to carryout drilling in some parts of rift valley. In the northern part of the country like in Turkana where there is total dependency on groundwater for all use, so many boreholes are drilled and due to over pumping the water table drops. the area is very dry and groundwater recharge is an issue. the geological formation contributes to high chemical composition in the groundwater eg fluoride and manganese High levels of iron and fluoride is common/iron and manganese occurs in some areas though not a big problem. Nairobi aquifer is over exploited leading to falling water tables, especially in Karen area and increased fluoride. Salinity is mainly in near the coastal aquifer such as in the Eastern region and the Turkana aquifer if you drill beyond 50metres. Different soluble geology in sedimentary basins or aquifers, areas in hot climate and areas with soluble volcanic geology. Areas with basement system geology can produce dry boreholes. Areas with dissolving aquifer geology such as olivine basalts have water quality issues.
Lesotho	<ul style="list-style-type: none"> Dry boreholes, levels of fluoride not in the recommended standards and many people have stained teeth. high risk of sanitary contamination due to pit latrines etc.
Madagascar	<ul style="list-style-type: none"> South area of Madagascar with high hardness, and coastal zone. Some areas with high risk of salinity and in other areas, there are high risk of dry hole due to geological formation.
Malawi	<ul style="list-style-type: none"> Salinity <ul style="list-style-type: none"> Some aquifers in Central Districts in Malawi contain salty water. There are areas in the south especially in Nsanje and Chikwawa districts where there is a lot of cases of high salinity. Lake Chilwa side has high chances of salinity. Dry holes/difficult to get water <ul style="list-style-type: none"> In high areas in northern Malawi and other highly areas dry holes are common. Dry holes are common because of poor geological surveys and lack of proper geophysical survey machine. Dowa and Kasungu districts in the central Malawi has high risk of dry borehole. Nkhoma and other parts of lilongwe have saline waters. In Mwanza, Neno and Ntchisi there is high risk of dry boreholes as these areas are dominated by weathered basement aquifers We have several higher terrain areas comprised of deep hard formations that its very difficult to get water.

Country	Descriptions of challenging geological environments
	<ul style="list-style-type: none"> Some areas have mica which always which give misleading information in terms of the values of resistivities hence the shape of the graph Most areas underlain by bedrock whose pores are not well connected. Also areas where there are micas the results of geophysical survey mislead the surveyor.
Mozambique	<ul style="list-style-type: none"> The hydrogeology of the country has not been mapped so far, except for few areas where particular investigations have been carried out. In the North of the country there are plateaus where water is very difficult to find and the hydrogeology still very unclear.
Namibia	<ul style="list-style-type: none"> Seawater intrusion in the Omdel dam, Omaruru River. There are some area with very saline water
Nigeria	<ul style="list-style-type: none"> Dry boreholes: <ul style="list-style-type: none"> Falling water table, around a basement area mostly characterise by gneisses rock known for its hard, resistant to weathering. During dry seasons most borehole tend to ceased completely while some tends to have a low to very low yield. The cause of this could be due to lack of sufficient fractures and not enough weathering of the basement rock. In some areas is coupled with excessive drawdown from multiple boreholes clustered in an area, thus reducing the yield of the borehole. Parts of Jos north Plateau State have issues of dry boreholes as a result of rocky terrain. We have areas of high risk of dry holes in the Basement Complex, while there are areas with issues of Groundwater salinity and pollution in the sedimentary terrains along the coast line of the country, especially Lagos. In some part of North Eastern state like Maiduguri and Extreme North west state like some part of Zamfara, Katsina, Sokoto and kebbi State and some parts of the states that are boarder to Niger Republic are at risk of getting dry wells. Water quality <ul style="list-style-type: none"> Pollution aspect and salinity Indiscriminate open dump site waste management as well as the poor location of septic tanks are the major cause of groundwater pollution in Nigeria. groundwater in major cities in Nigeria is polluted by septic tank interference and heavy metals from the open dump sites Northern Nigeria has challenges of dry hole, salinity, falling water tables and pollution High iron content and unfavourable geological formation Lantang. Wasse, Jos north in plateau state, Gombe State, have issues of water pollution. High fluorine content in Lantang and Gombe leading to brownish coloration of teeth. Pollution in Wasse is due to mining activities Lantang in plateau state and Gombe state has issues of high fluorine content in their groundwater leading to brownish coloration of teeth. wasse in plateau has issues of pollution as a result of Lead-zinc mining activities. Some part of Yobe and Maiduguri has Floride enrich in their groundwater which causes teeth mottle. Due to illegal mining that affected aquifer of some part of Zamfara state (Anka , Bukuyum) increased the lead content of their ground water. In Northern Nigeria where we are located, we have communities that the depth of groundwater gets to as far 60 metres which eventually has no water, easily polluted.
Rwanda	<ul style="list-style-type: none"> In the Northern part of the country (Musanze and Burera Districts) some groundwater wells contain high salinity, iron and sometimes Arsenic. This hinders groundwater development

Country	Descriptions of challenging geological environments
Senegal	<ul style="list-style-type: none"> There is an area stretching from the north to the south of the country up to 200km wide, called the central salt belt, with excessive levels of salt and fluoride exceeding WHO standards. In this band, the most important and most exploited water table in Senegal, the Maastrichtian, is of very poor quality, which is the cause of problems of access to quality water in this area. In the western part of the country, in the regions of Thiès and Dakar, there is the problem of overexploitation of the Maastrichtian, Paleocene and infrabasaltic aquifers, which is the cause of quality degradation through saline intrusions.
Sierra Leone	<ul style="list-style-type: none"> High manganese/iron, salt water intrusion and low yield mainly as a result of poor siting and improper well construction and development and also as a result of the geology in which 2/3rd of the country is covered by granitic rocks with little or no fractures
Somalia	<ul style="list-style-type: none"> Some the most challenge facing our groundwater is pollution, for example in Mogadishu the only water resource is groundwater and where the boreholes drilled becomes residential area that can cause groundwater pollution. The other challenges faced is salinity most of the aquifers in Somalia the water quality is very poor due to the high ranges of salinity. Puntland State of Somalia, Baido, baletwayn and Gedo regions and salt area like Kismayo and Garacad ports/towns
South Africa	<ul style="list-style-type: none"> Acid mine drainage, nitrate, salinity and nitrate are a problem In Limpopo province, almost as the rule, there will be heavy metals in the water, especially manganese. Also Arsenic and iron. Progressively we are also finding growing levels of nitrate contamination. The sources of contamination varies from poor sanitation, agriculture and moving activities. There are areas where groundwater is almost solely used to meet their domestic water demands. These areas have seen a significant drop in groundwater levels over time.
South Sudan	<ul style="list-style-type: none"> Juba City had much saline and arsenic water in most of the areas around the city so it is very difficult to use ground water for drinking.
Sudan	<ul style="list-style-type: none"> We need experience in how to conduct the cementing and blocking the saline layer in sudan basin. In some areas there is a problem of interference of salty and contaminated layers in the Khartoum basin. In South Darfur State, there are many boreholes were getting dry Particularly, in Otash and Draj camps. Water table falling down in Nyala town in summer season because the area is basement complex, wells drilled on the fractures and depend on rain for recharge.
Suriname	<ul style="list-style-type: none"> In the Southwest of Suriname, possible groundwater pollution In shallow well due to mining. Also salinization of the wells due to over-pumping. And in the hinterland a lot of dry wells. In the coastal area mostly, groundwater is used for water supply, and here we have high salinity levels at some of the stations
Togo	<ul style="list-style-type: none"> In Togo, we can subdivide the zones in 3: <ul style="list-style-type: none"> - In the coastal zone we have the problem of salinity and pollution risk for the Continental Terminal water table - In the plateau region of Togo, the concentration of iron generally exceeds the norm - In the plain of Oti, especially in the argillites, the failure rate for drilling is very high and can go up to 80% in some areas.
Tanzania	<ul style="list-style-type: none"> Areas with high Iron/Manganese also groundwater hotspots for falling water levels and potential for pollution. Salinity problems in the coastal zone, also Fluoride problems in the volcanic areas and water pollution in the urban areas
Tunisia	<ul style="list-style-type: none"> Falling water tables and salinity due to the intensive use/exploitation of groundwater and salinity.

Country	Descriptions of challenging geological environments
Uganda	<ul style="list-style-type: none"> ▪ Risk of dry boreholes: <ul style="list-style-type: none"> ○ There are areas in Malongo subcounty, Mayue District which have a very large high bed rock and chances for dry holes are high. ○ Areas with high risks of dry boreholes and some of these are found in transition zones and very rocky areas. ○ Some areas lie in the Dry Cattle Corridor³⁴, with complex geologic and geophysical conditions. These are characteristic of dry boreholes or low yields. ○ Dry belts, for example Nakasongola district, Sembabule District and others. ○ Dry wells especially in areas like the Northern part of Uganda, quite hard getting water. ○ Nakasongolo district has high risk of dry well, as search the contractors fears to bid for this district for borehole construction. The only source of water available is piped water system channels from the neighbouring district. ○ Some boreholes in villages have a high risk of dry hole. ▪ Urban areas are more polluted. Places with high pollution or contamination rates include Kampala and other major cities. ▪ Salinity, iron/manganese, and low PH. ▪ Low yielding wells, Water quality. ▪ There are long droughts.
Zambia	<ul style="list-style-type: none"> ▪ High risk of dry borehole, falling water tables and pollution ▪ Salinity <ul style="list-style-type: none"> ○ Challenging groundwater for development with high salinity in the western part of Zambia particularly Mwandi District, Sioma District, Sesheke District and Kazungula District. mostly boreholes are drilled but the challenge is the water not being used because of the salinity. From my experience shallow boreholes tend to have fresh water in some parts of the areas with saline. ○ Some areas have high salinity, like the western side of Zambia. others groundwater is too deep ▪ Dry boreholes <ul style="list-style-type: none"> ○ Areas like Chalala, Jamaica, Lilayi, part of Chilanga. There's a high risk of drilling a dry hole if not it will be a low yielding borehole, in Lilayi ○ Chadiza is one of the most Rocky areas and has high possibility of hitting dry holes. ▪ Water quality <ul style="list-style-type: none"> ○ Some areas in Lusaka like Kanyama, Chawama, Kamwala and Chalala has high ground water contamination. ○ The groundwater hotspots are in slums where wells are contaminated with waste from pit latrines and in the mining areas. ○ Yes there are various hot spots for pollution, particularly in the dolomite karstic aquifer. ○ In Lusaka town population growth has led to over abstraction of the resources, and therefore many boreholes have dried up. Deeper drilling is needed to find the watertable. Unplanned shanty compounds with poor sanitation and poor solid waste management have put a further strain on the quality of the water resources. ○ Additionally, there exist areas with hard water which is not ideal for drinking and domestic use ○ Ngwerere area in Chongwe district is polluted by crude municipal effluents and wastes from the sewage treatment plants hence very challenging. ○ High iron, low pH in Copperbelt and Luapula, sand in Western ▪ Falling ground water levels in the dry season.

³⁴ The cattle corridor districts in Western Uganda extending to the southern districts of the Central regions. The cattle corridor has districts of Kazo, Kiruhura, Nakaseke, Nakasongola, Kyankwazi, Lyatonde. Further extension to Kabarole.

Country	Descriptions of challenging geological environments
	<ul style="list-style-type: none"> ▪ Risk of dry borehole and iron. There exist areas with low ground water potential and risks of dry holes. ▪ 1. Lusaka Province-dry Boreholes, Contaminations 2. Copperbelt Province- Contaminations due to mining. 3. Luapula Province- Contaminations due to poor Sanitary and Hygiene, High content of Iron.
Zimbabwe	<ul style="list-style-type: none"> ▪ High risk of dry holes around the country. High risk of dry holes around Dande area. ▪ Salinity, high iron content as well as coal deposits. In the urban setting, some areas are prone to pollution from free flowing sewer, and chemical from the industry. ▪ Urban areas such as Harare are characterized by uncontrolled development, slams, dumping sites and uncontrolled sewage disposal which is putting both surface water and groundwater at risk of pollution. The problem is worsened by lack of investment by the government to facilitate groundwater monitoring programs and remediation activities. Point and non-point sources of pollution are evident whilst groundwater is largely invisible. ▪ There are areas with vast granites and there are a lot of dry holes ▪ There low lying areas with heavy clays the water is deep and salty

Annex 9 Potential actions by participants and for organisations

Table A9.1 Responses to the question: Please describe at least one action that you in your professional capacity, would like to undertake to improve the professionalism of borehole drilling in your organisation or country.

Response
1. Improvement of siting methods, we are purchasing the latest Terameter for hydrogeological survey
2. Using high quality materials that last longer
3. Proper drilling and construction"
Enhancing Professionalism in Supervision of the drilling works from the contractor's side through staff trainings.
I need to introduce or train to adapt groundwater management in every boreholes around the country (depth, quality,seasonal groundwater level fluctuation, e.t.c.).
Scrutiny of drilling contractors when drilling private boreholes. Most cases strict supervision is only handled by government on government projects.
a practical course during a real drilling
Acquire better understanding of the investigation and design component in relation to borehole procurement, to ensure funds are diverted where needed and to aid when monitoring component kicks in as what is required would have been clearly spelt out.
Activating the role of the state on specifications and activating drinking water laws
After the course I would like to apply all the procedures I learnt in order to try and highlight the correct way of borehole drilling
as a lecturer i will teach my students not only the theoretical part but also i will show them practical works and involve them in drilling projects.
Borehole siting
Capacity building , I will create awareness on borehole drilling profession , Transfer knowledge and Skills on Drilling , supervision and management of Borehole. And also create water association at our local level (Local government) with the help and approval of the Local Government Chairman.
Capacity building among the experts
Capacity building of junior staff at work.
capacity building of staff of the agency and drilling companies and ensure proper supervision of drilling activities
Capacity building, that's the area I have key interest in. I believe providing the right knowledge base can act as a catalyst for the achievement of professionalism in drilling here in Nigeria.
checking the data presented by the drilling companies as well as cross checking all the necessary data
Conduct Training wherever possible
Conduct trainings on drilling procedures and drilling report writing. also restrict the number of borehole companies in the country to a fixed number
Conformity to regulations
Consultancy should be emphasized and use of technical capacity for siting should be utilized to eradicate the use of rudimentary and conservative methods of water siting."
Create awareness and train consultants, supervisors, drillers with the knowledge I have earned here on this program to train the trainers so that this knowledge is cascaded down.
Creating awareness about groundwater protection and sustainable withdrawal. thus promoting professionalism among those dealing with ground water.
Creating awareness on groundwater and sustainable use of boreholes
Deregistering of non compliant drillers

Developing check list for drilling and not interfering with drillers roles.

Development of Code of Conduct for Borehole Drilling and Construction

Drilling data record keeping have to be taken and easily accessed by those who need it.

educate people about borehole drilling

Educating drillers to submit data for dry boreholes to the National water database

Emphasize on the need for proper borehole supervision

encourage and participate in data collection during drilling and also use my social handles to sensitize people about maintaining the quality and quantity of groundwater

Encourage other persons to go for training and certification to make the borehole drilling activities smooth enough for better wells

Encouraging Association of well drillers companies

Enhancing adherence to borehole technical specifications and construction of boreholes according to design.

Ensure that all boreholes drilled are pumped test to determine the safe yield and other aquifer parameters. If boreholes are pumped test, marginal yields or dry holes which drillers count as successful could be detected.

Ensuring adequate supervision of boreholes drilled and keeping groundwater information.

Ensuring that contractors are paid even after hitting a dry borehole

Establish of professional institute for water supply based this course to produce drillers- technicians , supervisors training and contribute challenges solving

establish of professionalism institute for groundwater

Extension seminar

Extension Seminar

Facilitate trainings in professional borehole drilling as a consultant

First to establish the areas where groundwater recharge is taking place. Also, to embark on aquifer management recharge. Again, sensitize people on the proper management of the catchment areas.

Forming a contract management team and a team for borehole drilling management and supervision.

Give input on the water laws that are still in draft

Have an experience of more field exposure to different drilling environment. with that exposure I believe I would be able to improve the professionalism of drilling.

Having being on the course and learnt what it requires, we have started making our citing of boreholes in a professional way starting from the geophysical and hydrogeological survey to call for proposals for contractors, site supervision

Hydrogeological Survey

I am currently the project manager assistant within _____. I am also part of UNESCO Groundwater youth network. So I plan to share the result of the project among my peer in sub-Saharan Africa in order to change or enhance the capacity of young hydrogeologist like me. I am also a member of the parliament of water in _____ where i am in charge of the groundwater section. I plan to raise awareness about the important of good borehole sitting.

I am planning to improve the inspection, design and appropriate supervision of the drilling in my organization and country.

I don't think I still have the capacity to inspect or take responsibility for a drilling, so one of my actions will be to carry out more studies and training.

I love to undertake and see the Training of Trainees (ToT) commences as soon as possible. So that we can all be well equipped with quality knowledge in relation to professional borehole Drilling.

I need to involve in establishing a database system for groundwater data management.

I plan to professionalize (increase my capacity) the supervision of drilling for my organization

I really need to put my finger print on groundwater data and resource management by producing a research output concerning to all the issues about groundwater hydrology.

I try to make encourage staff members to take up short courses related to the industry and the role they play in the organization, whether it is a drilling course or a solar pumping course for example.

I want to work freely in my country and apply everything I have learned during the training.

I will make sure i contribute to data managed of boreholes, its very cardinal.

I will make sure i supervise the drilling of boreholes and ensure the drillers are following the professional way of drilling, to have boreholes that last a life time.

I will make sure that before a drilling program starts, there is proper procurement planning, the tenders are awarded systematically to well experienced contractors, the project implementation is done in a professional manner with proper drilling supervision and that after the drilling project is done, monitoring and reporting of the results is done.

I will revise a checklist for the whole process of borehole drilling which will cover all aspects from procurement to siting to drilling and the rest of the steps

I would like to appreciate and participate on a training and workshops that related to borehole drilling

I would like to be engaged in professional groundwater assessment for borehole siting. i would like to have a clear understanding of various groundwater assessment methodologies and interpretation. this will reduce the occurrence of dry wells and understanding of the general geology of the country

I would like to emphasis on license for drillers. I will try to advocate for that with local authority enable to sort out the companies have capacity interim of machines, logistic and professional staff.

I would like to establish a database of all boreholes that the organisation has drilled within the last 10 years. Thereafter, I would want to advocate for a follow up of these borehole and consistent monitoring of the water points (monitoring may be difficult for me to undertake personally as projects would have long ended in some of the sites with boreholes. However, area stakeholders may be engaged for the task though chances are high that they won't undertake the task as diligent as the implementing partner because of lacking background of importance of the information). It would be great to even publish the findings of the study

I would like to increase awareness on the importance of adequate borehole supervision during drilling as it's the only real time data can be collected regarding the geology, which will enforce a database capable of informing solution finders.

I would like to recommend that more staff take this course, and I will spearhead the process. I will get in touch with the facilitators of this course

I would teach on tips of how to supervise efficient borehole drilling to maximise borehole potentials.

I'm definitely following-up on what the exact regulations are in South Africa. Also, in Zambia & Malawi, where I often work, I want to understand why we only pay for 'wet boreholes', and see if we shouldn't advocate for best practice.

I'm trying to engage in water quality assessment research.

In my Organisation i will be pleased if the siting method is improved

In my organisation I would like to improve drilling supervision and implement more frequent inhouse seminars, as well as be readily available/approachable for questions.

In my professional capacity I would like to raise the awareness that a good planning and good and motivated staff is essential. Don't listen to politicians ☹️

In my professional capacity, I would like to initiate a way where apart from being a registered association of a discipline, there should also be a regulatory body that can form like a 'conceptual model' of the various disciplines engaged in borehole drilling which would be a body that issues licence and recognised a registered member as certified. Thru regular training, retraining and organising workshops for both professionals and incoming ones.

Initiate the regulation on Licensing Groundwater service as a separate regulation to the existing regulation governing Water Supply Services that is general to all water services

Make a proper mechanism to establish a pathway for the professional drillers, develop their capacity and issue them license to drill. Strictly rules for non-professional to lead drilling of boreholes

mettre en place des forages piézométrique pour suivre le comportement de la nappe de base afin de permettre aux exploitants de pomper l'eau souterraine au bon moment.

My role to improve the professional of borehole drilling is site , proper design and Safe supervision to get good quantity and quality water.

On site practical experience with trained professionals or personnel.

One key action is to ensure that the right contractors with the right expertise and equipment and brought on board for drilling exercise.

Promote the training of actors and the control of drilling companies

Proper supervision is important from start to finish in line with drilling standards. This will improve the quality of services hence sustainability of boreholes

Proper supervision of borehole drilling and construction.

Proper supervision of drilling of boreholes

Provide consultation and supervision services to clients intending to drill a borehole for whatsoever purpose

Raise awareness in terms of borehole investment, and supervision

Review the Tender documents including BOQs to have some which will be cost effective at the same time not compromising quality

Sensitization on the need to pay for drilling and use of groundwater

strict supervision and proper borehole sitting

sure, during the course i learned many about Professional borehole drilling such Contract management as well as procurement process that will help my organization and my country.

The monitoring of drilled Boreholes to ensure they work efficiently after drilling.

The problem here in Malawi people have owned borehole drilling machines of different capacities as such there is highly rate of drilling dry holes. In this regard, there is a need to give them different borehole drilling licences. There should be put in categories according to their capacities.

The problem of information and especially the archiving of the data of sitting and drilling are most crucial in Togo and I intend to work to achieve this goal.

To be part of a team that assist a client from siting the borehole, awarding contract and supervising that borehole until the client get the water for the intended use.

To bring all drilling companies and professionals in that field under one umbrella

To build capacity not only to the students I teach in the university but to the community by raising awareness on issues around sustainable groundwater development to ensure cost-effective borehole development and sustainability

To carry out borehole siting and drilling professionally.

To take more trainings on professional drilling, procurement and contract tendering process so that we produce quality actions when they arise!

Train and sensitize the newly employed engineers in borehole drilling supervision and also train the drillers in reporting

Train government partners, supervisors and private sector on best practices and push for sector regulation

Train the Technicians in Water and Environmental Engineering to be Good Supervisors in borehole drilling and being Drillers also.

Train young professionals in the government sector on effective borehole supervision. Assist the government and my organization in managing groundwater data to improve national access.

Training of borehole drillers in the norms involved in drilling operation

Training of drillers on good practices for borehole drilling an health and safety. It shouldn't be just about the money but the quality of the work.

Training, skills development and knowledge sharing

Understanding professional supervision of borehole drilling

Table A9.2 Responses to the question: Please describe at least one action that the organisation you work with should take to improve their professionalism with respect to borehole drilling.

Response
purchase of precision equipment for data collection
training the team to collect and process field data
Ensuring adherence to the technical specifications.
I must admit that the entire contracting chain and the procedures for carrying out drilling in Togo respect the regulations. What Togo can correct in its process of professionalism is the management of post-project data.
Purchase of own rig to drill own wells
Save some fund to organise for us extra capacity building on drilling supervision and professional.
Should clearly state the guideline for borehole drilling
the company I work for does not drill yet, but we do process data collected in the field. We have already taken some measures such as:
Advanced geophysical siting
All professionals concern with borehole drilling should be a member of certified government association and should undergo training and retraining.
Always engage the services of a qualified professional supervisor and driller during drilling
Before any Engineer is deployed to his/her station (District), the Organisation should insure that these are well quipped and orientated in relation to Borehole Drilling.
Borehole development management
Building staff capacity in issues of groundwater development nd management
But we still need to improve on the technology side."
Capacity building in the monitoring of drilling works at all levels; from implementation to acceptance
Capacity building of staff to do quality services to the public!
Capacity building of their staff on drilling, then to disseminate to drilling contractor
Conduct capacity building training for the drillers and also to register all the boreholes being drilled and submit borehole siting and drilling reports to _____
Conduct more trainings to the hydrogeologists and drillers
Decentralized registration of drillers
Do more training
Ensure borehole project are performed like all the other infrastructure project, by carrying out proper investigation and producing a design that shall inform the BoQ.
Ensure that the borehole completion record is done as soon as the drilling is completed so that the correct data is documented to avoid the driller losing the data the coming up with data that is misleading.
Ensuring effective supervision and sensitization of university community
Ensuring training for the staff together with availing of several machines for the better results
Equipping staff with regular trainings on drilling supervision and proper siting of boreholes
Facilitate trainings in professional borehole drilling
Follow all the methodology in design of a succesful borehole siting, implementation, supervision for a borehole that will last for 10 years and above.
Following the norms and values of the borehole drilling professionalism
geophysical survey
have personnel with the necessary skills and talents for water supply projects, using drilling techniques
Hold capacity build workshops to train engineers, and drillers on professional drilling

I am working closely with _____ which are in charge of the execution of the project _____. The third part of this project is the capacity building of consulting company and professional working in borehole siting.

i wish my organization can afford the students to see the practical work of hydrogeologist.

I've only recently joined _____. So far, all seems extremely professional. But, the 'no pay for dry boreholes', is followed by Zambia - I'll be following-up on why this is done.

improve data collection, numbering of boreholes we drilled and supervision to check their functionality

Improve life quality standards of groundwater professionals for more enthusiasm and responsibility in groundwater awareness.

improve on data collection and management as well as improve on quality supervision

Improve the methods of awareness on professionalism, holding quality standards overall and employment of other technical fields disciplines to improve professional drilling.

increase awareness in Supervision

Increase awareness on potentiality of GW resources to support Rwanda to meet its targets and SDGs on safely managed water and sanitation as well as updating boreholes supervision manuals

Increase financial resources towards development of boreholes.

Internal training of staff

invest in capacity building

Invest more in drilling supervision

Investment of funds in improvement of capacity (both human and equipment) to improve professionalism.

It will be good if my company plan to produce a skilled and experienced man power by giving them a chance to have an intern time with other industries in summer time to see the theoretical ideas in to actual practice (industry linkage) before they tend to work actively."

learn about the principles of good of borehole siting, design, construction and well development. Find out about casing and screen, gravel pack, and the sanitary seal and see that silting is one reason for boreholes failure. this will help to improve their professionalism of borehole drilling

Licensing of the drillers of the company and better storing of hydrogeological data

Maintain their equipment.

make the available of borehole siting and supervision material as well as drilling material for exploration program to minimize the risk of dry well

Making sure that construction of boreholes is according to the design.

Monitoring and evaluation of any project is important.

Monitoring and evaluation of driller

More capacity and hands on opportunity to increase experience for the members.

More training of staff on sustainable handling, exploration and exploitation of groundwater

More training of workers plus sensitization of the need to maintain professional standards.

More trainings with the rest of the engineering team on borehole supervision.

Most actions are taken by the organisation I work for in offering consultation services, supervision services am

Must make intensive survey and manage to supervise borehole drilling in all aspects

My organisation should respect all steps of borehole drilling. It should employ qualified personal with appropriate materials.

My organization offers consultancy services for borehole drilling. Explore the use of geophysical surveys in the siting of wells, where applicable.

My organization should employ dedicated supervisors for the drilling of boreholes who are committed to the work and always be on site for the supervision.

Often time pressure leads to lower quality work. I would like to afford the teams with enough time to go through checklists, think before they act and value quality over quantity.

Preparation for siting of the boreholes

Proper siting for boreholes and also develop a proper database for keeping the borehole data.

Proper supervision of contractors during borehole drilling

provide siting and supervision material as well as some drilling material to perform exploration program and minimize the risks of failure

Purchase of siting equipment "

Put in place stringent penalties for defaulting individuals or companies

Quality checks

Regular short courses and training of staffs regards to water well drilling profession will go a long way to improve professionalism and the way they deliver their work.

regulate drilling activities

Regulate groundwater abstraction

Regulation and Licensing

Renforcement de capacité du secteur et sur l'hydrogéologie volcanique

_____ should ensure specific technical backstopping to programs that include ground water development as specific knowledge is required and program managers practically never have such knowledge

should give a chance for the staffs to take a training and workshop.

should put legal regulations concerning to borehole drilling

Sometimes monitoring drilling in government projects

Sponsor female engineers to take up the course on drilling supervision and professional."

strengthen supervision and should be made a mandate for a hydrologist/ water engineer to be on site when drilling is done

Supervision

supervision at borehole drilling and tight laws for drillers to share borehole information after drilling

the borehole supervisors should be given intensive training including on-the site training before they commence their supervision roles.

the department of water resources should improve on implementation of drilling regulations to the drilling contractors to reduce drilling of illegal boreholes

The department to come up with professional trainings on borehole drilling management and groundwater management.

The issue of engaging the independent fully time borehole drilling supervision should be encouraged in Malawi. I am sure by doing that the problems of dry boreholes could be put to a minimum level.

The knowledge gained in this course will be imparted to the staff and B.Sc students in the Department of Geosciences and other departments at the University of Dar Es Salaam at large.

The organization is taking all the steps as per the guidelines and instruction of the special directorates of the local government and according to the global standards.

The origination planning in 2023 to conduct workshop involving government, donors, INGOs, UN and private sector to discuss on how could we improve wells drilling and robust the relationship between private sector and water sector.

The promotion of utilization of surface water much more groundwater because replenishing of groundwater is not as quick and information is scanty as compared to surface water

There in need to improve on supervision during the drilling process. Many times, during drilling, contractors are not frequently supervised and some of the key steps like borehole development sometimes are done when there is no supervisor on ground.

There should be individual consultant to supervise borehole drilling process

They need to work smart and hard.

They should improve on the supervision

They should provide all necessary resources to officers to enable them properly carry-out supervision.

To give a lot of training related to drilling

To pay realistic price for borehole drilling

to promote capacity building via training for drilling professionals

To provide short courses that I specifically tailor-made for for borehole drilling

Train more people in this field of borehole drilling

Training of agency's staff in enforcing the borehole drilling regulations

Trying to process payment of contractors within the shortest possible time rather than having outstanding payments more than 1 month after service has been rendered.

We have a database on the drillings, on the piezometers but the technical data (lithological section) and even the geophysical reports are not centralized and archived. This creates a gap in the information on groundwater on the national level.

We have started implementing what we learnt and hope we can still have access to the resources for continued development as well as peer group discussions sharing experiences

We need to create more training opportunities on the borehole drilling to increase the skills of our personnel.

We will train more staff who are involved in drilling to improve their knowledge

Annex 10 Professional borehole drilling – anything else?

The survey asked participants to share anything else that they would like to in relation to professional borehole drilling. The full details are presented in the table below. A number of practices, observations and experiences have been shared, which may be useful for other in-country stakeholders, as well as for consideration in the planning of future regional courses.

Country	Anything else in relation to professional borehole drilling in your country that you would like to tell us, please write it below.
Chad	<ul style="list-style-type: none"> The professional bodies like UN bodies and NGOS also give its water projects to non-professional companies.
Ethiopia	<ul style="list-style-type: none"> In Ethiopia there are many drilling companies at NGO, Private and Governmental level. But still know there is shortage/water. Qualifying and certifying independent offices that certify the drawdown and discharge capacity of the well.
Ghana	<ul style="list-style-type: none"> There are a lot of knowledge and expertise in the industry but the absence of an association to be able to stand with one voice and kick out the quacks among them. Even though, drilling companies must apply for drilling and abstraction license, most companies are drilling without the license.
Iraq	<ul style="list-style-type: none"> Unfortunately, the drilling process in Iraq is not going straightly according to the global standards, due to poor inspection and design, lack of supervision and record keeping and available database.
Jamaica	<ul style="list-style-type: none"> Supervision of well drilling is seen as an additional cost to be bypassed by some private sector entities contributing to some wells not being cost-effective.
Kenya	<ul style="list-style-type: none"> 80% of the country is arid and semi-arid. Ground water exploration and exploitation in Kenya is still low. Little knowledge about groundwater among the greater population. The market is flooded with brokers who are well positioned to get work but unable to deliver. Resulting on outsourcing works yet the costs can not be borne by new contractor. I think there is a general outcry for increased borehole professionalism from both the users and the drillers, however, this is impeded by one, competition within the business sector of the industry which tends to push prices down ridiculously leading to shortcuts from those caught up in low pricing. And secondly the governments seemingly lack of interest in seriously regulating the industry. Making it mandatory for clients to engage government staff to supervise their drilling would ensure the drillers adhere to set down procedures. Often there is a way of giving faults to other parties when a drilling fails (drilling company, site supervisor, hydrogeologist, Survey etc..)
Lesotho	<ul style="list-style-type: none"> We really need such training as in other countries like Zambia
Madagascar	<ul style="list-style-type: none"> This kind of formation is essential because there is lack of qualified person in borehole drilling in my country.
Malawi	<ul style="list-style-type: none"> Lack of proper supervision during drilling and other related activities. Authorities only give contract to drillers and just go there during handovers as a result any problems occurs communities are always at risk Putting the drillers in categories. This should be done in relation to the capacity of each driller in terms of drilling equipment and expertise. The department of water resources in Malawi is advocating for well qualified drilling contractor who can understand different geological formations and drill boreholes in accordance to the way the geological formation is being encountered. The department is also conducting research on various aspects of groundwater development and professional drilling. currently, they are trying to access deeper aquifers whereby trial boreholes of depths beyond 150m are being drilled. Beside the professional borehole drilling we also struggle with the management side of the infrastructure-post drilling

Country	Anything else in relation to professional borehole drilling in your country that you would like to tell us, please write it below.
Mozambique	<ul style="list-style-type: none"> ▪ The course covers the most important aspects... the next step will be installation design, operation and maintenance
Nigeria	<ul style="list-style-type: none"> ▪ Lack of in-depth capacity all over the country ▪ groundwater drilling is not regulated at all. most drillers are quacks ▪ The government of the country have not been helping the professionals towards actualizing their aim in professional borehole drilling ▪ The only thing that is common in my country Nigeria is that a business man buys and drill and start drilling boreholes for government, NGOs and private charging exorbitant amount of money and believe that the first strike of water is enough thus leading to plenty of failed water holes. No supervision or professionalism in siting a borehole. ▪ There is no code of practice or conduct on how borehole are to be drill. Local drillers are not encouraged as most of the drilling companies are owned by foreigners. ▪ There are no implementation of code of practice and conduct in drilling operations, and drilling companies are mostly owned by foreigners which is not helping local drillers. ▪ Most of the relevant and Ministries agencies in Nigeria give more emphasis on managing surface water with less interest on managing and regulating groundwater. And there is departments established to take care of groundwater but unfortunately they are not active. So policy need to be put in place to consider groundwater management and give it equal priority as that of surface water.
Rwanda	<ul style="list-style-type: none"> ▪ Professional borehole drilling in my country is growing up, it is like we are starting a fresh in this area. ▪ Actually, UNICEF & Living Water International are the only leading institutions for GW development in Rwanda. But the life span of most borehole develop is too short (2-5 years only). Lack of technical capacity for water committees (users) and expensive spare parts are hindering on the sustainability of boreholes in Rwanda
Senegal	<ul style="list-style-type: none"> ▪ It must be said that in Senegal, we have a project to organise drilling companies for the granting of licences, which would allow for better control of their work and promote compliance with the regulatory provisions of the water code in terms of exploitation of the resource
Sierra Leone	<ul style="list-style-type: none"> ▪ That the agency has passed into law borehole drilling and groundwater development regulations three weeks ago.
Somalia	<ul style="list-style-type: none"> ▪ In our country Somalia there is no any other related professional borehole drilling
South Africa	<ul style="list-style-type: none"> ▪ We have almost completed two very large Water Treatment Works with groundwater as resource. Both are in Polokwane, Limpopo Province. The one has a capacity of 18ML/day the other of 14ML/day (of which 12ML/day comes from groundwater). Thousands will be served. This project centralises the treatment and distribution of around 40, well-managed, boreholes.
South Sudan	<ul style="list-style-type: none"> ▪ In Northern part of the Country, there is no groundwater available so we use surface water treatment for safe water drinking.
Tanzania	<ul style="list-style-type: none"> ▪ Increase awareness by providing training to private water well drilling companies including mobilizing them to establish their Association ▪ The borehole survey and Drilling are undertaken with unskilled people in such a way that there are no good reports for surveys and borehole completion reports. To obtain a well-organized borehole data in the country is an issue.
Togo	<ul style="list-style-type: none"> ▪ In Togo, strategic documents on the management of water resources, the water code, the guide to drilling, the authorization to drill and to take water are in force, but we have to admit that drilling is carried out in an uncontrolled manner by the population, most of them without authorization and without being carried out according to the rules.

Country	Anything else in relation to professional borehole drilling in your country that you would like to tell us, please write it below.
Uganda	<ul style="list-style-type: none"> ▪ All abstraction licenses move with stringent groundwater monitoring and management conditions upon which annual renewal of licensing depends. ▪ Corruption is one main challenge i see that affects seriously professional drilling in Uganda. I have experienced this in one of the organizations I worked with. The project Engineer got some money from the contractor as "Kick back". Later on the project took long as the contractor struggled a lot to finished the work. It was also very hard for this Engineer to supervisor the work since he had been compromised ▪ in Uganda there are very few professionals in line with borehole drilling, this might be due to inadequate awareness creation to the engineers who could specialize in this field of drilling profession. There are also high cost of machinery of which few people have drilling rigs, compressors etc that could employ professionals. ▪ There need to train more engineers and hydrogeologists especially in ministry of water and environment. ▪ We have yearly update of the profession personnel from siting, drilling, test-pumping and other works.
Zambia	<ul style="list-style-type: none"> ▪ Forming an independent supervision committee ▪ Need to improve the capacity of the drillers in basic hydrogeological data collection and borehole completion report writing ▪ Professional borehole drilling is a requirement for the ministry of water development and sanitation in Zambia but what tends to hinder it is the policies made by the political players without knowledge on how important it is to follow all the steps required to have a cost effective borehole. e.g they come up with a policy that stops a supervisor to get an incentive for conducting his work which compromises full time supervision and partial. Boreholes drilled in far flung places are rarely supervised. ▪ Skills training for drillers and siting ▪ Supervision is not done as per recommended, rather it is more of monitoring ▪ The is need for Government to provide guidelines to who can supervise drilling, and carry out siting due to people privately purchasing siting machines for business due to the good returns it offers ▪ The national water and sanitation policy is being revised and taking issues of capacity building and creating a national boreholes and dams database into consideration. ▪ The country has put laws for registering drilling companies and getting a permit before drilling
Zimbabwe	<ul style="list-style-type: none"> ▪ The country has a Rural WASH information Management System (RWIMS) that was supported by UNICEF which can be further developed to include groundwater management data. However, the current challenge is the availability of real time credible data in the system. ▪ There a lot of fly by night borehole drilling companies making it difficult to maintain standards ▪ There is need for more training on borehole supervision in Zimbabwe ▪ We need more training on professional drilling. ▪ There is so much short cuts done and there is lack of transparency when undertaking drilling activities. In my opinion, that just translates to the country having quite a huge task to ensure that professionalism is upheld in borehole drilling.