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Hand Augered Garden Wells

by Jonathan Naugle

Revised third edition July 1996
Country Map of Republic of Niger

- Major towns in Niger
- Towns and villages in which LWR have installed hand augered wells.
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<th>Definition</th>
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</thead>
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<tr>
<td>AFVP</td>
<td>Association Française des Volontaires du Progrès.</td>
</tr>
<tr>
<td>Borehole</td>
<td>A hole dug in the soil by the augers.</td>
</tr>
<tr>
<td>F CFA</td>
<td>Francs Communauté Financière Africaine (US$ 1 = 500 F CFA).</td>
</tr>
<tr>
<td>LWR</td>
<td>Lutheran World Relief.</td>
</tr>
<tr>
<td>PVC casing</td>
<td>Poly Vinyl Chloride pipe which comes from the factory.</td>
</tr>
<tr>
<td>Pilot hole</td>
<td>A starting hole which sometimes has to be dug through soft sands or hard pans.</td>
</tr>
<tr>
<td>Slotted PVC casing</td>
<td>Poly Vinyl Chloride pipe with narrow slots cut into it to allow water to enter the well.</td>
</tr>
<tr>
<td>Well casing</td>
<td>Poly Vinyl Chloride pipe that has been placed in the borehole.</td>
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Introduction

Lutheran World Relief is an overseas relief and development agency based in New York City which responds quickly to natural and man-made disasters and supports more than 200 long-range development projects in countries throughout Africa, Asia, the Middle East and Latin America.

LWR was founded in 1945 by Lutheran denominations in the United States primarily to help Europeans displaced during World War II. LWR’s mission has since broadened to “support the poor and oppressed of less-developed countries in their efforts to meet basic human needs and to participate with dignity and equity in the life of their communities; and to alleviate human suffering resulting from natural disaster, war, social conflict or poverty”.

Through an Office on Development Policy in Washington, D.C., LWR also monitors legislation on food and development, and serves as an advocate for public policies which address the root causes of hunger, injustice and poverty in the developing world.

In West Africa, LWR has concentrated its activities in Niger where, since 1975, it has supported more than 50 rural development projects focused on market gardening and the construction of more than 4,000 garden wells. In 1986, LWR raised the profile of its West African program by opening offices in Mali, Burkina Faso and Senegal in order to better placed to respond quickly and effectively to requests for assistance. LWR is not itself an operational NGO, preferring to work through a network of partners who implement the projects. LWR’s partners are national NGOs or other local organizations recognized by the government. LWR provides financial as well as technical and logistical support.

LWR in Niger

LWR has worked with gardeners in Niger since 1978, and has constructed more than 4,000 LWR-type concrete wells. Many other organizations are currently using similar well construction methods to provide water to villagers for dry-season gardening, watering animals and potable water. Even with these construction efforts, the demand for wells is greater than the capacity to build them. Many gardening sites still suffer from a lack of water even though it is often less than 10 meters below
the surface. In 1987, LWR began looking for a technique that would allow wells to be constructed more rapidly and at a lower cost than the now common LWR-type concrete wells.

In January 1988, the first “improved” hand augered wells using Poly Vinyl Chloride (PVC) casing (i.e. plastic pipe) were installed in the District of Magaria in eastern Niger by LWR staff. In May 1988, two additional wells were built at Foulan Koiria, a small community on the outskirts of Niamey.

Presently, there are nine working wells at the Foulan Koiria demonstration site, as well as several types of water lifting devices (see special topics on page 22). Three other well and water lifting demonstration sites presently exist in Niger. They are located at Magaria, Birni N’Konni and Baléyara.

Interest in this well digging technique has grown throughout Niger resulting in the construction by LWR staff of more than 1,000 hand augered wells using PVC casing. Additionally, other NGOs and development organizations have constructed an estimated 3,500 hand augered wells in Niger as of June 1994. In June 1994, LWR funded an evaluation of the hand augered wells program and spin-off activities which reconfirmed a strong local and donor response to the technology. This well digging technique has been demonstrated by LWR staff in Chad and Mali. NGOs from Mauritania, Senegal, Burkina Faso and Togo have participated in hand augered well training workshops given by LWR staff in Niger.

The technique that has been developed, and is still developing, is similar to methods used to install hand augered wells for village water supply in other parts of Africa and in Asia. The major difference between the LWR system and the other systems is that the equipment used is lightweight and designed for augering shallow garden wells. Specialized augers have been developed to make the construction procedure easier. The LWR system uses hand augering techniques with direct installation of PVC casing to line the well, and a specialized bailer to remove water from the well. A polyester filter cloth, covering the slotted PVC casing, eliminates the need for a gravel pack around the well. This combination allows for an inexpensive and durable gardening well that can usually be installed in less than 6 hours.

Before the devaluation of the FCFA in January 1994, PVC casing was becoming more readily available in Niger. It had reached the point where it was accepted as the norm for lining small diameter wells. However, since the devaluation LWR has had
difficulty in procuring PVC casing in Niger. Merchants in Niger are still reluctant to stock the PVC casing because the manufacturers require that a minimum of 200 linear meters be purchased. Even wholesale merchants are reluctant to tie up the amount of capital required to make a purchase of that size, so the problem of buying PVC casing remains. In the past, LWR bought quantities of PVC casing from both Abidjan, Ivory Coast and Kano, Nigeria. The PVC casing would then be stored in Niamey, and sold at cost to whoever wanted to install a hand augered well.

This manual was first published in February 1989 by Jonathan Naugle, an LWR staff member, after extensive research, and trail-and-error experimentation in Niger. It was revised by Mr. Naugle in 1991 to reflect the considerable experience of LWR in the construction of hand augered wells using PVC casing in Niger. The manual is divided into two parts. The first part describes the current method of installing a hand augered well; and the second part describes the tools needed to dig a hand augered well, including detailed plans on how to make them (see appendix 1).
Description of the system

What is a hand augered well?

A hand augered well is a small diameter borehole that is drilled into the ground. The borehole is drilled using soil augers that are turned by hand. The augers used by LWR drill a borehole that is 180 mm in diameter. Thick walled Poly Vinyl Chloride (PVC) casing (160 mm 10 bar) is installed inside the borehole to prevent it from collapsing on itself. The completed well has at least 4 meters of PVC casing in the water table. The lowest three meters of the PVC casing have narrow slots cut into it to allow water to enter the well. This slotted portion of the PVC casing, known as the well screen, is covered with a polyester filter cloth (referred to as a sock) that prevents fine sands from entering the well.

Where can a hand augered well be installed?

Hand augered wells, because of their small diameter, cannot store a lot of water. For this reason, they work best in a water table with a fast recharge rate, such as former watercourses where the soils contain large quantities of sand and fine gravel. These soils are very porous, so water flows easily through them.

Wells in soils with a high silt or clay content have slow recharge rates. These types of soils are more suited to larger diameter concrete wells which have a greater water storage capacity. Stones, laterite, or hard clay can prevent augering. If these conditions are encountered near the surface, they may be broken up using a mining bar or shovel, allowing augering to continue. However, if they are encountered deeper down they often prevent the well from being completed.

The depth of the water table will also determine if it is possible to install a hand augered well. Because the wells are augered by hand, and an additional 4 meters of the piping must extend into the water table, the maximum water table depth for installing a well is about 10 meters.

Who can learn to install a hand augered well?

Anyone can learn to install a hand augered well. All you need are a few simple tools and to see a few wells being drilled by trained well diggers. The work is hard, but with patience and courage you too can auger your own well.
How much does it cost to install a hand augered well?

The cost of a hand augered well consists almost exclusively of the PVC casing, which is currently about US$ 20 per meter in Niger. LWR has experienced major difficulties finding a reliable source of pipe and has scoured Nigeria and even searched as far as Abidjan (Ivory Coast) for casing. Importing PVC casing leads to increased costs (e.g., transportation, customs fees). Additional costs including labor, filter cloth, well cover and bailer add another US$ 50 to the well. A 10 meter well therefore costs about US$ 250.

PVC casing: US$ 20/meter

Labor, filter cloth, well cover and bailer: US$ 50.

Tools which can dig 25 wells: US$ 200.

Total cost: about US$ 250 for a 10 meter deep well, (as opposed to around US$ 3000 for a large concrete well).
The tools needed to install a hand augered well are simple and can be made locally at a cost of about US$ 200 per set. These tools are lightweight and are easily transported to the site and can be used to drill about 25 wells. After this amount of digging, the equipment is usually worn out and must be either constantly examined or replaced. Additional costs include wire, pliers, hack-saw (see list of additional tools on page 40); and, the re-welding of damaged or broken parts.

It normally takes from 4 to 6 hours to construct a well 6 to 10 meters deep in suitable soils. Augering of the pilot hole (i.e. starting hole) in sandy soils often takes less than 1 hour. In heavier soils, augering is slower and may take several hours per meter. Augering in the water table is time consuming, taking on average about 1 hour to auger 1.5 meters.

### Hand augered wells

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of construction. A hand augered well up to 10 meters deep can be constructed in about a day by one trained well-digger working with 4 labors.</td>
<td>1. Adverse soil conditions. Hard clay or rocky soils can make the installation of hand augered wells difficult or impossible.</td>
</tr>
<tr>
<td>2. Cost of the well. Hand augered wells are inexpensive, costing an average of about US$ 200 per meter.</td>
<td>2. Small storage capacity. Due to the very small water storage capacity of hand augered wells, they need to be installed in water tables with high recharge rates.</td>
</tr>
<tr>
<td>3. Cost of equipment. The tools needed to install a hand augered well are uncomplicated and can be locally made for about US$ 200 a set.</td>
<td>3. Individual use. Only one person at a time can use a hand augered well. This can lead to long waiting times if the well is the sole water source for a community or school garden.</td>
</tr>
<tr>
<td>4. Space required. The well occupies almost no space in the garden, unlike traditional wells which take up areas of up to 10 square meters.</td>
<td>4. Depth of installation. The maximum depth of a hand augered well is about 10 meters.</td>
</tr>
<tr>
<td>5. Safety. Because of their small diameter, users cannot fall into hand augered wells.</td>
<td>5. Dependence on imported pipe. PVC casing is not available in Niger. Importing it in bulk from Ivory Coast or Nigeria demands a large initial outlay of capital.</td>
</tr>
<tr>
<td>6. Clean water. The well opening can be protected with a locking cap which prevents contamination.</td>
<td></td>
</tr>
</tbody>
</table>
Method of construction

A hand augered well of about 10 meters can be installed in a day by one trained well-digger working with 4 laborers. The construction procedure can be broken down into six separate stages.

**Stage one: Finding the water table**

Construction begins with the augering of a pilot hole. The choice of auger depends on the type of soil.

In sandy soils, a 180 mm diameter conical auger is used until the water table is reached. In hard soils, a small diameter conical auger is used to drill a pilot hole to the water table. The pilot hole is then enlarged using the 180 mm conical auger or large-diameter clay auger. Choosing the most appropriate auger is an art which comes with experience. Often a combination of several augers yields the best results.

![Diagram of augers](image)

**Care should be taken to ensure that the initial pilot hole is dug vertically.**

**Drilling the pilot hole**

In sandy soils water must be added to the surface soil to prevent the hole from collapsing on itself. After the first half meter there is usually enough moisture in the soil to support the wall of the pilot hole during construction. If there is not, a small amount of water is added to the pilot hole to increase the cohesion of the soil. The auger is turned until it has gone 0.5 meters into the soil or until the handle becomes too difficult to turn. Now the auger must be removed to be emptied of soil. Sometimes it is necessary to turn the handle backwards a few times in order to...
surface. This is in order to prevent the extension rods from bending. As the extensions are uncoupled, have someone hold on to the bottom extension so that the auger does not fall into the well. Care should be taken to ensure that the initial pilot hole is dug vertically.

Stage two: Fitting the filter cloth

An important feature of the hand augered well is the use of a filter cloth (i.e. a tube of cloth) to prevent fine sand from entering the well. The filter cloth must be made from 100% synthetic fiber; polyester is a good choice because it is very resistant to rotting in the water table as long as the soil pH is between 5 and 9.

It is very important that the filter cloth is attached properly and securely.
The first step is to sew the cloth into a three meter long tube, open at each end and wide enough to fit over the PVC casing. Nylon thread should be used as it is more resistant to rotting.

While the pilot hole is being augered, one or two workers can attach the filter cloth onto the slotted PVC casing. This a length of PVC casing three meters long with many little slots to allow the water to flow into the well. The filter cloth is attached to the slotted PVC casing using galvanized wire, if available. Galvanized wire is best because it will not rust.

**Important tip**

**Protect the threads of the casing during augering**

A simple trick is to cut off the bottom end of the slotted PVC casing (i.e. the male-threaded end) about two inches above the end of the threads. These threads are not needed for installation, and by cutting them off a protection piece is made which can be screwed onto the sections of PVC casing that are added as augering continues. If you don't use a protection piece, the joints on the extension rods may hit the threads while using the percussion auger and chip or crack them, rendering the section useless.
It is very important to make sure the filter cloth is tightly secured to the slotted PVC casing. If it isn’t, it may slip off during installation of the well, especially once the pounding starts after the water table is reached (see stage 4). If the filter cloth slips off, the slotted PVC casing must be removed and the filter cloth re-attached. To stop the filter cloth from slipping off, grooves are cut about three inches from each end of the slotted PVC casing using a hack saw. The wire holding the cloth is embedded into these grooves to give a very tight fit. Make sure the wire fits snugly inside the grooves and neatly snip off any extra bits so that it does not get ripped off during well installation.

It is also very important to ensure that the filter cloth covers all the slotted openings to prevent sand from entering the well. A well installed without a filter cloth will probably not even last one gardening season before being refilled by infiltrating sand. It is very important that the filter cloth is properly and securely attached.

Stage three: Installing the PVC casing

When the water table is reached, the bottom of the hole will start to collapse. This can be seen from the surface because the auger will be higher when it is put back into the hole after emptying than it was when it was taken out. The PVC casing must now be installed.

The PVC casing is assembled as it is lowered into the borehole. The slotted PVC casing with its filter sock is inserted first, female threads up, and a casing clamp is attached to it to stop it from falling into the borehole. Then a section of pipe without slots is screwed onto the slotted PVC casing. All PVC casing with or without slots must have male and female threading at either end. Additional sections are added until the end of the slotted PVC casing is sitting at the bottom of the borehole. At this point, the protective piece that was cut from the slotted PVC casing is screwed onto the top section of the PVC casing and augering can continue using the percussion augers.
Installing the PVC casing

Mann casing clamp

Slotted PVC casing with filter sock

Topsoil

Subsoil

Watertable
Choosing your auger

The bottom end of the PVC casing is left open to allow augering to continue. The 180 mm diameter conical auger is now put aside and augering continues inside the PVC casing using a 110 mm diameter auger. One of the most useful 110 mm augers in aqueous sandy (i.e. sandy soils with water) or light soils with a high proportion of clay is a valved percussion auger. This auger is pounded up and down into the borehole, breaking up the soil which mixes with the water to make a sort of liquid mud (i.e. slurry) that is removed with the auger. The auger is specially designed with a metal and leather foot valve, to let the slurry enter but not escape from the auger.

In heavy soils, only rotary augers are used because the percussion auger tends to get jammed or blocked by the sticky clays. In these soils, the cohesion is enough that open augers can be used without the soil falling from the auger back into the borehole.

Augering through the water table

Augering through the water table is hard work. Workers need to stand above the borehole to be able to pound the auger into it. A Mann casing clamp with foot plates gives a stable working platform for the augers and allows an increased downward force to be exerted on the casing during augering. It is best if 1.0-1.5 meters of casing pipe are left protruding above the borehole to ensure there is plenty of room to attach the casing clamps, which should be about 0.5 - 1.0 meters above the surface of the ground.

Two or four workers may be used for this work as it is very strenuous. If four workers are involved, two casing clamps may be used at 90 degree angles from each other to ensure ample foot space. If only one casing clamp is available, a pair of 200 liter drums can be used to give a raised working platform which makes the work easier, especially immediately after a new section of casing pipe is added. After several repetitions of this pounding motion, the auger will be filled and must be removed quickly and emptied. If the auger is not removed quickly it will become stuck, due to cohesive forces at the bottom of the well.

As soil is removed from the borehole, the PVC casing will descend under the weight of the well-diggers who are standing on the casing clamps. It helps if the workers jump on the casing clamps, especially while pounding. When the casing clamp reaches ground level, a new section of pipe is screwed on and
Augering through the water table

Mann casing clamp

Valved percussion auger

Topsoil

Subsoil

Water table
the casing clamp is moved to the next section of pipe. Remember always to remove the protection piece when adding the next section of PVC casing, and to replace it over the exposed threads of the next section of PVC casing.

Augering continues until there are at least 4 meters of PVC casing in the water table. In fine sands, as much as 0.3 to 0.5 meters of sand may remain in the well after it is finished. This means that there is only 2.5 meters of slotted PVC casing available for inflow of water into the well. The deeper the slotted PVC casing is in the water table, the greater the volume of water the well will store.

**Using the casing cover**

When removing the auger from the borehole to empty it, a special casing cover is put over the PVC casing before the extensions are uncoupled to prevent the auger and remaining extensions from dropping into the well. The couplings are put on the casing cover and uncoupled, and then another section of extension shaft is removed from the well, until the auger bit is retrieved (see page 38).
Two annoying problems

1. Augering beyond the PVC casing.

The well diggers must always be aware of where their auger is in relation to the bottom of the PVC casing. This is important because if the auger passes beyond the end of the PVC casing, it may become trapped and be impossible to retrieve without removing the PVC casing, and even then retrieval may prove impossible.

2. Augering continues, but the PVC casing does not descend into the hole.

This can be for two reasons. The first is that the friction of the PVC casing against the sand is too great. The second is that there may be a small lip at the bottom of the borehole that the PVC casing is resting on. The auger can't get rid of this lip because its diameter is smaller than that of the PVC casing. A possible solution would be to remove the PVC casing from the borehole and attach a 10 cm cutting ring to the bottom of the slotted PVC casing. This cutting ring would be made of 3 mm thick sheet metal and would be attached with screws. The cutting ring would fit over the slotted PVC casing like a sleeve. The PVC casing would then be re-installed into the borehole and the cutting ring would cut its way through the lip of hard soil.
When the PVC casing is 4 to 6 meters in the water table it is time to plug the bottom of the well in order to prevent fine sand filling up the well.

Ideally, the bottom end of the PVC casing will be embedded in an impermeable layer of clay. This would seal the bottom of the well. But this is often not possible because the depth of penetration of the PVC casing into the water table is limited by the friction between the pipe and the soil. The depth of penetration is also limited by the inflow of fine sand through the bottom of the PVC casing.

Gravel sack

If an impermeable layer is not reached, a small sack (i.e. 30 cm by 15 cm) may be made from the same material as the filter cloth. The sack is filled with gravel and dropped into the PVC casing when as much sand as is possible has been removed from the well. Experience has shown that by tamping the sack gently with a 110 mm tamp, attached to an extension rod, the sack can be firmly fixed into position at the bottom of the well.

A gravel sack inserted into a well that has been dug deeper than the PVC casing is useless. The gravel sack will sink to the bottom of the borehole; but since the PVC casing isn't resting on the bottom of the borehole, fine sands will infiltrate between the PVC casing and the sack thus filling up the well. The PVC casing must therefore rest at the bottom of the borehole.
Plugging the bottom of the well
Stage six: Protection of the hand augered well

Each hand augered well is equipped with a locking well cap and an external protective ring. The well cap prevents rubbish from being thrown into the well. Wells installed in the Magaria region without a locking well cap dried out after about a season. When it is not in use, the bailer can be stored inside the well by hanging it from a loop welded on the inside of the cap. The external protection ring protects the top edge of the PVC casing from being damaged by friction from the bailer rope.

Each well is fitted with a locking well cap and external protective ring.
Using the bailer to draw water from the well

Bailer

The bailer is made from a 1 meter length section of thin wall PVC casing (110 mm) reinforced at the top and bottom with a heavy wall PVC casing. The bailer holds 7.5 liters of water and on average it is possible to draw three bailers per minute, giving a rate of 1,350 liters per hour.

Water is released by setting the bailer on a hard surface which opens a special release valve, called a "pop-it valve".
Record keeping and monitoring

Accurate records should be taken for each well that is constructed: where is the well located; when was the well constructed; how many meters of PVC were installed; how many meters of water were in the well at the time of installation? This is important because with accurate records it is easier to check up on the wells to make sure that they have water and to re-dig them if they have gone dry (see an example record sheet in appendix 2).

Well maintenance

Well diggers and well owners should realize that periodic maintenance will have to be performed on the wells and bailers. This will ensure that the wells continue to work for many years. The well owners should be told who has been trained to repair bailers that have worn out, as well as who to see if they have any problems with the amount of water in the well.

Repairs should be made on the wells in the dry season, when water levels are at their lowest. Here is a quick checklist to determine whether your well needs maintenance:

- Are the locking well cap and external protection ring firmly attached to the PVC casing?

- Is the bailer cracked or otherwise damaged?

- Is there enough water in the well for the garden space to be irrigated? It should be noted that if a water-lifting device is being used on the well that the water table must be very permeable. The recharge rate of the well must be equal to or greater than the discharge of the water-lifting device. If problems occur, the well may need to be deepened or hand-bailed instead of pumped.

- Check the well’s records to see how many meters of PVC casing were installed. Use a plumb bob to determine how much water is in the well at the present time. If the two measurements are not the same, the well should be cleaned out to at least the depth of the original well. Use the valved percussion auger to do this. Remember not to dig further than the bottom of the PVC casing. You will need to replace the gravel sack with a new one because the old one usually gets destroyed during the cleaning operation.
Well casing removal and re-use

If for any reason the well runs dry or requires other major repairs, the PVC casing can be easily removed and re-installed. The procedure for removal is to attach a casing clamp to the PVC casing and use two car jacks to lift it out of the ground. This method can be used even after the well has been in the ground for several years. Frequently the filter cloth is lost or damaged during the removal process. It is a good idea to replace the filter cloth anyway, since the whole PVC is already out of the ground.

The ease of salvaging the majority of the materials is another advantage of a hand augered well over a concrete well. In the case where a well is unsuccessful, there is little lost investment, except the time it took to dig the well. The PVC casing can be re-used.

Potable Water

Hand-augered wells can be used to provide potable water if several precautions are taken to prevent contamination of the well. If a bailer is used to draw water, the rope must be prevented from dragging on the ground. Regardless of the method of drawing water, a concrete apron should be constructed to prevent pounding around the top of the well, thus reducing the possibility of surface contaminants flowing into the well along the PVC casing. In addition, the area around the PVC casing should be backfilled with clay soil, again to reduce the risk of surface contaminants reaching the aquifer. A minimum of 30 meters from latrines or other sources of fecal contaminants should be maintained.

Water-lifting devices

LWR has been experimenting with different types of water-lifting devices, such as treadle pumps, shadufs, Foulanta pumps, Ader (Segou) pumps, rope and washer pumps, and pulley systems.

At the LWR test site in Foulan Koira, outside Niamey, there are examples of most of the water lifting devices described below. There are also 9 tube wells (another name for hand augered wells) at the site. The farmers like these well/pump systems and use every possible space in their massive gardens. It should be noted however that the Foulan Koira site has a high water table with a very strong recharge rate.
Foulanta Pumps

The Foulanta pump is a single piston, hand-operated pump which costs about US$ 110. It can pump water from a depth of 6 meters at a rate of about 2,500 - 3,000 liters/hour. It is heavier than a treadle pump, but can be pushed like a wheelbarrow to and from the garden site. The piston system for the Foulanta pump is internal, and thus more difficult to repair and maintain than the treadle pump.

Man from Foulan Koira, Niger demonstrates use of a Foulanta pump.
Treadle Pumps

Treadle pumps are the among the better water-lifting devices that we have found, because they are one-third the cost of a motor pump, they require little maintenance, and they are locally made. We have been working with the ATI-type treadle pump which can pump water from a depth of 7 meters, at a rate of about 5,000 to 7,000 liters/hour. Some farmers have been able to more than double yields in their gardens with this pump. The life-span of a treadle pump is about four years after which minor welding may be needed. The pistons are made of leather and rubber cups that are easily replaced. The pump costs about US$ 90.
Ader Pump
The Ader pump is the direct descendant of the Segou hand pump which was developed in Mali. Both are locally made products. The Ader pump can draw water from depths of 12 meters at a rate of about 3,000 liters/hour. The cost of the pump for a ten meter water table before devaluation was about US$ 140.

Pulley systems
Pulley systems are the simplest of all water lifting devices but they are under-utilized. More work is needed to develop the technology. Ideas include block and tackle systems, manual crank or foot crank pulley systems. No pulley systems are presently used in LWR's Niger program.

Rope and Washer Pump
LWR has experimented with a water-lifting device which can pull water from a depth of up to 10 meters. Many rope and washer pumps have been set up in Niger, and LWR and Peace Corps are working to popularize this effective and inexpensive water-lifting devise. It can pump 6000 liters/hour at a depth of 3 meters, and 3000 liters/hour at a depth of 10 meters. The cost of building a rope and washer pump is very low (US$ 15-30 depending on depth) as it uses only local materials which are mostly second-hand, and easily available. The pumps are also simple to understand and easy and inexpensive to maintain for any gardener.
Shadufs
Several shadufs have been constructed and assembled in Niger. These are excellent water lifters (up to 3,600 liters/hour) and are less expensive than a treadle pump. They are simple to build and repair and can be made locally. A wooden shaduf can be made for about US$ 14, and has a life-span of about two years. Metal shadufs have been made for about US$ 70 and have a life-span of about ten years.
Perched Water Tables
Occasionally, well diggers will reach a perched water table before reaching the main water table. If there is not enough water in the perched water table, augering must continue. Sometimes, however, the hole will refill with sand faster than it can be dug out in which case the PVC casing must be installed. Augering continues inside the PVC casing with a smaller set of augers.

Hardpans
Pans of hard clay or laterite can slow down or even stop the hand drilling process. When hard clay is encountered, the rate of augering drops from meters per hour to centimeters per hour. The best solution is often to relocate the well. LWR experienced this in Mali, where there were pockets of hardpan and gravel, which made augering difficult. Increasing the downward force of the augering by having someone sit on the handle while others turn is not a solution. The increased torsional stress on the auger extensions could twist or snap them. It is important that the auger blades be as sharp as possible, especially the open clay augers.

Fine Sands
When drilling in saturated fine sands there is a tendency for the sand suddenly to flow a meter or more into the PVC casing from the open bottom. Unfortunately, this often happens when the well is nearly finished. The auger is removed to be emptied and when it is replaced, the level of sand in the PVC casing is higher than it was before the auger was removed. This is due to a pressure gradient between the inside of the PVC casing and the outside of the casing. Adding water to the PVC casing before removing the auger has helped in some instances, because the weight of the water offsets the pressure gradient, but patience and persistence are usually the only answer.
Conclusion

Hand augered wells are relatively inexpensive and simple to install. Well diggers are easily trained in a few days and can install hand augered wells in much less time than it takes to dig a larger diameter well. However, if this technology is to continue helping small-scale gardeners, we need to overcome the problem of PVC casing supply. In the past LWR has kept a small supply of PVC casing in stock, but this is not a sustainable practice. Merchants who will stock PVC casing need to be identified and encouraged to collaborate with local well diggers.

LWR is interested in further experimentation with hand augered wells. Possibilities include well-jetting, a technique used in Senegal which involves the use of a motor-pump to dig the pilot hole. Other possibilities include a “sludging technique” from Peace Corps in Chad, or the introduction of a metal cutting ring which is attached to the bottom of the slotted PVC casing to aid in the penetration of heavy clays.

Beginning to dig a hand augered well at Foilan Koira in Niger.
Checklist

Are Hand Augered Wells For You?

☐ Is your water table less than 8 meters?

☐ Are soil conditions in your area suitable for hand augering (i.e. no rocks or laterite)?

☐ Do you have a permeable water table that is mainly composed of particles ranging in size from medium sand to fine gravel?

☐ Are you working with motivated gardeners who are not afraid to try new things?

☐ Do the gardeners realize that the wells are best suited for individual use?

☐ Is the garden space to be irrigated from one well less than 1,500 square meters?

☐ Is PVC casing available? If not, are you willing to import it and deal with inconveniences at borders and with transport?

☐ Can you identify a merchant who will stock PVC casing and, if necessary, make a minimum order of 200 linear meters?

☐ Do you know a competent welder who could learn to make the tool kits?

☐ Can you find 100% polyester cloth and nylon or polyester thread?
Materials

PVC casing

LWR uses commercially available 140 mm or 160 mm diameter 10 bar PVC casing and slotted PVC casing. The slotted PVC casing is 3 meters long with 1.0 mm wide slots cut perpendicularly to the axis of the casing. Casing is available with slots 120 degrees apart, but experience has shown that if the slots are at 60 degree angles from each other the inflow of water is much higher. The casing is threaded at both ends (male and female threads) with the depth of the threads being 1/2 that of the thickness of the PVC casing. This gives joints that are flush inside and out. Having a smooth interior surface is especially important when using a bailer because the bailer tends to catch on any protrusion on the inside of the PVC casing. This leads to a shortened life span of the bailer.

Studies have been made trying different types of PVC casing (140 mm 6 bar and 160 mm 6 bar), but for overall ease of construction and durability the 10 bar thickness is by far the best. On a 10 bar pipe, the threads are much deeper, giving a larger surface area on each thread. This makes screwing sections of PVC casing much easier. On a 6 bar pipe where the threads are shallower and there is less surface area, there is a greater risk for the threads to cross-thread. Another problem with the 6 bar casing is that the threaded ends of the casing are not threaded all the way to the end like the 10 bar pipe. This “sleeve” that fits to the end of the threads is very thin and if bent hard will crack, leaving that section of pipe useless.

LWR uses both 1.5 m and 3.0 m sections of PVC casing. The 3 meter long sections of both plain and slotted PVC casing are standard, but the 1.5 meter casing sections need to be specially ordered, usually at a higher cost and a minimum order of 200 linear meters. However, these short sections allow the well-drillers to work at ground level or on 200 liter drums, whereas the 3 meter sections would require a drilling platform 2.5 meters high.

The well casing can also be made from 6 meter lengths of PVC casing cut into 1.5 meter lengths. This requires forming bell joints or the use of PVC couplings so the sections can be joined together. Bell joints are made by heating an end of casing in hot oil until it is soft and then inserting another piece of casing into the softened end to form a bell. The casing is then cooled in water. Casing using bell joints or PVC couplings must be glued together at the
site. Under hot weather conditions the glue dries very quickly which leads to weak joints and subsequent joint failure.

It is also much more difficult to pull out the well if the need arises because the casing sections cannot be dismantled. That is, the sections are glued together and cannot be unscrewed and must be cut with a hacksaw.

Filter cloth

A good filter cloth must be permeable to water but must prevent the entry of fine sand into the well. LWR has used both nylon and polyester cloth for this purpose. It is important to use a 100% synthetic fabric that will not decompose rapidly in soil or water. Polyester is resistant to rotting in the soil as long as the soil pH is between 5 and 9. Another factor in the choice of the fabric is its resistance to tearing. Choose weaves that do not tear or run. Using a 100% polyester or nylon thread, the cloth is sewn into a tube that fits snugly over the slotted PVC casing.

Bailer

The bailer is simple to make and use. It should fit easily in the well and have a capacity of 7.5 liters. Village artisans have been taught to make and repair them.

Opening the bailer to water a garden plot.
Initially, heavy wall PVC casing was used. But the disadvantages of higher cost and weight were not offset by any greater durability. Now the baiier is made from a 1 meter length section of thin wall 110 mm PVC casing that is reinforced at the top and bottom using heavy wall PVC casing. A lifting loop is attached to the top of the baiier to provide an attachment point or a retrieval point should the rope break and the baiier need to be retrieved from the well.

Several different designs have been used with the major difference being the bottom valve. The disk for the valve is always made of locally cast aluminum.

The first design was a simple flat disk with four large holes in it and a rubber flap valve attached to the disk in the center by a bolt. This design was simple to make and very durable, but to be emptied, it had to be tipped upside down. Farmers didn't like this because it was too time consuming, especially for gravity-fed irrigation. The "improved" model uses a poppet valve which allows the baiier to be emptied simply by placing it on a hard surface (stone or concrete slab). The valve opens and the water flows out the bottom. LWR has experimented with a 1.75 meter baiier with the capacity for 15 liters. Its design is the same as the regular baiier but longer. It works well with a rope and pulley system or a shaduf counter-balance system; it is too heavy to pull by hand, though.

Well and protective ring

Each well head is installed with a protective ring, made of a piece of re-enforcing rod bent into a circle the diameter of the well (i.e. 140 mm or 160 mm). This circle of re-enforcing rod will protect the wellhead from the baiier rope. Then it is spot welded onto a 10 cm long tube of number 2 sheet metal. Holes are drilled into the sheet metal so that screws may be used to firmly attach the internal protective ring to the wellhead. Pilot holes must be burned through the wellhead because the PVC casing is too hard for the screws to go through. Because PVC casing is susceptible to heat, an awl that has been heated is then applied to the PVC casing in order to "burn" a pilot hole for the screw. The internal locking ring fits like a sleeve over the wellhead.
The locking well cap is composed of a flat piece of number 2 sheet metal that is spot welded onto another tube of number 2 sheet metal whose diameter just exceeds that of the internal protective ring. A small lock may be attached to this pair to prevent surface contaminants from entering the well. A small loop is welded to the inside of the locking well cap so that the bailer rope may be attached, and the bailer stored inside the hand augered well, away from the harmful rays of the sun when not in use.

Attaching the bailer to the well cap to store it inside of the well.
The augering tools

The following paragraphs describe the tools used for hand augered well construction. Detailed plans for the fabrication of the tools can be found in Appendix 1.

Making the tools requires a competent welder who has metal cutting tools and an electric drill. The descriptions that follow are for tools that work well under soil conditions found in Niger. When making new augers imagination plays a key role and the modification of cutting angle and pitch of auger flights may make a given auger work better in one soil type than in another. Minor variations in auger shape have not proved to be very critical, although some sets of tools have performed slightly better than others.

A complete set of augering tools.

The conical auger is a spiral and shaped like a wood screw, with the largest flight 180 mm in diameter. An auger any wider than this is very difficult to work with because the ground suction is too great. These look complicated to build, but by using the templates in Appendix 1 to cut the flights from 3 mm thick sheet metal, the fabrication becomes quite easy. The conical auger works best in sandy soils. Sometimes water needs to be added to the pilot hole to increase the soil cohesion. A small diameter conical auger is useful when augering pilot holes through very hard soils, which will later be enlarged with the 180 mm conical auger.
Valved percussion (Tarka) auger

The Tarka project in the Department of Tahoua (northern Niger) has installed over 2,000 hand augered wells in the past few years. They have designed a percussion auger that works extremely well below the water table in most soil types. It can even be used to remove gravel. Its design is simple: a steel tube with sharpened teeth on its lower extremity, and a leather flap valve which has a steel plated backing. When the auger is pounded up and down inside the PVC casing, the teeth bite into the soil and loosen it up, and the broken soil enters the auger body through the flap valve. When the auger is lifted, the flap closes and the auger can be retrieved without losing too much soil. The leather flap has a life expectancy of about 20 wells and is easily replaced.

Enclosed conical auger

The enclosed conical auger is used when very fine sands are met in the water table. These sands are so fine that the valved percussion auger cannot hold them and thus another approach is needed. The enclosed conical auger combines the actions of a sand bailer and a conical auger and is used in rotation and percussion movements. The auger itself is a simple conical auger with a 110 mm PVC housing that fits over the flights of the auger. When the auger is turned, sand enters into the housing of the auger. By pounding the auger up and down, the sand is moved further up into the housing. When the housing is full, the auger is lifted out of the PVC casing and the fine sands are removed by sliding the PVC housing away from the auger flights. This auger has performed very well in the Goudamaria region of eastern Niger where fine sands are often encountered.

Open and closed clay augers

Clay augers are used in soils with a high clay content. They cut through the clay quicker than the conical auger and can be used before or after the water table is reached. The cohesion of the clay keeps it from falling out of the auger as it is lifted from the borehole.

The open clay auger can be made from PVC casing cut into long strips and formed into spoon-shaped cutters. It works best in heavy clays, but must be kept sharp.

The closed clay auger is made from a 45 cm long section of steel tube that is of the desired diameter (either 180 mm or 110 mm), the bottom of which is cut to form spoon-shaped cutters which are sharpened on their leading edges for 25 cm. This auger works best when the valved percussion auger gets jammed by sticky clay, but not enough clay is in the soil to keep the soil from falling out of the open clay auger.
The most critical part of the tool-making process is the construction of the extensions. The square ends must be perfectly aligned with the long axis of the extension or it will be difficult or impossible to drill a vertical well. In addition, all the holes for the securing pins must be positioned in exactly the same place on all the extensions so that they will be fully interchangeable. The pins are attached to the extension by a length of chain. A good supply of pins must be on hand at all times. New pins should be used with each new well dug.

All augers are approximately 1 meter long and are equipped with a female joint made from a 35 mm x 35 mm square hollow section. The 1.5 meter and 3.0 meter long auger extensions are made from 27 mm diameter galvanized steel pipe. LWR has experimented with heavier gauge steel pipe to increase the durability of the tool sets, but the well diggers prefer the lighter weight tools.

Handle attachment points are placed every meter along the length of the 3 meter extensions and at the midpoint of the 1.5 meter extension. One end of the extension has a male joint made from 30 mm x 30 mm square hollow section which fits into the 35 mm x 35 mm female joint on the auger. The other end of the extension has a female joint identical to the one on the auger. The number of 3 meter extensions needed varies with the desired depth of the tube well, but only one 1.5 meter extension is necessary per set of tools.

The auger handle is a simple T that slips over the auger or auger extension and is secured by a pin connection. The placement of the pin holes on the male and female joints is critical to ensure the interchangeability of the extensions and augers.

The ideal size for the auger handle is 0.60 cm. It could be longer (e.g. 0.75 cm or 1 meter), but the longer it is, the harder it is to manipulate.
Center pin

There are several methods for securing the center pin when attaching the extension sections. One method involves wrapping non-galvanized wire around the pin, firmly securing it in place through the extension's attachment housing. However, this method wastes a lot of wire.

The pin should be made of size 8 iron bar. Note the small hole at the end. This is so that a small piece of wire can be inserted to secure the pin.

Another method for securing the center pin is to insert a piece of wire through a small hole at the extremity of the pin. This wire is then twisted and the center pin cannot be withdrawn without first taking out the wire. This second method of securing the attachment pin seems to work much better. It is faster which is important when the well casing is being installed in fine sands because of back-filling.

Attaching the center pin securely is important because if it comes loose during the actual construction of the well, the auger and remaining extensions will fall in the well and their retrieval can be difficult and time consuming.

Mann casing clamp

The casing clamp is placed around the PVC casing and tightened to allow a downward force to be exerted on the PVC casing. The clamp is made from a 15 cm long section of steel pipe.

Make sure the casing clamp is secured below the threads inside the PVC casing.
approximately the same diameter as the casing pipe. If the welder can have a small sample of the PVC casing, chances are the casing clamps will be made to the right size. Handles are welded onto the steel pipe. Footplates are welded onto these handles to provide a place for workers to stand or sit. This work platform provides the necessary downward force required to force the PVC casing into the ground. Be sure not to attach the casing clamp too close to the threads, because it exerts pressure on the pipe which may distort the threads making additions of pipe difficult to secure.

The PVC casing cover is a simple but important tool. It supports the extension rods during coupling and uncoupling and prevents the loss of the auger and extensions into the well. It is made from a 3 mm thick piece of plate steel with a notch cut into it. The tab from the notch is not removed but bent back under the cover to prevent the cover from sliding off the PVC casing. The PVC casing cover is strong enough to support the weight of the auger and extensions, but it is a good idea to have someone hold onto the extensions just in case.
Gravel tamp

Sometimes when the gravel sack is inserted into the well, it will not sink to the bottom of the PVC casing. This presents a problem, and for this reason we have designed the gravel tamp. It is a disk-shaped attachment that can be attached to the end of the auger extensions by means of a pin, just like all the other auger bits. Its diameter is 110 mm. If there is no gravel tamp, the extension rods themselves may be used, but take care to tamp gently as the gravel sack may rip, or even accompany the auger bit when withdrawn after tamping. It is clearly easier to have a tamp as part of each tool kit.

A gravel tamp is a useful tool to ensure the gravel sack is firmly in place at the bottom of the well.

Additional tools

In addition to the specialized tools described above the following hand tools are required for the installation of a hand-augered well: a hacksaw, a hammer, a screwdriver, two size 19 open/closed wrenches, a pair of cutting pliers, a half round file, a sturdy needle and nylon thread, wire (galvanized and non-galvanized), an awl, size 19 nuts and bolts, and a tool box.
Appendix 1

Detailed Drawings For Tool Fabrication
Notes:

1. Auger flights are cut from 3 mm thick plate steel according to the patterns on Sheets 2 - 4 and then stretched to give 10 cm between flights and welded to the center support to make a continuous spiral.

2. Center support is 27 mm O.D., 2.8 mm wall thickness galvanised steel water pipe. (2.1 mm wall can also be used, but tools are not as strong)

3. Upper auger end is identical to the female end of the auger extensions. See auger extension plans for details.

4. Total length of the auger is 1.10 m

[Table]

<table>
<thead>
<tr>
<th>Conical Auger</th>
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<tbody>
<tr>
<td>18 cm Diameter Conical Auger</td>
</tr>
</tbody>
</table>

Lutheran World Relief Niamey, Niger

Scale 1:2

All Dimensions in Centimeters

Sheet 1 of 4
Notes:

1. Cut along line and separate to form auger flight. Shorter edge is joined to next smaller auger flight.

2. Templates are full size and can be used to trace auger flights onto steel plate.
Notes:

1. Cut along line and separate to form auger flight. Shorter edge is joined to next smaller auger flight, longer edge is joined to next larger auger flight.

2. Templates are full size and can be used to trace auger flights onto steel plate.

Conical Auger

Lutheran World Relief Niamey, Niger

Scale 1:1

All Dimensions in Centimeters

Sheet 3 of 4

4.2 DIA

1
Notes:

1. Cut along line and separate to form auger flight. Shorter edge is joined to next smaller auger flight, longer edge is joined to next larger auger flight.

2. Templates are full size and can be used to trace auger flights onto steel plate.

Drawn: J. Naugle  
Date: 4 December 1990

Conical Auger Template Lower Flights 18 cm Diameter Conical Auger

Lutheran World Relief Niamey, Niger

Scale 1:1  All Dimensions in Centimeters  Sheet 4 of 4
1. Auger flights are cut from 3 mm thick plate steel according to the patterns on Sheet 4, then stretched to give 4 cm between flights except the top flight which is 2 cm, and then welded to the center support to make a continuous spiral.

2. Center support is 27 mm O.D., 2.8 mm wall thickness galvanized steel water pipe. (2.1 mm wall can also be used, but tools are not as strong)

3. Upper auger end is identical to the female end of the auger extensions. See auger extension plans for details.

4. Total length of the auger is 1.10 m

5. Leather flap is attached to top auger flight with a 6 x 15 mm bolt.
Notes:
1. For details of components see subsequent drawings.
Notes:

1. 35x35 mm square steel tube, 2 mm wall thickness.

2. 30 x 30 mm square steel tube, 1.5 mm wall thickness.

3. Center support is 27 mm O.D., 2.8 mm wall thickness galvanized steel water pipe. (2.1 mm wall can also be used, but tools are not as strong)

4. All holes for pins are centered with respect to the long axis of the extension.

5. Total length of the extension is 3.1 m.

Section A-A

Section B-B

Section C-C

Drawn: J. Naugle  
Date: 8 November 1990

Additional Tools

Long Extension

Lutheran World Relief Niamey, Niger

Scale 1:2  All Dimensions in Centimeters  Sheet 2 of 6
Notes:

1. 35x35 mm square steel tube, 2 mm wall thickness.

2. 30 x 30 mm square steel tube, 1.5 mm wall thickness.

3. Center support is 27 mm O.D., 2.8 mm wall thickness galvanized steel water pipe. (2.1 mm wall can also be used, but tools are not as strong)

4. All holes for pins are centered with respect to the long axis of the extension.

5. Total length of the extension is 1.6 m.
Notes:
1. The casing cover is made by cutting two 10 cm long cuts 3 cm apart in a 3 mm thick piece of plate steel and then bending under the cut tab.
Notes:

1. Bailer is constructed from 11 cm O.D. PVC waste pipe with a wall thickness of 0.25 mm.

2. Reinforcing at the top and bottom of bailer is 11 cm O.D. PVC pressure pipe with a wall thickness of 0.6 cm. A 1.6 cm wide piece is cut out of the circumference to allow the pipe to be placed inside the bailer.

3. Bottom reinforcing ring is attached to bailer with two screws to allow disk to be removed. Other reinforcing rings are glued to the bailer.

4. Poppet valve - for details see Sheet 2.

5. Disk for poppet valve - for details see Sheet 3.

6. Handle is 6 mm rod with sheet metal welded to it, in order to bolt it to the bailer, using four 4 mm x 20 mm bolts.

Drawn: J. Naugle  Date: 24 October 1990

<table>
<thead>
<tr>
<th>Bailer Complete</th>
<th>Lutheran World Relief Niamey, Niger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale 1 : 4</td>
<td>All Dimensions in Centimeters</td>
</tr>
<tr>
<td>Sheet 1 of 3</td>
<td></td>
</tr>
</tbody>
</table>

XVII
Notes:

1. 1.2 cm hole drilled in casting 0.5 cm deep to allow welds on valve stem to seat.

2. Disk is an aluminum sand casting made by local craftsmen. The 0.37 cm diameter hole is drilled after the casting has been smoothed.

3. Slight imperfections can be tolerated in the casting for the large holes, but the support for the valve stem, spokes and outside diameter should be as shown.

---

**Bailer**

Lutheran World Relief Niamey, Niger

**Scale** 1:1

All Dimensions in Centimeters

**Sheet 3 of 3**

**Drawn:** J. Naugle  
**Date:** 22 October 1990
Notes:

1. 8mm rerod is welded to thin sheet steel collar and serves to protect top edge of plastic pipe from wear.

2. 6 mm rerod loops allow the cover to be locked to the collar, when the well is not in use, to prevent children from throwing objects into the well.

3. Bailer rope is attached to loop inside cover allowing bailer to remain in the well.

4. Screws are used to attach collar to well casing. They are trimmed flush with inside of casing.

---

**Drawn:** J. Naugle  
**Date:** 25 October 1990

**Well**  
**Well Cover and Collar**

**Lutheran World Relief Niamey, Niger**

**Illustration**  
**Sheet 1 of 1**
## Hand augered well record sheet

### Geological profile

<table>
<thead>
<tr>
<th>Depth</th>
<th>Texture</th>
<th>Color</th>
<th>Water holding capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

### Textures

- **C**: Clay
- **FS**: Fine sand
- **G**: Gravel

### Colors

- **B**: Black
- **W**: White
- **S**: Silt
- **MS**: Medium sand
- **Lat**: Laterite
- **Y**: Yellow

### Water holding capacity

- **D**: Dry
- **M**: Moist
- **W**: Wet
- **S**: Soaked
- **CS**: Coarse sand
- **L**: Limestone

### Installation of well

- **A**: 
- **B**: 
- **C**: 
- **D**: 
- **E**: 
- **F**: 

### Well test

- Depth of water table before pumping
- Time at start of pumping
- Time at end of pumping
- Depth of water table after pumping
- Flow rate of well
References

P.O. Box 35059, Dar es Salaam, Tanzania.


DHV Consulting Engineers (1978) "Shallow Wells".
Second edition. P.O. Box 85 Amersfort, The Netherlands.


Appendix 4

Additional Resources

Lutheran World Relief
B.P. 11624, Niamey, Niger.
Fax: (227) 72 33 47
Phone: (227) 73 22 27

Appropriate Technology International,
1828 L Street NW, Suite 1000, Washington DC 20036, USA.
Fax: (202) 293-4598
Phone: (202) 293-4600

Appropriate Technology International/ Senegal
Sicap Liberté II, Villa N° 1356, B. P. 10251, Dakar, Senegal.
Fax: (221) 25 36 82
Phone: (221) 25 45 23

Peace Corps Niger
B.P. 10537, Niamey, Niger.
Fax: (227) 74 13 99
Phone: (227) 73 46 86/88

ACREMA
B.P. 147, Tahoua, Niger.
Food security is one of the major concerns of people living in sub-Saharan Africa. Since 1978, Lutheran World Relief has worked with gardeners in Niger to find ways to provide them with a ready source of water for dry-season gardening. This book presents LWR’s experience in Niger of developing a simple, low cost well-digging technique easily afforded and mastered by farmers - Hand Augered Wells.

The manual is divided into two parts. The first part describes the current method of installing a hand augered well; and the second part, describes the tools needed to dig a hand augered well with detailed plans on how to make the tools found in the appendices.

* Major towns in Niger
* Towns and villages in which LWR have installed hand augered wells.