

# Hand Drilling in Nigeria

Why kill an ant with a sledgehammer?



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This field note provides an overview hand drilling practices in Nigeria, which are being utilised to provide water sources for both domestic use and small scale irrigation. It is estimated that approximately 30,000 hand-drilled wells have been constructed throughout the country. Hand drilling as a business is being undertaken by farmers, artisans, university graduates, former civil servants and conventional drillers.

## Executive Summary

This field note gives individual householders, farmers, communities, institutions and policy-makers information on hand drilling in Nigeria. It provides a basic understanding of affordable drilling technologies for Nigeria and beyond. Costs, limitations and risks associated with hand drilled wells are also described in order to assist informed decision-making at all levels.

With simple equipment which is locally available, hand drilling has the potential to provide low cost water supplies. However it only works where the formation is not too hard and the depth to the aquifer is not very great. The cost of the hand drilled boreholes in Lagos, Kano, Niger and Rivers States is about a third of machine drilled holes.

It is recommended that the areas of the country where hand drilling is feasible be identified and hand drilling techniques promoted as a cost effective means of meeting the demands for communal and domestic water supply. However there is need to set up a quality assurance system to ensure the effectiveness of the drilling process and quality of the product, as well as to address concerns regarding water quality.

## Introduction

Manual or hand drilling is widely practised in different parts of Nigeria for both domestic water supply and irrigation. Hand drilling techniques started to be used in the 1980s to tap water for agricultural purposes from the river floodplains. It is estimated today that there are over 30,000 hand drilled wells in Nigeria. Hand drilling techniques are practiced by farmers, artisan and conventional drillers, university graduates and retired civil servants.

UNICEF Nigeria completed a study of public and private borehole drilling in Nigeria (Adekile and Olabode, 2008) to look at what affects the cost of borehole drilling in the country. This included a study of current practices in hand drilling. Hand drillers and conventional mechanised drillers were interviewed in Lagos, Kano, Niger, Rivers and Kaduna States and information was collected from other states. This forms the basis of this field note.

## Hand drilling techniques

Hand digging to construct a water-well requires a person to be working inside the hole; hand drilling allows the driller to stand at ground level. This may be achieved using a number of techniques:

- **Hand augering:** drilling a small-diameter hole with a soil auger (Figure 9).
- **Hand percussion:** manually lifting and dropping a cutting tool suspended at the end of a rope into the hole.
- **Jetting (or washboring):** injection of water into the hole through a drilling pipe to loosen and remove material (Box 1).
- **Hand sludging:** raising and dropping a drill pipe and use of water to carry the drilling cuttings up the drill pipe.

Please see the references for more detailed description of these methods as well as how they are being combined.

In Nigeria the most commonly used technique is jetting (Box 1). The equipment is simple and available locally. However, it only works in particular terrains, i.e. where the formation is not too hard, the depth to the water-bearing formation is not too great and sands are not too coarse (leading to loss of water when drilling).

Once drilled, the hole is lined with plastic tube (casing) to prevent it from collapsing. Screens, which allow water to flow into the well, are made on site by cutting slots into the tube. A petrol-driven pump is used to clean the hole by pumping until the water is clear. This assists the free flow of water into the well. This process is known as well development.

In the case of domestic water supply, an electric submersible or hand pump is used to lift the water out from the completed well. Petrol driven surface pumps are used for the irrigation. This means they can only be used where the static water level is not more than 6m deep. In Zamfara state on the Sokoto/Rima River floodplain, some farmers use a human operated suction pump known as the treadle pump.



**Figure 3** Traditional Well



**Figure 4** Shadouf



**Figure 5** Hand Drilled Tubewell (Kano State)

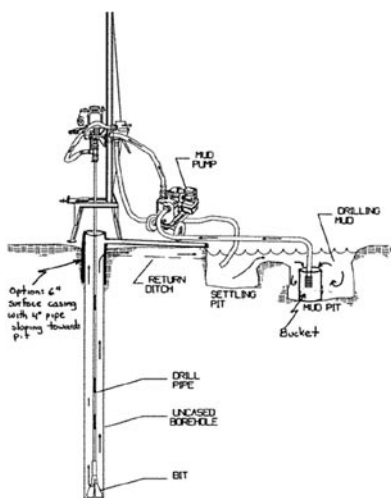
**Box 1** Jetting, Washboring or Hand Turning

Usually the hole is opened up by using a hand rotated cutting tool (known as a hand auger) to a few meters depth or to the water table (Figure 1).



**Figure 1** Opening the hole with a hand auger

Subsequently water is pumped (by hand or with a motor pump) from a tank or circulation pit through a hose attached to a 50mm galvanised iron (GI) drill stem with a drilling bit at the end. The water flows back up through the well annulus and brings the cuttings to the surface.



**Figure 2** Washboring Rig

The loosening and removing the material from a hole by the washing action of a water jet gives the technique the names jetting as well as washboring. The drill stem is rotated back and forth by four men to break the formation, hence the local Nigerian name "hand turning". In an unstable formation drilling mud is added to the water.

**Historical background**

In Nigeria and most of Africa, ground water abstraction for water supply and irrigation has traditionally been through hand dug wells and water holes (Figure 3). The water is lifted from the well by a rope and bucket.

In the northern parts of the country water lifting for irrigation was done by the shadouf (Figure 4). This comprises a pole on a fulcrum with a rope and container at one end and a counterweight at the other end and was brought to the Sahel by the Islamic culture.

In the 1930s tin miners on the Jos plateau introduced the banka<sup>1</sup> drill for mineral exploration. The banka is a manual auger/bailer rig with a round platform on which two or three men stand, using their weight to push the drill rods into the ground whilst others rotate the platform. It was also adapted for the construction of water supply boreholes but on a limited scale.

The Fadama studies carried out by the World Bank in the 1980s to evaluate the irrigation potential of the alluvial aquifers of the floodplains of major rivers in the northern parts of Nigeria led to the development of hand drilling for irrigation boreholes. In 1982 the Kano Agricultural and Rural Development Authority were trained in the washboring technique.

The initiative launched in the 1980s persists, and most State Agricultural Development Programmes train fadamas farmers groups to construct washbores. The Kano State Agricultural and Rural Development Authority has registered 1,500 Fadama Farmers Associations. In each association (of up to 25 farmers), at least 3 people have been trained in washboring. The situation is similar in all the northern States and Niger State. It is estimated that of the 30,000 manually drilled wells in Nigeria, over 10,000 have been constructed for irrigation.

The presence of groundwater resources at shallow alluvial depths (less than 20 meters in most of the fadamas throughout the dry season) plays a key role. These aquifers are recharged annually with the onset of the rain and river flow.

<sup>1</sup> Banka - from the isle of Bangka (Indonesia), where this set of drilling tools was first designed and used by the Dutch to prospect alluvial tin ore.

The availability of water for irrigation from these boreholes allows farmers, previously dependant on rain fed agriculture to be relieved from the agony of failed crops as a result of poor rains. They are then able to benefit from two or three cropping seasons per year.

The practice of washboring has extended from irrigation, to domestic water supply (e.g. Box 2).

In the southern parts of the country, the origin of hand drilling is not known although the author witnessed a borehole being drilled by hand percussion technique in 1978 in Lagos. It may have started as an adaptation of percussion drilling for ground investigation.

## Groundwater Sources

The rock types underlying the country are approximately 50% sedimentary and 50% crystalline. On the crystalline rocks the weathered zone overlying the fresh granite bedrock often stores water which can be reached by manual drilling to a depth of 35 m (e.g. in Kano and Kaduna State). However in Minna, Niger State the terrain is too rocky for hand drilling. Some of the sedimentary rocks in the country are compacted and some have aquifers at great depth, which cannot be reached by hand drilling but there are other areas where sediments are not compacted and ground water can be reached at a shallow depth.

## Prevalence of Hand Drilling

Figure 8 shows the project states and areas where hand drilling is known to operate. From interviewing the drillers, it is estimated that of the 30,000 hand drilled wells in Nigeria, approximately 20,000 were constructed for water supply in the major cities of the country. These are mostly in the southern cities of Lagos, Benin, Warri and Port Harcourt.

In addition to the numerous locations for hand drilling shown, shallow alluvial aquifers also occur along the floodplains of major rivers which are exploited for both irrigation and water supply.

### Box 2. Hand drilled well for domestic water

At Gurin in Adamawa State, the groundwater from sedimentary rocks is saline. In the wet season the community depends on rain water harvesting. Every dry season a tubewell is drilled manually into the alluvium in the dry bed of the River Faro (figure below), which provides fresh water which the water vendors sell to the community. A recent intervention proposes drilling tubewells in the river bed as the source of improved water supply for the community.



**Figure 6** Tubewell fitted with petrol pump on the dry bed of River Faro



**Figure 7** Water vendors at Gurin

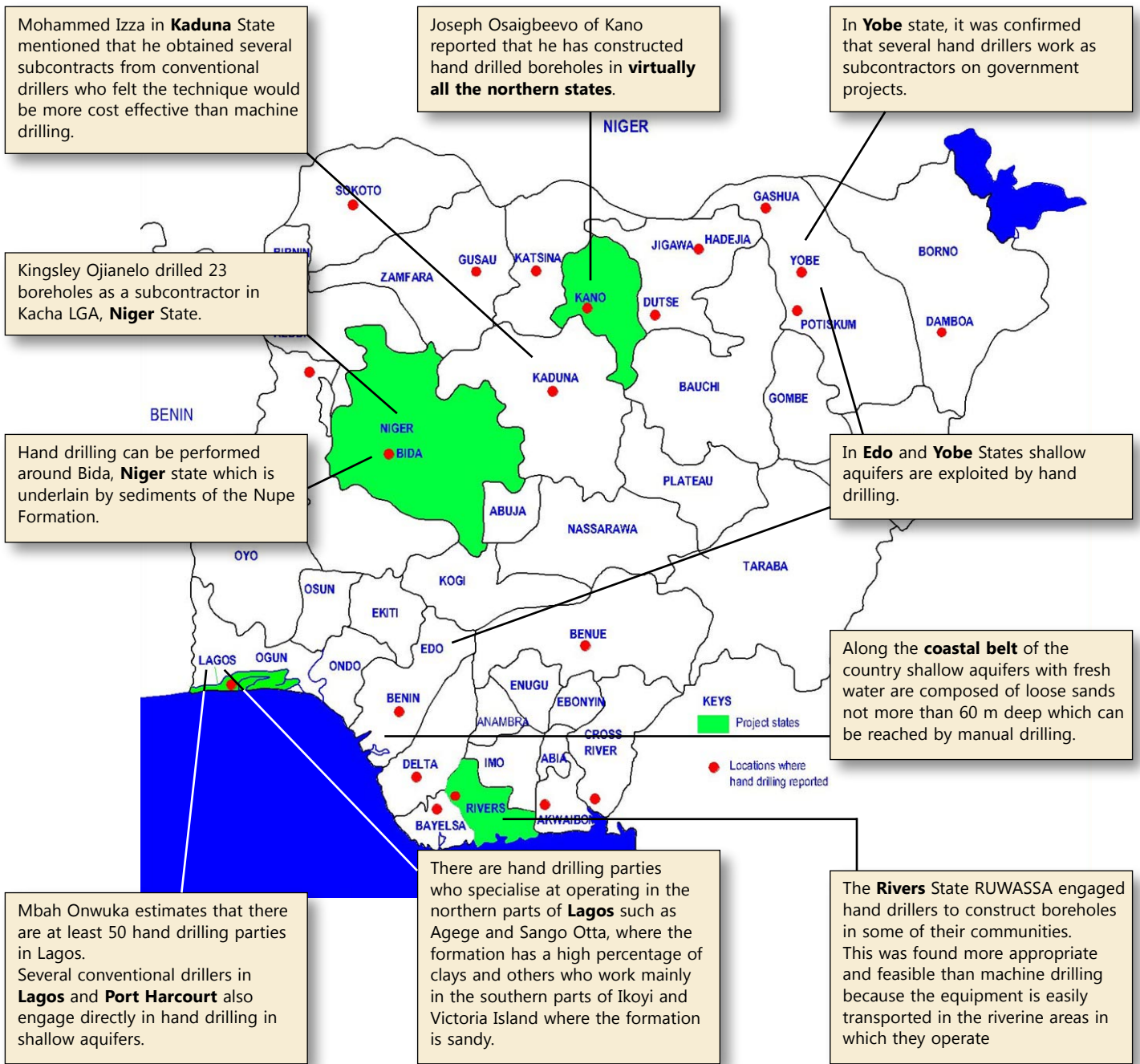


Figure 8 Annotated map showing areas of hand drilled boreholes



**Figure 9** Augers, Bailers, Clamps and Casings

## Hand driller profiles

Hand drilling enterprises are run by fadama farmers, artisan drillers, conventional drillers, university graduates and retired government hydrogeologists. It is not unusual to find an enterprise that utilises both conventional and hand drilling. Hand drilling artisans tend to operate in parties of 5 men who have bonded together and developed a rhythm and synchrony of turning the drill pipes.

Hand drillers are patronised because their prices are much lower than that of conventional drillers. Their clientele include householders, fish farmers, car wash owners, bottled water and sachet water manufacturers, conventional drillers and, to a very limited extent state agencies.

Several of the farmers and personnel trained by the ADPs and others have adapted to provide boreholes for domestic and industrial water supplies. Apart from the fadama (which literally means swampy ground) farmers, who primarily construct wells for other farmers, several of the hand drillers possess some level of entrepreneurial skills – they may have offices, prepare quotations and proposals for assignments and do some book keeping.

The profiles of a number of specific hand drillers are given below. Most of the hand drillers interviewed aspire to owning a conventional drilling rig and expanding their operation. Mohammed Izzah, who aspires to become one of the biggest drilling contractors in Nigeria in the next five years provides an example of a business using hand drilling developing into a conventional drilling enterprise.

### Mohammed Izzah, Kaduna

Mohammed, a 27 year old from Borno state has a national diploma in management studies. As a student he worked part time for a manual drilling contractor. After graduation he borrowed N300,000 (\$2500) from his parents to buy a set of drilling tools.

On Christmas day 2006 he completed his first borehole and by June 2008 he had drilled 253 boreholes. One conventional driller employed him to drill 15 boreholes in Kano State government. The Kaduna Petroleum Refining Company (KPRC) contracted him to drill 6 boreholes for their host communities.

Although he has ordered a conventional drilling rig from the US he intends to continue with hand drilling.

### Joseph Osaigbeevea, (Kano)

45 year old Joseph previously trained as a plumber and worked with an expatriate drilling company. In 1991 he set up his own hand drilling company from personal savings. He has worked all over the northern parts of the country. He has lost count of the number of boreholes he has drilled over the years but he is certain that it is more than 500. He presently has a staff of seven.

The average completion time for a borehole is 2 days. His pricing depends on the distance of the drilling location from his base in Kano. He said he has never had a dry hole but he hires a drilling rig when the terrain is a bit rocky and suspects he may have to use a hammer to get to the aquifer.

### Mbah Onwuka, Lagos

*"Why kill an ant with a sledge hammer?"* is how hydrogeologist and past president of the Nigeria Water and Sanitation Association justified his use of hand drilling. Mbah runs a drilling company in Lagos. He has a conventional drilling rig imported from Germany, another made in Nigeria and two sets of hand drilling tools.

In the shallow loose sand water-bearing formations of Lagos, where drilling is not expected to be more than 80 m, Mbah finds hand drilling has several advantages over conventional drilling. The equipment is simple and can be hand carried to any corner of a property, drilling is quick (on average one day) and so little drilling chemical is required. Well development<sup>2</sup> is fast.

This ensures that the cost is a fraction of that for machine drilled holes so affordable for many householders. Hand drilling represents 40% of Mbah's business turnover.

<sup>2</sup> Development of the well ensures that water can flow freely, is clean and free of fine materials.



**Figure 10** Hand turners work at a private residence

### Olumide Bamisaiye, Lagos

32 year-old Olumide graduated 5 years ago with a degree in geology. He engages in hand drilling in Lagos. He started with a loan of N700,000 (US\$5,000) from his parents. In the past 4 years he has drilled about 100 boreholes. He would like a regular job, but if can he build his operation to two boreholes per week he will continue with drilling.

### Rich Drill Ltd and Bee Drilling Ltd, Port Harcourt

These organisations utilise hand drilling along with their conventional drilling operations.

### Kayfem Consult, Lagos

Kayfem Consult specialise in deep drilling (>250m depth). If there is no clean water for drilling close to a site, Kayfem employs hand drillers to drill a shallow borehole in order to abstract water for the drilling process.

### Joe Akpabio, Akwa Ibom State

Joe retired as a hydrogeologist from the Federal Ministry of Water Resources in 2000 and currently runs a hand drilling enterprise.

### Kingsley Ojanelo

Kingsley has a degree in business administration and has been running his hand drilling operation since 1992.

Item	Dangarba Engineering Kaduna		Neat Drilling Limited, Kano		Links Hydro-engineering Lagos		McTonis Technical Services, Port Harcourt	
	Naira	US\$	Naira	US\$	Naira	US\$	Naira	US\$
Transport (Pick up for 3 days)	15,000	125	12,000	100	12,000	100	12,000	100
Drilling fluid – bentonite <sup>3</sup>	1,200	10	1,200	10	10,000	83	10,000	83
Additives – CMC & extender	10,000	80	12,000	100	5,000	41	12,000	100
Water	8,000	67	10,000	83	24,000	200	15,000	125
Labour (5 man crew)	75,000	625	80,000	666	50,000	416	55,000	453
Casing and screens	30,000	250	30,000	250	39,000	325	30,000	250
Gravel pack – 10 wheel barrows	2,000	17	3,000	25	3,000	25	3,500	30
Fuel (petrol in mudpump)	1,800	15	2,400	20	1,800	15	2,000	17
Sanitary seal	10,000	80	12,000	100	12,000	100	14,000	117
<b>Total Cost</b>	<b>153,000</b>	<b>1,263</b>	<b>162,600</b>	<b>1,355</b>	<b>156,800</b>	<b>1,305</b>	<b>153,500</b>	<b>1,275</b>
<b>Price paid by client</b>	<b>240,000</b>	<b>2,000</b>	<b>210,000</b>	<b>1,750</b>	<b>220,000</b>	<b>1,844</b>	<b>220,000</b>	<b>1,844</b>

**Table 1** Prices and costs of hand drilled wells in 4 States in July 2008 (150 mm diameter PVC lined, 35m depth)

<sup>3</sup> Bentonite is often used to keep the drilled hole open prior to placing casing and screen. However, the disadvantages are that it is expensive and can seal the water-bearing formation thus reducing the yield. It has been suggested that commercially available biodegradable drilling mud should be used as an alternative.





**Figure 11** Hand drilled well (Maraban Rido)



**Figure 12** Gambo - gardener in a private residence with the hand drilled borehole used for watering

## Prices and Costs of hand drilled boreholes

The **price** of the borehole is what the customer (government, project or householder) pays. The **cost** is what the driller spends on delivering the product. The difference between the cost to the driller and the price paid by the client will cover depreciation, maintenance and replacement of equipment and other overhead costs as well as profit. Since most of their clients are private individuals the hand drillers are able to avoid paying withholding tax or Value Added Tax.

The cost of construction of irrigation washbores lined with 50 mm plastic casing and hand slotted screens, but without the pump varies between \$20 and \$50 depending on the depth. Analysis of the data in table 1 shows that the costs are US\$ 1,300 ± 4%, while the price is US\$ 1,860 ± 8%, illustrating that there is little variation between the States. However, the labour cost is lower in the two southern states than the northern states. This may be due to greater competition in the south. There are many hand drilling parties in Lagos and Port Harcourt. The drillers on the crystalline terrain of Kano and Kaduna also use less drilling fluid than those on the sediments.

As the hand drillers are patronised mostly by private householders they go from one borehole to another and do not benefit from the economies of scale that a contract for several boreholes at a time would provide.

Other examples of hand drilling costs are as follows: Mbah (Lagos) charged N 400,000 (\$3300) inclusive of the pump for an 80 m deep industrial borehole producing 12,000 l/hour in Ilupeju, Lagos. He reckoned that if he had used his German conventional rig he would have had to charge N 1,600,000 (\$13,300).

Joseph (Kano) charges \$1850 (excluding the pump) for a 140 mm borehole in Kano city. For a 12 m deep irrigation tubewell he charges \$375. Olumide charges N160,000 (\$1300) per hole excluding the pump in Lagos state.

## Quality Assurance

The Agricultural Development Programmes (ADPs) monitor the quality of the washbores drilled by farmers and use of the pumps amongst those they have trained. However, there is no quality assurance procedure for hand drilled domestic water supplies. In order to prevent surface water incursion into the well and contamination there is need to ensure that the lining

material is of the required standard and that sanitary seals are properly placed.

There are complaints from both end users and other drillers, of unscrupulous hand drilling operators who do not maintain standards or honour contractual terms thus giving the industry a bad image. This problem is likely to be addressed by some of the on-going initiatives to regularise drilling activity within Nigeria. For example the Lagos State government has proposed a Ground Water Monitoring, Regulatory and Licensing Strategy and a Borehole Repository Format and Coding System as presented at the 19th meeting of the National Council on Water Resources in July, 2008. The proposals were approved by the Council and it further recommended that all states adopt the initiative.

The Rural Water Supply Network (RWSN) with support from the Water and Sanitation Programme (WSP) of the World Bank is promoting the formation of a drillers association in the country. This is aimed at professionalizing drilling activities and setting industry standards.

The National Water Resources Institute in conjunction with the Standards Organisation of Nigeria is developing a National Code of Practice for the drilling industry.

## Water Quality & Water Resources

In order to avoid over-abstraction and pollution, it will be necessary for ground water level and quality monitoring to be implemented as proposed by the Lagos State Government and recommended by the National Council on Water Resources.

The abstraction from rural community supply boreholes fitted with hand pumps is usually low and poses no threat to environmental sustainability so long as the sources are well constructed. In most urban areas, as population increases and public water systems become increasingly unable to cope with demand more and more households are investing in their own water supply. Often the only option is to access groundwater through boreholes fitted with submersible pumps. The abstraction points tend to be close together and there may not be enough space to locate them at an adequate distance from potential sources of pollution such as latrines and soakaways. If the sanitary seals are not properly placed there may be contamination.

There is also some concern regarding over-abstraction particularly in densely populated urban coastal areas which are underlain by unconsolidated sediments. During the industrial boom of the 1970s groundwater level decline was observed in the Lagos area. This has stabilised over the years but it may recur if the rate of abstraction continues to increase. A decline could lead to a reversal of flow and saline incursion into the aquifers.

Some farmers use irrigation boreholes as a source of drinking water. As these tend to be shallow, there is risk of contamination from poor excreta disposal, fertiliser and pesticides. Unless surface layers afford some protection, shallow groundwater is vulnerable to pollution from agriculture (fertilisers), domestic waste and industry. Thus if water is used for domestic supply it is important ensure that there is no major risk to public health. However, wide scale water quality monitoring is expensive and logistically difficult. The capacity of local governments and water boards to carry out water quality testing should be developed.

## Conclusion

Hand drilling has been practised for a long time in Nigeria both for irrigation and water supply and has the potential to enable increased access to water supply.

Hand drillers are presently being patronised by householders and owners of small scale industries. Some hand drillers are well educated and display a high level of entrepreneurial skills. They could be brought into the mainstream of government contracts and projects at a much lower cost than conventional drilling.

The areas of the country where hand drilling is feasible should be identified and it should be promoted as a cost effective means of meeting the demands for communal and domestic water supply. However, it would be necessary to implement a quality assurance system to standardise the drilling process and guarantee quality of the final the product.



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