Rural Water Supply Network

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C H Kane & Dr K Danert

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A Turning Point for Manual Drilling in the Democratic Republic of Congo

Dedication

The authors dedicate this publication to Gambo Nayou (1963 to 2016).

Gambo was a man of vision, a person who looked into the future and saw things that many could not even imagine. He passionately shared what he knew with others.

Following his experiences of manual drilling in Niger and Chad, Gambo reached out to the Association of Manual Drillers from Chad (Tchadienne pour la Promotion des Entreprises Spécialisées en Forage à faible Cout (ATPESFORC) to join a process of professionalising the manual drilling sector industry while working for UNICEF in the Democratic Republic of Congo (DRC). On their first day in DRC, the Chadian crew broke the previous record of 27m by drilling a 42m deep well.

Thanks to Gambo, hundreds of skilled technicians in DRC have been trained to carry on the work of manual drilling and ensure the supply of clean drinking water sources in some of the most remote provinces of DRC. Thank you Gambo! We truly miss you in the sector, but we carry our memories of you as an inspiration.

Kerstin Danert, Kelly Anne Naylor and José Gesti Canuto

Abbreviations and Acronyms

ATPESFORC	Chadian association for the promotion of cost effective boreholes *(Association Tchadienne pour la Promotion des Entreprises Spécialisées en Forage à Faible Coût)*
DFID	Department for International Development (United Kingdom)
DHS	Demographic and Health Survey
DRC	Democratic Republic of the Congo
MDG	Millennium Development Goals
MPSRM	Ministry of Planning and Surveys of the Modern Revolution *(Ministère du Plan et du Suivi de la Révolution de la Modernité)*
MSP	Ministry of Public Health *(Ministère de la Santé Publique)*
NGO	Non-Governmental Organisation
PNEVA	Healthy Schools and Villages National Programme *(Programme National Ecole et Village Assainis)*
SDG	Sustainable Development Goals
SME	Small and Medium Enterprises
SNHR	Service National de l'Hydraulique Rurale
UNICEF	United Nations Children's Fund
UK	United Kingdom
WASH	Water, Sanitation and Hygiene

Summary

This publication provides a source of inspiration from a country that tends to otherwise be associated with humanitarian crisis, persistent conflicts, recurrent civil wars and a generally obsolete road infrastructure.

It describes over a decade of pioneering efforts by UNICEF, the Government of the Democratic Republic of Congo and partners to introduce and professionalise manual drilling. This professionalisation programme is very important as it is estimated that only 43% of the population have access to a basic drinking water service (JMP, 2019).

In addition, the majority of the DRC is favourable to manual drilling (42% classified with very high or high potential, and 24% as moderate). The most favourable area for manual drilling is in the western part of the country, which has a soft geological layer of considerable extent and thickness.

Over a ten-year period, manual drilling, using the rota-jetting technique, has gone from a little-known technology in the DRC to an effective technology that has enabled about 650,000 people to be provided with a water service. A total of 1,806 boreholes were drilled and installed with handpumps in rural and peri-urban areas between 2010 and 2018, financed through the Government's Healthy Schools and Villages National Programme (PNEVA). People living in difficult to access areas have been the principal beneficiaries. Manual drilling equipment can be easily transported in these remote and isolated areas. Manual drilling has also considerably boosted borehole use in the country.

The promotion of the technology in DRC over the past decade comprised three phases: (i) introducing the technology; (ii) raising standards and innovation and (iii) expansion, improving trust and building confidence while documenting successes, failures and best practices.

At present, uncertainties regarding further financing of manual drilling mean that it is not possible to guarantee the continuation of the programme on the same scale beyond 2020. As a result, manual drilling sector in the DRC is at a tipping point where it could either continue to develop and become widespread, or fail and loose the gains obtained thanks to the PNEVA.

Regardless of context, a considerable amount of time is needed to successfully transition from introducing a new technology to widespread uptake. PNEVA, which contracts out the drilling of boreholes and installation of handpumps on behalf of end-users, remains the main client for manually drilled wells and ensures quality

Manual drilling is not just about drinking water; it is also about job creation, entrepreneurship and private sector development. Its impacts extend beyond Water, Sanitation and Hygiene (WASH), and thus support could come from beyond WASH-specific stakeholders and agencies.

Thus, the authors recommend that efforts to support the professionalisation of manual drilling continue, alongside support for the government to reflect on the advantages and disadvantages of manual drilling and publish guidelines and standards. They also recommend undertaking an assessment of what is needed to further embed manual drilling in other projects and programmes, undertaking an analysis of the market for manual drilling in rural areas and small rural towns, and reaching out to actors beyond the WASH sector to support the next stages of manual drilling scale-up and uptake in the DRC.

Contents

Introduction

In 2017, it was estimated that only 43% of the population of the Democratic Republic of the Congo (DRC) had access to a basic drinking water service (JMP, 2019). Based on the slow progress of the past several decades, there is need for some radical change to enable the country's population to secure universal access to a safe drinking water supply in the future. Innovative and affordable solutions, coupled with substantial, predictable and long-term funding are among what is required. Groundwater resources have enormous potential to contribute towards safe and sustainable water supply services in the country. Protected spring catchments as well as hand dug wells and boreholes fitted with suitable pumps are viable technologies for a sizable proportion of the country's population.

Manual drilling, a low-cost method for reaching and developing groundwater resources, provides an innovative solution for the DRC. This case study on its introduction and uptake over the past decade presents an encouraging story (Figure 1).

Figure 1 Use of a manually drilled borehole equipped in peri-urban Kinshasa (Source: UNICEF)

In 2000, the Government of the Democratic Republic of the Congo (DRC) committed to meet the Millennium Development Goals (MDGs). It set out to raise the proportion of the population with access to safe drinking water to 71% by 2015. The starting point in 2001 was 46%[1]. Despite attempts at reform alongside investments by partners, by 2015, only 50% of the Congolese population had access to safe drinking water (MPSRM, 2015), representing a four percentage-point increase in 15 years.

With a new focus on the Sustainable Development Goals (SDGs), the National Strategic Development Plan (2017-2022) aims to "*ensure equitable access to affordable drinking water and appropriate sanitation and hygiene services for all*" by 2030 (PNSD, 2016). However, a combination of such a low starting point, a population growth of 3.4% (MPSRM, 2014) and relatively modest investments by authorities made this endeavour an almost impossible challenge, highlighting the need for affordable alternatives and innovations to bring lasting change at-scale.

In 2009, the DRC government adopted a strategy and launched an initiative to promote low-cost access to water supply using manual

[1] Note that there are differences between Government figures of water supply access and those published by the JMP (2019). A discussion of these differences is beyond the scope of this publication.

drilling techniques. The Ministry of Health and the Ministry of Rural Development, together with UNICEF, set out to develop the capacity of the private sector and NGOs in manual drilling techniques and handpump installation. Considerable learning took place throughout this initiative, which comprised three phases:

- introducing the technology (2009 – 2012)
- raising standards and innovation (2013 – 2015)
- expansion, improving trust and building confidence (2015 – 2020)

Over a ten-year period, manual drilling, using the rota-jetting technique, has gone from a little-known technology in the DRC to providing an estimated 650,000 people with a safe drinking water supply. People living in otherwise difficult to access areas have been among those to benefit.

In addition to the benefit of expanding water supply, the professionalisation of manual drilling is also contributing towards much-needed employment creation. There are new jobs emerging in borehole construction and the supply of materials, tools, handpumps and spare parts.

This publication describes the decade of pioneering efforts by UNICEF and its partners to introduce and professionalise manual drilling in the DRC, including training and quality assurance efforts. It should enable others to learn from the experience in the DRC and encourage donor agencies to consider investing in similar initiatives in the DRC and beyond. The publication also aims to spark interest in finding answers to the many questions that it raises[2].The DRC tends to be associated with its troubled history, conflicts, challenging politics, poor infrastructure and a deteriorating humanitarian situation. However, if one takes a closer look, the country has always been a pioneering land, and this story is yet another example of the potential it holds.

Country Context

The DRC straddles the equator and extends from its eastern borders with Uganda, Rwanda, Burundi, Tanzania and Zambia to the west with the Republic of Congo and the Atlantic coast (Figure 2). The DRC borders the Central African Republic and Sudan in the North, and Angola in the South.

With a landmass of 2,345 million km^2, the DRC is the second largest country on the African continent after Algeria (FAO, 2019) and the 11th largest country in the world (Nationsonline, 2019).

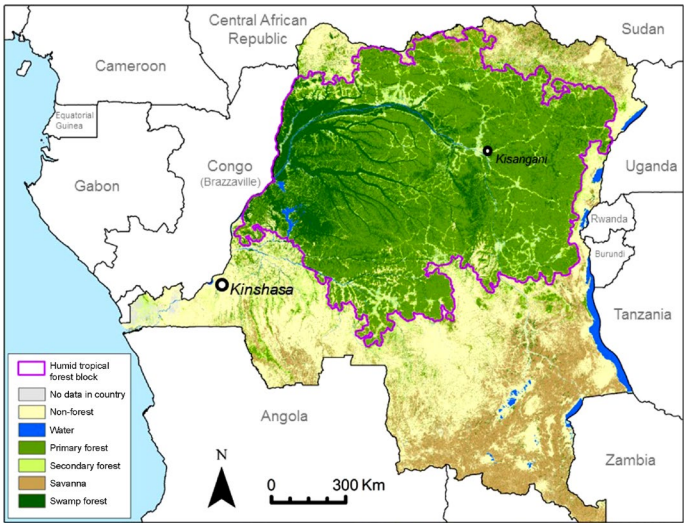


Figure 2 Map of Democratic Republic of Congo showing climatic zones (Molinario et al, 2017)

It is estimated that only 0.05% of DRC's total renewable water resources is withdrawn (FAO, 2019). With its tropical climate, fertile soils and rich underground resources, and harbouring enough sources of energy for itself and most of the rest of the African continent, the DRC could be the economic engine of central Africa. In 2017, the DRC's primary exports were cobalt, refined copper, copper ore, cobalt oxides and hydroxides, and cobalt ore (OCE, 2019).

Van Reybrouk (2016) emphasises that the country is as much a pioneering land as it is the world's storage chamber; Congolese history has determined and shaped world history and will most likely continue to do so well into the future (Box 1). Alas, historical, political and economic forces have contrived to prevent a large proportion of people of DRC from truly benefitting from the country's vast natural resources. "*Instead it has been, and continues to be looted*" (Englebert, 2014)[3]. Conflicts between communities, between non-state armed groups and Congolese security forces are ongoing in several parts of the country, with armed groups in some areas splintering and proliferating. Stearns and Vogel (2017) estimated that around 120 different armed groups were operating in north and south Kivu.

"Centred on the Congo Basin, the territory of the DRC was first inhabited by Central African foragers around 90,000 years ago and was reached by the Bantu expansion about 3,000 years ago. In the west, the Kingdom of Kongo ruled around the mouth of the Congo River from the 14th to 19th centuries. In the centre and east, the kingdoms of Luba and Lunda ruled from the 16th and 17th centuries to the 19th century" (Wikipedia, 2019)

The DRC of today was born in the 1880's, as the private property of Belgium's King Leopold II, who exploited the resources of the territory through predation and violent extraction. This historical origin of managing the territory and its population for resource extraction, with an underlying culture of the state as private property, has arguably persisted for over 130 years.

[2] There has been at least one other manual drilling initiative within the DRC (see Danert, 2015b).

[3] Englebert (2014) argues that "a large number of Congolese state actors at all levels of responsibility, continue to wield their public authority as the source of private material rewards". Englebert and Mungongo (2016) also point out that "Congolese decentralization reforms have been accompanied by an increase in predatory extraction, provincial centralization of power, unbridled lack of accountability, and widespread rent seeking by provincial elites".

In 1908, Congo became an official Belgian colony under which concessionary companies, with objectives of profit maximisation, managed the territory (Englebert, 2014). The country gained independence in 1960. From the outset, political conflict and instability featured in the newly independent nation.

It is well known that over the last 130 years, the people and landmass that now form the DRC have provided the economies of the world with the raw materials for billiard balls (ivory), pneumatic tires (rubber), cartridge cases (copper), the atom bomb (uranium) and consumer electronics (tantalum).

Less is known about the influence that the country has on other key aspects of world history. For example, the resistance to the rubber politics of the early 20th century led to one of the largest humanitarian campaigns in history. The involvement of Congolese soldiers in both world wars contributed to key victories on the African continent. In the 1960's, the Cold War in Africa began in the Congo. The country has witnessed the largest UN operation in history and the first large military deployment of the European Union. The 2006 elections were the most complex elections that the international community has ever significantly financed and supported. The DRC's contracts with China provide another important milestone in the world economic order.

Box 1 Democratic Republic of Congo – at the forefront of world history

In 2017, the DRC had an estimated population of 81.3 million, with 48.6 and 32.7 million living in rural and urban areas, respectively (FAO, 2019). The DRC hosts a diversity of cultures, as exemplified by the 213 languages spoken (Ethnologue, 2019). Administratively, the country is divided into 25 provinces and Kinshasa city (Figure 4). The country's river network is paramount to transportation within the country as only a few roads are in good condition[4]. The DRC's road, track and path network is 170,000 km, of which only 1.3% is paved (UNJCL, nd). As illustrated by Figure 3, the poor state of bridges and ferries used to cross the county's rivers provides an additional bottleneck to transportation of goods and people (UNJCL, nd).

The DRC ranks in position 184 out of 190 in the ease of going business rankings (World Bank, 2019a). Whereas starting a business is ranked in position 62, the country performs poorly in the other nine indicators[5]. However, in 2017-18, the DRC was one of the 46 countries where the ease of doing business improved (World Bank, 2019b).

Only 47.3% of the population participate in the country's labour force, and an estimated 21.4% of youth (between the ages of 15 and 24) are not in employment, education or training (ILO, 2019). Job creation is key to the development of the economy and the improvement of living standards in the DRC.

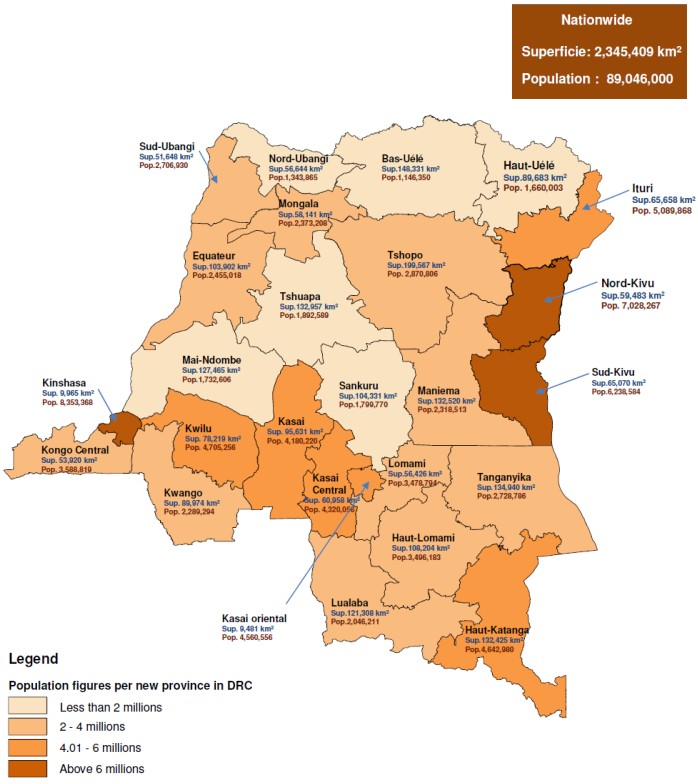


Figure 4 Map showing the provinces of the DRC with area and population (Source: UNICEF)

Figure 3 Examples of transporting manual drilling equipment in DRC (Source: UNICEF and Chiekh Hamidou Kane)

[4] Mainly from the Port of Matadi to Kinshasha and in Southern Katanga

[5] Including dealing with construction permits, getting credit, paying taxes and enforcing contracts.

In 2018, an estimated 4.5 million people were displaced from their homes, with 130,000 fleeing to neighbouring countries (HRW, 2019). According to UNOCHA (2019), "*an estimated 12.8 million people in the DRC are in need of humanitarian assistance and protection … Deterioration, observed mainly in the* Kasaï, *North Kivu, South Kivu and Tanganyika provinces, is taking place against the backdrop of one of the world's largest and most complex humanitarian crises.* Currently, just as the end of the 10th epidemic of the Ebola virus was announced in the east of DRC, another epidemic was declared for the second time (2008 and 2020) in the west of the country in the Equateur province.

Types of Drinking Water Supplies in the Democratic Republic of Congo

Groundwater plays a tremendous role in the provision of drinking water in the DRC. In 2016, 80% of the rural population (33.9 million people) relied on groundwater, including 49% using unprotected springs (JMP, 2019). In rural areas, there is a gradual shift from the use of surface to tap water, protected and unprotected wells and boreholes (Figure 5). In 2014, 1.6% of the rural population (700,000 people) and 3.7% of the urban population (1.1 million people) relied on a borehole to provide their main drinking water supply[6]. This is a considerable increase from 2007, when 0.9% of the rural and 1.4% of the urban population relied on a borehole.

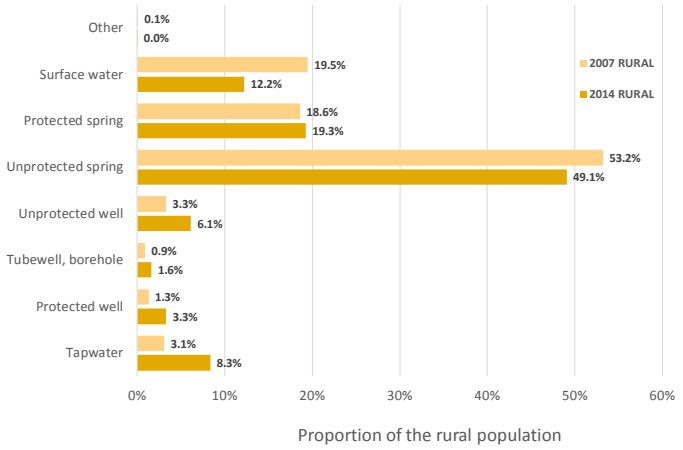


Figure 5 Proportion of the rural population using type of water source as the main drinking water supply in the DRC in 2007 and 2014 (Source: DHS data from 2007 and 2014 as collated by the JMP, 2019b)

Based on the data above, and assuming that each borehole is used by approximately 400 people, the authors estimate that in 2014, there were approximately 1,700 boreholes in rural areas and 2,800 in urban areas of the country. This is a relatively small number of boreholes for such a large country endowed with such plentiful groundwater resources. The limitations of mechanised drilling may be one of the reasons for this. Mechanical drilling rigs can drill quickly in hard rock and to provide deep boreholes, but the equipment is very heavy and cannot be easily deployed due to the lack of adequate road infrastructure (Figure 3).

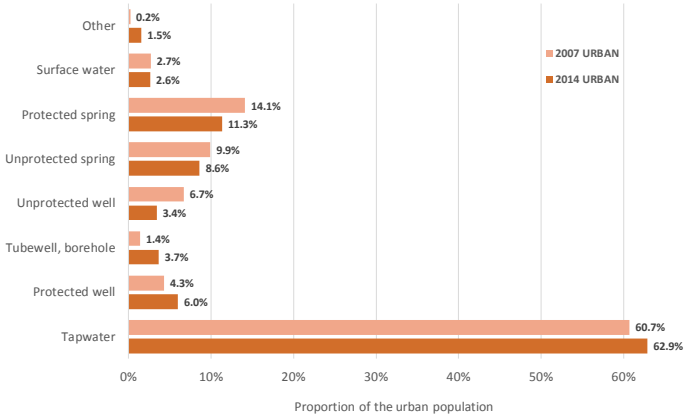


Figure 6 Proportion of the urban population using type of water source as the main drinking water supply in the DRC in 2007 and 2014 (Source: DHS data from 2007 and 2014 as collated by the JMP, 2019b)

Manual drilling (described further in Annex 1) offers a cost-effective alternative. The easy to transport equipment is highly suited to many of the remote and difficult to reach villages of the DRC (Figure 3).

The 650,000 people that have benefited from a manually drilled borehole corresponds to about 0.8% the estimated population. Given that in 2014, only 2.3% of the population were estimated to rely on a borehole for their main source of drinking water this figure is substantial. Manual drilling has boosted the use of boreholes for drinking water among the population.

Manual drilling could considerably increase the number of boreholes in the country, and its widespread uptake has the potential to significantly improve access to safe drinking water supplies in the DRC.

The Manual Drilling Initiative

Results

Between 2010 and 2018, a total of 1,806 boreholes were manually drilled and installed with handpumps in rural and peri-urban areas of the DRC[7] (Figure 7 and 8). The manual drilling technology used was rota-jetting, one of several techniques (Annex 1). The boreholes and pumps were financed almost exclusively by UNICEF, in particular through its technical and financial support to the Healthy Schools and

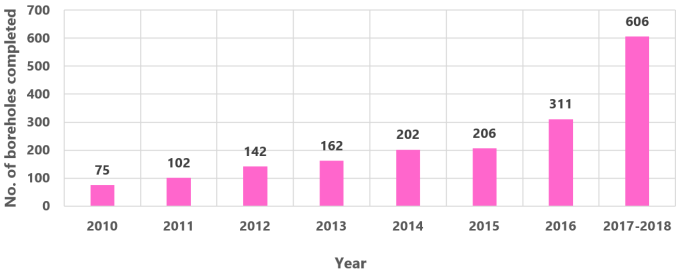
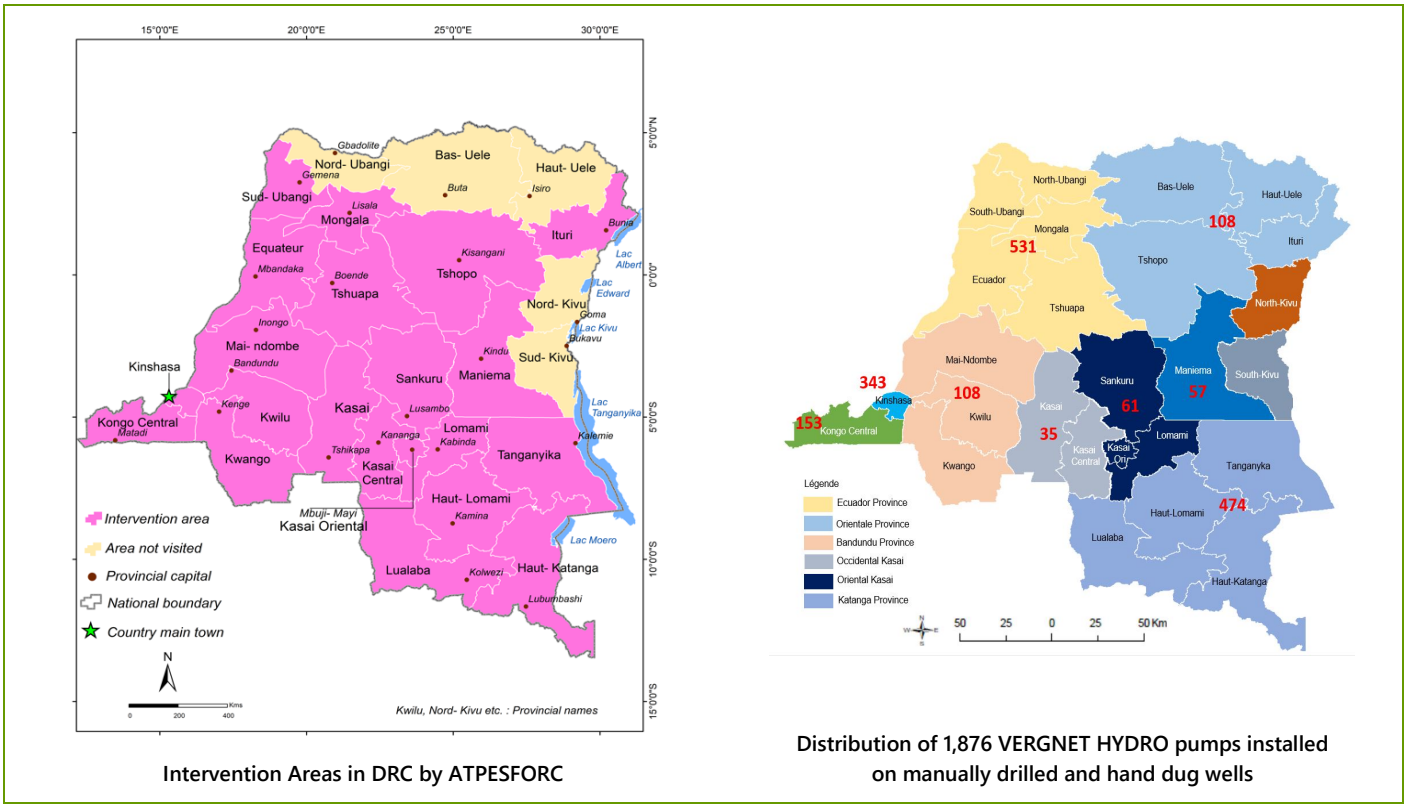


Figure 7 Number of manually drilled boreholes completed per year (2010 to 2018)

[6] Population data for 2017 from UN DESA Population Division World Population Prospects (2017) and World Urbanization Prospects (2018) as used in JMP (2019). DRC urban population - 31.096 million and rural population - 42.627 million.

[7] As recorded by UNICEF DRC



Intervention Areas in DRC by ATPESFORC

Distribution of 1,876 VERGNET HYDRO pumps installed on manually drilled and hand dug wells

Figure 8: Manual Drilling Initiative Intervention Areas and Installed Pumps[8]

Villages National Programme (PNEVA)[9]. Assuming that 90% of these boreholes are still operational, and that each borehole serves 400 people, an estimated 650,000 people have gained an improved drinking water service thanks to the initiative. Over the past decade, efforts to introduce and professionalise manual drilling have been undertaken in 21 of the DRC's 26 provinces (Figure 8).

In addition to the boreholes that have been drilled already, achievements from the collaboration with the ATPESFORC team pave the way for more manual drilling in the future, i.e. 19 workshops trained and equipped to produce drilling equipment, 25 shops identified and trained to sell materials for manual drilling, 105 small and medium enterprises trained in the rotary jetting drilling technique and 185 government controllers trained to supervise drilling operations. Guidance documents defining the drilling procedure, water quality testing requirements and the roles and responsibilities of the different stakeholders involved in the implementation and monitoring of drilling works have been prepared. In addition, eight provincial drillers' associations and a national federation have been created and they currently have directories for small and medium enterprises (SMEs) and drilling workshops present in the DRC.

The Process

Diffusion of innovation

Successful adoption (or failure) of any technology depends on technical, social, economic and policy factors, all of which are interrelated. Different challenges arise over time. A basic understanding of the different stages in the diffusion of innovations (Box 2) provides a framework to consider the introduction of manual drilling technology in the DRC. [*]

Diffusion of Innovation considers how new ideas or technologies are taken up and spread. Innovations, whether Bronze Age tools, paper or mobile phones take time to be taken up on a large scale. The time taken varies from years to decades and even centuries, and provides a useful. Broadly, there that technology uptake passes through three stages (Figure):

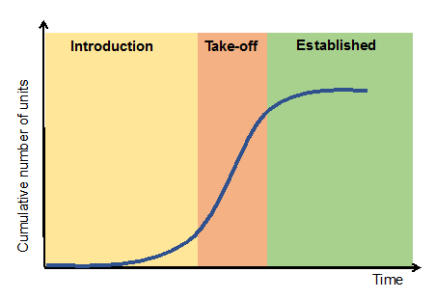


Figure (above): Three phases of technology uptake

[8] Note that the map (right) of handpump distribution included hand dug wells and manually drilled boreholes
[9] See UNICEF RDC (2019) for information about the programme.

- **Invention or introduction** – when a technology is developed and tested or introduced into a new context. At this stage, the uptake is quite low.
- **Take-off (or valley of death)** – when there is a sharp increase in the number of people adopting the technology, often copying others. This stage is also referred to as the "valley of death" or tipping point as the transition from testing and introduction to widespread establishment is extremely difficult. Within the context of products for the poor, this phase tends to be under-resourced.
- **Established** – when the technology is common, generally accepted and widely used.

Box 2 The three stages of innovation diffusion (Danert, 2015b)

The Ministry of Rural Development and the Ministry of Public Health, together with UNICEF, were responsible for the oversight of a series of projects to introduce and professionalise manual drilling in the DRC. The initiative comprised three phases: (i) introducing the technology, (ii) raising standards and innovation and (iii) expansion, improving trust and building confidence. In terms of the stages set out in Box 2, the authors argue that currently, manual drilling in the DRC is about halfway through in the take-off (or valley of death) stage in Box 2.

Phase I – Introducing the technology (2009 – 2012)

Between 2009 and 2012, UNICEF entered into partnership with Bush-Proof SARL, a Malagasy consultancy firm with experience in manual drilling. Bushproof facilitated the training of a few NGOs, as well as some SMEs, in manual drilling, bio-sand filtration and sanitation platform construction. Training was confined to the western provinces of the country. Over this three-year period, more than 300 boreholes were drilled manually and outfitted with handpumps.

Despite this seemingly encouraging result, a lack of formal capacity on the part of the implementing organisations and a lack of suitable drilling equipment was noted. Poor quality construction and rapid breakdown of the facilities was observed. Something was clearly wrong. On closer investigation, the following constraints were noted:

- Drilling equipment was inadequate for the construction of sustainable, high quality boreholes.
- Drillers had limited technical knowledge, which was based only on what they had learned on the job.
- There were no government-validated technical standards and norms on drilling for companies to refer to.
- There was a lack of quality control or supervision of construction work by qualified specialists
- A maintenance strategy for the completed water sources was lacking.

Phase II – Raising standards and innovation (2013 – 2015)

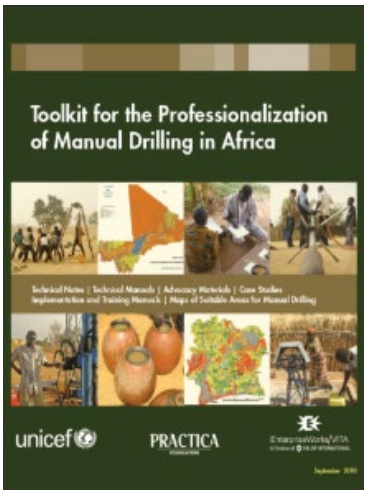


Figure 9 Cover of UNICEF Manual Drilling Toolkit

The aforementioned concerns led UNICEF to improve its approach and seek new technical support. The Chadian Low-Cost Drilling Companies Association (ATPESFORC) was approached to help improve the quality of drilling in the DRC through a professionalisation process in line with the UNICEF. '*Toolkit for the Professionalization of Manual Drilling in Africa*' (UNICEF, 2009). This included introducing improved drilling equipment and ensuring that it could be manufactured in-country (ATPESFORC, 2013).

Within phase II, more than 100 demonstration boreholes were drilled. Improvements to the technology enabled manual drillers to increase the depths drilled to 40m and raise drilling efficiency[10]. The main achievements of this phase were as follows:

Training

- Development of an in-depth training module in hydrogeology applied to manual drilling (ATPESFORC, 2013).
- Training of SMEs in basic hydrogeology applied to manual drilling in Kinshasa, Bas Congo, Equateur, Bandundu provinces, and subsequently Kasaï Occidental, Kasaï Oriental, Katanga and Maniema provinces.

Figure 10 Training by the late Gambo Nayou (Source: UNICEF)

10 As reported in the reports submitted to UNICEF DRC by the supervisors and/or drilling companies.

- Training of enterprises in manual drilling (Figure 11).
- Training quality controllers in the western and southern provinces.
- Coaching of NGOs in manual drilling programmes, with a view for them to establish private enterprises.

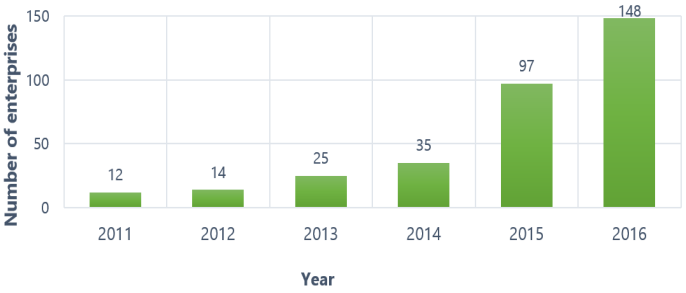


Figure 11 Cumulative number of manual drilling enterprises trained (2011 – 2016)

Equipment

- Identification and training of manual drilling tool manufacturing workshops.
- Coaching workshops to manufacture newly-introduced manual drilling tools.

Certification of enterprises and drillers associations

- Development of a rating criteria for the certification of drilling (ATPESFORC, 2015).
- Establishment of provincial associations of manual drilling SMEs.

Norms and standards, and tendering

- Elaboration and technical validation of a document setting out national norms and standards for manual drilling (ATPESFORC, nd). The document is available online and in print form.
- Technical note for water quality testing by partners[11].
- Launching tenders for manual drilling according to approved norms and standards.

Technological Improvements

- ATPESFORC introduced several technological changes to the manual drilling equipment that had been used by the Congolese drillers (described in more detail in next chapter). Subsequently, the Congolese drillers improved the equipment further, and now use more efficient drilling bits than those introduced by ATPESFORC (Figure 12).

This South-South cooperation experience was so successful that UNICEF supported the continuation of the collaboration between ATPESFORC and Congolese drillers until 2016. The plan was to establish a potential market for manual drilling in the DRC and take the process of professionalisation to a national scale.

Drill bit of the jetting toolkit from Chad

Customised drill bit designed by the local drillers

Figure 12 Design improvements to the drilling bits in the DRC by DRC drillers (Source: left - UNICEF and right Cheikh Hamidou Kane)

Phase III – Expansion, improving trust and building confidence (2015 – 2019)

The third phase of the introduction and professionalisation of manual drilling in the DRC focused on expansion, improving trust among service providers and their clients, and building the confidence of both. Notably, 2019 was the final year of DFID's funding contribution to the PNEVA, through which this manual drilling initiative was embedded, with activities described below.

Drillers association

- Collaboration with the Chadian Drillers' Association from 2013 triggered a process of reflection on the need for an association of drillers in the DRC. This ultimately led to the establishment of eight provincial associations, each with statutes and regulations that govern their operations. In addition, a National Federation has been formed that brings together the provincial associations.

Directories

- A directory of NGOs and SMEs engaged in manual drilling (see ATPESFORC, 2013) and a directory of workshops for the production of equipment and stores for the supply of materials were published in a document prepared by ATPESFORC (ATPESFORC, 2013).

Mapping the potential for manual drilling

- The areas within the country with favourable hydrogeological conditions for the manual drilling technologies were identified and mapped. It was found that an estimated 42% of the country has a very high or high potential for manual drilling (Figure 13).

Groundwater database

- The study to map manual drilling potential enabled the collection of fragmented data from across the country, leading to the creation of a national database to store and organise the information (Box 3).

[11] The Water Act (Cabinet du Président de la République, 2015) states that the project owner must ensure that the project manager has carried out water quality tests before proceeding with the technical and provisional acceptance of the works. Water quality analysis is thus included in drilling contracts. The technical unit of the *Villages et Ecoles Assaini* programme (PNVEA) developed a technical note to support the implementation of water quality tests by partner NGOs, companies and the Ministry of Health after the infrastructure works are completed.

The study to identify and map the areas favourable for manual drilling enabled the collection of tremendous amounts of fragmented data from across the country. This has led to the creation of a national database to store and organise the information. This database contains reports, maps and more than 800 stratigraphic logs. The database provides a tool for planning and decision support for stakeholders in the water sector, which can improve the efficiency and effectiveness of future interventions, not only for manual drilling, but also for borehole drilling more generally.

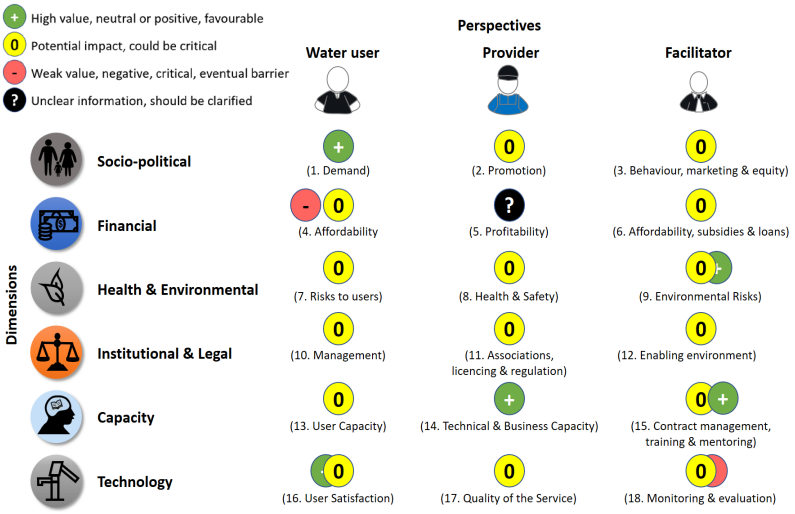
Additional efforts are needed to make the best use of the data obtained from manual drilling. These data are useful for mapping groundwater and reducing failure rates. UNICEF DRC, in collaboration with government actors, plans to support the Service National de l'Hydraulique Rurale (SNHR) in Kinshasa to set up a mechanism for the reporting and storage of data in all provinces in order to update the maps that have been produced. It is also envisaged that UNICEF will contribute to the financing of the SNHR website where the national database of water points in the DRC will be housed. This data will thus be made accessible to technical and financial partners and all stakeholders in the sector through a web portal.

Box 4 Groundwater data – a national treasure for the DRC

The figure below is a visualisation of socio-political, financial, health and environmental, institutional and legal, capacity and technology aspects of manual drilling from the perspectives of water users, providers and facilitators. The symbols reflect consensus at the workshop.

Workshop participants scored most of the dimensions of the neutrally, with the exception of affordability to the provider, which was considered unclear. This may reflect that to date, the providers have primarily operated within the PNEVA rather than in the open market or with other projects.

Figure (below) Analysis of stakeholder perspectives of six dimensions of manual drilling technology



Water user	Communities, households, farmers and businesses
Providers	Driller, drilling tool suppliet, handpump supplies & handpump mechanic
Facilitators	Political leders, government, UNICEF, NGOs, finance organisations & researchers

Box 3 Participatory Assessment of Manual Drilling (Danert and Gesti Canuto, 2016)

Quality control

- By 2016, 185 controllers from government technical services had been trained to regulate the sector (ATPESFORC, 2016).

Participative assessment of manual drilling

In April 2016, a participative assessment of manual drilling was undertaken to understand the key opportunities, constraints and bottlenecks for upscaling manual drilling in the DRC[12]. The assessment found that there is a demand by water users for manually drilled boreholes fitted with handpumps, but it was not clear whether they are affordable to operate.

Given the low household income and the perception that water is free, the current cost of drilling cannot be borne directly by the users. Communities have limited skills in the proper management and maintenance of infrastructure and need regular support in this regard. It was noted that ongoing support is necessary to ensure adequate operation and maintenance of the infrastructure, given the capacity constraints of the communities. Weaknesses and outstanding questions also related to the enabling institutions, including a perception of negative attitudes towards the technology within the political leadership, government and other potential financing partners. There was a lack of clarity regarding how the enabling environment can either support or hinder technology uptake, and a lack of information from monitoring and evaluation of the technology post-construction (Box 4).

Opportunities and Challenges for Manual Drilling and Water Services

The initiative to introduce and professionalise manual drilling in the DRC was adapted over time. Although already mentioned above, there are seven important activities that stand out as particularly important for the success of the initiative to date, and as a basis for the future.

Where is manual drilling feasible?

Based on methods developed through a UK government research programme (UPGro), the areas within the DRC with favourable hydrogeological conditions for manual drilling technologies were identified. A national map of manual drilling potential was developed alongside a series of three regional maps (Figure 13). The majority of the DRC is favourable to manual drilling (42% classified with very high or high potential, and 24% as moderate). The highest potential is in the western provinces of the country, where both the extent and thickness of the soft formation is very high, Eastern DRC being less favourable. The scale of the maps is suitable for overall planning and identifying of target areas for manual drilling, which is an important prerequisite for national and provincial planning. However, the maps do not allow the selection of the exact drilling sites.

[12] The assessment comprised a one-week participative field survey in rural zones of Kinshasa Province by a team comprising UNICEF staff, NGO partner staff, Skat Foundation, a Chadian representative and the media, followed by a 2-day workshop with stakeholders to reflect on different stakeholder perspectives from the survey.

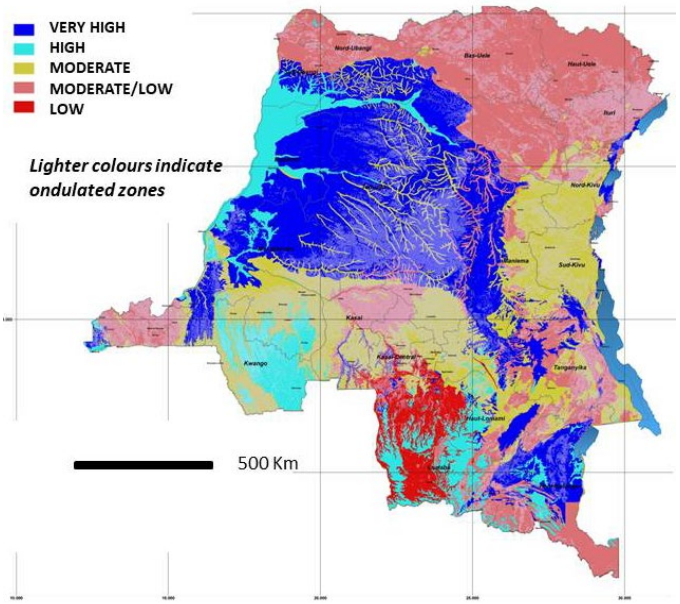


Figure 13 Suitable areas for Manual Drilling in DRC (national map) (source: UNICEF)

Improving the drilling equipment and techniques

In 2013, ATPESFORC visited NGOs/SMEs undertaking manual drilling in order to diagnose technical and ergonomic weaknesses and propose solutions (Table 1). This physical audit formed the basis of introducing drilling equipment from Chad. Further improvements were made to the technology by DRC drillers later on (Figure 12). The manual drilling technique now being used widely in the DRC is rota-jetting (Figure 14).

A National Federation of SME associations specialising in drilling

Following the establishment of the eight provincial drillers' associations, a National Federation of associations specialising in manual drilling was established in 2015, with the following objectives:

Figure 14 Rota-jetting equipment used in the DRC (Source: UNICEF)

- Create and maintain **a network and good relations** between its members.
- Defend the **general interests of the profession**, maintain collaboration and represent the profession to public and private institutions, and contracting entities, as well as to local authorities.
- Examine economic, social, administrative, legal, technical, regulatory, financial, fiscal and other **issues related to groundwater abstraction.**
- Follow and take up general or collective **legal interests** related to groundwater abstraction before any court of law.
- Promote the **continuous professional development** of specialised staff and provide the technical and communication support for the profession.;
- Issue Professional Qualification Certificates to 'Water Drillers' and 'Master Water Drillers' and establish a short list of **certified manual drilling professionals.**
- Support exchange and circulation of **information** between water drilling professionals both nationally and internationally.
- Promote sound **environmental practices** and improve the quality of the low-cost infrastructure built by its members.

Component	Diagnosis	Proposed Solution
Drill pipe/rod	The 40 mm diameter drill pipes of galvanised iron have several disadvantages. The narrow diameter does not allow a high water pressure at the drill bit, and the pipe regularly buckles with the force exerted by the drillers from above and the resistance of the rocks below.	Replace with two-inch (63 mm) diameter drill rods. Fit the 3m long pipes with male and female steel sleeves. The threads of the sleeves are made of hardened steel knives. These rods resist the forces exerted by drillers and the stresses of hard rock. The larger diameter allows more water to be pumped, exerting more pressure on the cuttings, promoting a better rise of the excavated material and thus increasing the removal of debris.
Injection head	The tool does not enable a complete 360° rotation and does not allow sufficient water to flow for the evacuation of the cuttings.	Replace with a swivel head that allows a complete 360° rotation. This rotation enables the drill bit to crush the rock with more ease.
Handle	The two-armed handle limits rotation and is painful to use. It is not strong, and twists and breaks regularly.	Replace the sleeve with a four-armed vice handwheel that primarily locks the drill rod and allows continuous 360° rotation movements to be performed with ease.

Table 1 Audit of the manual drilling equipment used in the DRC and proposals for new tools

In mid-2019, each of the eight board members of the federation[13] was from an enterprise that was member of one of eight provincial associations[14]. A major achievement of the federation has been to bring SMEs and financial institutions together as described below.

Raising finance for investment in water service provision

Aware of the difficulties faced by members of the National Federation of Manual Drillers in financing their drilling activities in rural areas, UNICEF initiated a meeting between Kinshasa-based banks and manual drilling SMEs in April 2017.

As a result of this meeting, four banks (EcoBank, TMB, ProCredit, Advance) offered financing solutions such as bank loans to help implement projects, start projects in the field and other investments in the manual drilling sector. Over the past three years, several business leaders have obtained bank loans as soon as they have signed contracts with UNICEF.

In September 2018, UNICEF, in cooperation with Elan DRC, facilitated a workshop on the water profession, in which the Federation of Drillers and more than 200 private investors (including banks and venture capitalists) participated. Eighty per cent of the investors indicated that they were willing to invest on long-term or short-term initiatives in the water sector. This strong interest of private investors in financing the water sector in the DRC remains an untapped potenial. UNICEF is continuing to explore ways for engaging the private sector on these issues in 2020 and in the future.

Ensuring construction quality

From the outset of the initiative, governmental staff, as part of the PNEVA, were responsible for controlling the quality of drilling operations. However, UNICEF observed problems regarding the completion of works within agreed timeframes, incorrect drilling depth, poor choice of drilling sites that did not respect required environmental criteria and insufficient development of the boreholes. In order to address these issues, and as recommended by the participative assessment in 2016, on-site control by specialised enterprises rather than government staff under an initiative called '*permanent on-site monitoring*' was introduced. UNICEF also established a full-time consultancy post for a hydrogeologist to manage drilling contracts and oversee drilling operations. This was taken up in 2016 by the lead author of this publication.

Full-time supervision has increased the cost of boreholes by an average of 50% (Figure 15). Initial feedback from the field suggests that this on-site control to ensure that the drillers adhere to specifications is providing good results. In addition, the regular updates on progress of drilling which are reported to UNICEF by the controllers enable closer follow-up. It is envisaged that this new approach should not only improve the construction quality, but also strengthen manual drilling enterprises, more generally.

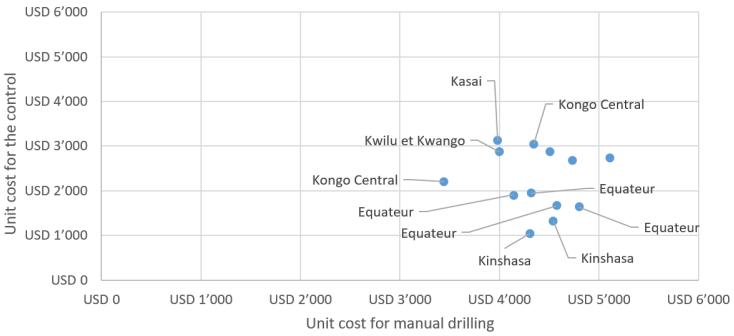


Figure 15 Comparison of the cost of drilling and control for 181 boreholes in six provinces[15] (excluding the cost of the pump)

Water quality

In contracts that are initiated by UNICEF, the control offices and drilling enterprises ensure that environmental criteria are met upon installation of water points. This includes ensuring a minimum distance of 15 m from latrines, garbage pits, cemeteries, floodplains and other factors which may compromise drinking water quality and the sustainability of the water source.

Further, water quality tests are mandatory for each new or rehabilitated installation. They must be carried out in certified laboratories that are accredited by the Ministry of Health. Water quality is certified as potable and suitable if it meets drinking water standards of the DRC, or failing that, WHO guidelines. Additional parameters are analysed according to the specific hydrogeological conditions of some provinces including those located in mining areas or those with volcanic activity.

Private sector capacity, legal status and government coordination

In the past, implementation activities financed by UNICEF relied primarily on civil society organisations, including NGOs. Many actors in manual drilling still have an associative, rather than private company, legal status, which limits their economic development and access to capital. UNICEF considers it important for these NGOs to become private companies, or for them to establish one. From the outset of the manual drilling initiative, considerable efforts were made to enhance the number of private enterprises undertaking borehole drilling. Notably, improvements in their performance was observed during the second phase of the initiative (2013 – 2015).

To date, several NGOs have transformed themselves into private enterprises and have also acquired new drilling equipment in order to explore new markets. These new machines make it possible to drill wells mechanically, and thus reach greater depths and provide higher flow rates than manually drilled wells, and improve drinking water access for the population.

The Federation of SME associations specializing in manual drilling, plans to set up a legal department to sensitise and support NGOs to

[13] Président National, vice-président en charge des techniques, 2eme Président en charge de l'administration, Secrétaire Rapporteur, secrétaire rapporteur adjoint, Trésorier(e), Trésorier Adjoint, Chargé de relation extérieur.

[14] Enterprises represented on national federation board : PRADEC (Province Ville de Kinshasa), DECAS (Province de TSHOPO), Assistance aux Communauté (Province de KATANGA), CATDR - Centre d'Appui Technique pour le Dév. Rural (Province du Kwilu), CEILU (Province Kasai Oriental), GAPROF (Province de l'Equateur), INTER ACTION (Kongo Central), EMSCO (Province du Kasai Occidental)

[15] Data from boreholes drilled by five manual drilling enterprises and controlled by three supervising agencies.

make the transition to private companies while retaining and institutionalising their experience acquired in the past.

In addition, the initiative to strengthen links between companies and the banking system is a means of integrating manual drilling professionals into the formal sector, which should help to support their development and growth.

Handpump components and maintenance and total guarantee

A manual borehole alone does not provide a water supply service: it must be equipped with a pump. The installation of hand pumps and the quality of their components, as well as the purchase, storage, management and maintenance of parts are all important aspects for consideration.

Notably, the drillers faced several weaknesses in the local market, including a lack of supply of certain components (e.g. polyethylene pipes, hand pumps, spare parts) and unreliable services (transportation and storage facilities). To address this, a central procurement office for hand pumps and spare parts has been set up in Kinshasa with plans for branches in Lubumbashi, Mbuji Mai and Kasai to facilitate the transport of pumps and components throughout the country.

In addition, an economic model of hand pump maintenance called "full warranty" is gradually being introduced, which works on similar principles to insurance. This model, implemented since 2017, is being tested to meet the challenge of equipment maintenance in communities. Repairs are supposed to be carried out within 72 hours of reporting the breakdown. A detailed analysis of these efforts is beyond the scope of this publication. However, it is important to acknowledge the efforts of UNICEF, the Government of DRC and partners to ensure that the boreholes that have been drilled continue to provide sustainable and reliable services to the beneficiary populations.

What's next?

Financing the capital cost of water infrastructure in rural areas, as well as its operation and maintenance, remains a significant challenge and is largely dependent on NGO projects and programmes such as the PNEVA, within which the manual drilling initiative has been embedded. Uncertainty over future donor funding for the programme, low financial participation on the part of the DRC government, the continued lack of access to capital, lack of an enabling environment for emerging companies and the devaluation of the Congolese Franc threaten the continuation of the gains made through the initiative so far.

To mitigate the impact of a reduction in financing in activities, UNICEF DRC is exploring the possibility of pooled funds and approaches that integrate different sectors (e.g. WASH and health/nutrition, emergency/transition, job creation/private sector development, youth, vocational training and rural development). It is hoped that such an approach could maximise the effect of programming while benefitting from sharing costs.

Despite the improvement of water supply through manual drilling, its implementation is not fully embedded in legislation. The manual drilling documents published are not DRC government documents, but have mainly been published by the Chadian drillers' association for the DRC. There also remain unresolved issues regarding standards, certification of drillers, fair prices, how to best ensure consistent quality of drilling equipment and how to further boost private investments, e.g. through the tax provisions. Furthermore, there are questions regarding the political will and financial capacity to support manual drilling at scale.

Conclusions and Recommendations

Thanks to a decade of learning, adaptation and promotion by UNICEF DRC and its partners, manual drilling has become widely accepted in the country. The technology can provide quality drinking water services at a lower cost than mechanised drilling, and can reach remote areas. However, manual drilling is not just about drinking water, it is also about job creation and private sector development. Its adoption in the DRC has led to training, the establishment of technical standards and the capacity building of stakeholders in the manual drilling sector. In short, manual drilling is much more than Water, Sanitation and Hygiene, and thus needs to reach out beyond WASH stakeholders and agencies.

Despite its huge potential, the widespread uptake of manual drilling in the DRC has yet to take place. Ten years may seem like a long time, but in order to successfully transition from introducing a new technology to its widespread uptake, a decade is actually a very short period. In addition, the challenges of the legal, social and economic context that drilling companies and equipment suppliers in the DRC face are not to be underestimated.

Manual drilling remains one of the few low-cost available technical options to raise access to safe drinking water supplies in rural communities which are scattered, remote and which have been neglected by water polities and strategies. However, with financial uncertainties and more interest in investing in urban and peri-urban areas, there is a risk that the gains made so far may be eroded.

UNICEF intends to carry on supporting the processes of change and tackling legal, economic and social aspects so that a vibrant, nationwide manual drilling industry can emerge and thrive, while continuing to sustainably meet the water supply needs of disadvantaged, rural communities. This industry could provide services, including privately funded wells, and contribute to the improvement of people's wellbeing, as well as benefit the DRC's economy more widely.

The authors of this publication conclude that manual drilling in the DRC has reached a turning point where it could either take-off and become widespread or lose its foothold in the country. Orders for boreholes and pumps are make through the PNEVA, which remains the primary client for manual drilling. No research has been undertaken on other clients requesting boreholes and handpumps from the SMEs and NGOs, but anecdotal evidence suggests that this demand is limited.

The authors recommend the following:

- Continue to support the professionalisation of manual drilling by financing the construction of manually drilled boreholes in key areas of the DRC where feasible, and where needs are most pressing.
- Support the government in reflecting on the advantages and disadvantages of manual drilling, and reviewing and publishing the guidelines, standards and directories on manual drilling.
- Undertake an assessment of what is needed to further embed manual drilling in other projects and programmes.
- Reach out beyond the WASH sector to professional trainings, employment creation and business development to garner support for manual drilling and its professionalisation.
- Analyse the market for manually drilled wells in rural areas, and for private boreholes in small rural towns as well as peri-urban areas.
- Follow-up the SMEs and workshops trained and support the associations to share lessons. Document and share experiences.
- Continue to monitor water point functionality and maintenance.
- Support the use of a national groundwater database.

The authors hope that existing and potentially new funding partners, as well as researchers, are able and willing to support and join the exciting journey of taking manual drilling in the DRC beyond the tipping point. It would be a pity for a decade of investments in such a promising technology and approach not to be able to reach its full potential.

Annex 1 Manual Drilling Explained

By 2015, a suite of manual drilling techniques (Box A1 and A2 and Figure A2) had been used in at least 36 countries around the world. Manual drilling technology is well established in Chad, Niger and Nigeria. It has been demonstrated that manual drilling can make a significant contribution to improving access to safe water for drinking, as well as for other domestic use, industry and agriculture (Adekile and Olabode, 2009, Danert, 2015a; Danert, 2015b, Danert *et al*, 2014, Healy, 2019, Holme *et al*, 2013, UNICEF, 2009).

Manual drilling refers to several drilling methods that rely on human energy to construct a borehole and complete a water supply (Figure 7). The various techniques can be used in areas where formations are quite soft and groundwater is relatively shallow (i.e. down to 40 metres). Not all formations can be drilled using manual methods. Sometimes the groundwater is too deep or the rock is too hard. In the right conditions, manual drilling can provide low-cost, but high quality water supplies. The main advantages of manual drilling techniques are:

- **Cost:** the cost of manual drilling is significantly lower than for machine-drilled wells (at 10 to 25% of the latter's cost). This also makes it economically feasible for some small communities or households to pay for the water supply themselves.
- **Accessibility:** manual drilling equipment is light and transportable and can reach places that conventional drilling equipment, with its heavy machines cannot. Indeed, tools and supplies needed to drill a well manually can be transported on a bicycle or a motorcycle and can reach even the most remote areas where accessibility is a major constraint (see Figure 4).
- **Local economic development:** local employment and income generation from borehole construction contributes to the local economy by enabling productive uses of water at the household or farm level.
- **Time savings & safety:** manual drilling allows construction of shallow wells faster than hand digging and does not require labourers to work underground.

Box A1 Manual Drilling Advantages

Manual drilling comprises four methods or techniques which are often used in combination:

- **Augering & Bailing:** penetrating the ground with a cylindrical or helical soil auger. Either the auger itself or a bailer is used to remove the loose materials. Augering can penetrate certain sands and silts and some clay formations. Very little water is required to remove the drilling spoil.
- **Jetting** (or washboring): injection of fluid or drill mud down and out of the bottom of a drilling pipe to wash the spoil up to the surface via the annulus (i.e. the gap between the drill pipe and drilled hole). Considerable amounts of water are used. Equipment includes a small petrol pump or manual pump to inject the fluid down the drill pipe. There have been a number of improvements of the original "rapid well jetting technique", including self-jetted well-screens, additives to the water to stabilise the hole, improved drilling bit and rotary arm to grind compact materials.
- **Percussion & Bailing:** lifting and dropping a cutting tool suspended at the end of a rope. The cuttings are usually removed with a bailer. Only a little water is added to remove the spoil. Cable tool rigs use a motor and winch to help lift and drop the cutting tool. A driven well is a variation of percussion, which involves driving a well point and well screen directly into the ground using a hammering tool. The material is forced aside rather than excavated by this technique. Driven wells are sometimes used in conjunction with hand augering.
- **Sludging** is a continuous drilling method. The drill stem, fitted with a cutting shoe is lifted and dropped into the hole to loosen the formation. Drilling fluid (water, mixed with thickeners known as drill mud) flows down the annulus and carries the cuttings up through the drill pipe. A hand placed at the top of the drill pipe acts as a flap valve to release the drilling fluid and cuttings, or a check valve is used at the bottom of the drill pipe to achieve the same result. As with jetting, sludging requires considerable volumes of water.

For more information, see:
https://www.rural-water-supply.net/en/sustainable-groundwater-management/manual-drilling

Box A2 Manual Drilling Methods

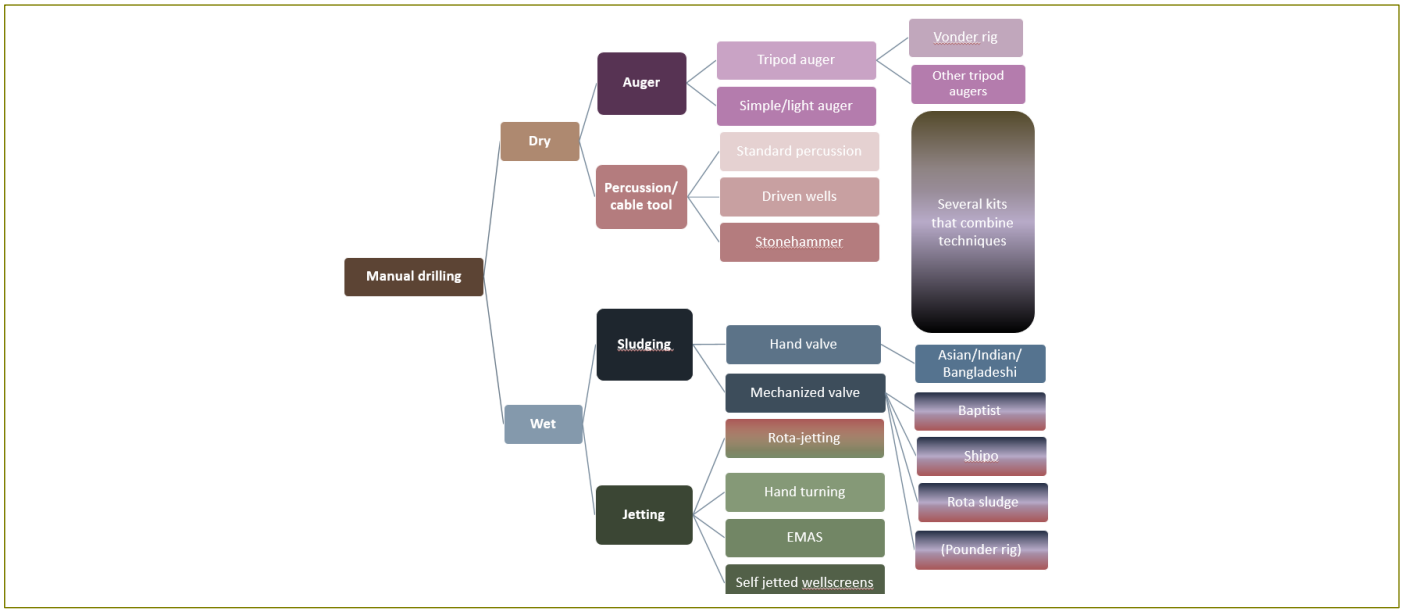


Figure A1 Manual drilling family tree

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[*] In **the early years of introduction**, influential leaders may need to be convinced that manual drilling is a viable technology. Selecting suitable sites can be a challenge (failure rates can be high) and there may be difficulties in obtaining the necessary equipment and materials. Targeted and carefully applied subsidies may be useful at the introduction stage. **At the stage at which the technology takes off**, demand can outstrip supply, and entrepreneurs with little technical expertise jump onto the bandwagon to try and make money. This can lead to poor quality workmanship which can damage the reputation of manual drilling. Alternatively, the trained and equipped drillers are not able to generate enough work, lose motivation and turn to other activities (i.e. the "valley of death" scenario). Knowledge by the enterprises of marketing, business development, financial management, record keeping and business ethics, as well as the formation and nurturing of associations to self-regulate is vital. **Once manual drilling methods have become established** and are widespread, quality assurance can continue to be a problem. Problems of over-abstraction of groundwater may also emerge depending on the level of abstraction and rates of recharge. Groundwater resources monitoring as well as regulation of abstraction is recommended. Generally, policies and regulation are not able to keep up with the expansion of manual drilling. In the meantime, populations benefit from more accessible water supply sources. Overly strict regulation can prevent the spread of manual drilling before it gets started.

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About the Authors

With a doctorate in hydrogeology, Dr Cheikh Hamidou Kane has more than 20 years of professional experience of managing programmes in community settings, and he has participated as principal consultant in numerous national and international studies funded by international organisations and United Nations agencies. He has been involved in developing technological options and innovative approaches for improving the supply of drinking water and sanitation in villages from Senegal, in particular, but also in many other villages in Africa. As a teacher at the University of Thies, Dr Kane took an unpaid leave of absence and joined the WASH section of Unicef-RDC – Kinshasa in August 2016, to work as an international consultant to support the management of the WASH contract and support the programme.

Dr Kerstin Danert has worked in rural water supplies in sub-Saharan Africa for over 20 years. Her work in groundwater commenced with her PhD research in Uganda (1998 to 2003) to develop new manual drilling technology and introduce it to government and the private sector. Since then, she has continued to develop and share knowledge of groundwater for rural water supplies, particularly in relation to drilling professionalism and manual drilling. This included leading a participative assessment of manual drilling in DRC in 2016. The International Association of Hydrogeologists (IAH) presented her the Distinguished Associate Award in 2017. After working for Skat Consulting in Switzerland for over eleven years, she launched her own company, *Ask for Water* GmbH in May 2020.

Contact

The Rural Water supply Network (RWSN) is a global knowledge network for promoting sound practices in rural water supply.

RWSN Secretariat
SKAT Foundation
Vadianstrasse 42
CH-9000 St.Gallen, Switzerland

Phone: +41 71 228 54 54
Fax: +41 71 228 54 55
ruralwater@skat.ch
www.rural-water-supply.net

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