Affordable water for irrigation: An experience in Niger

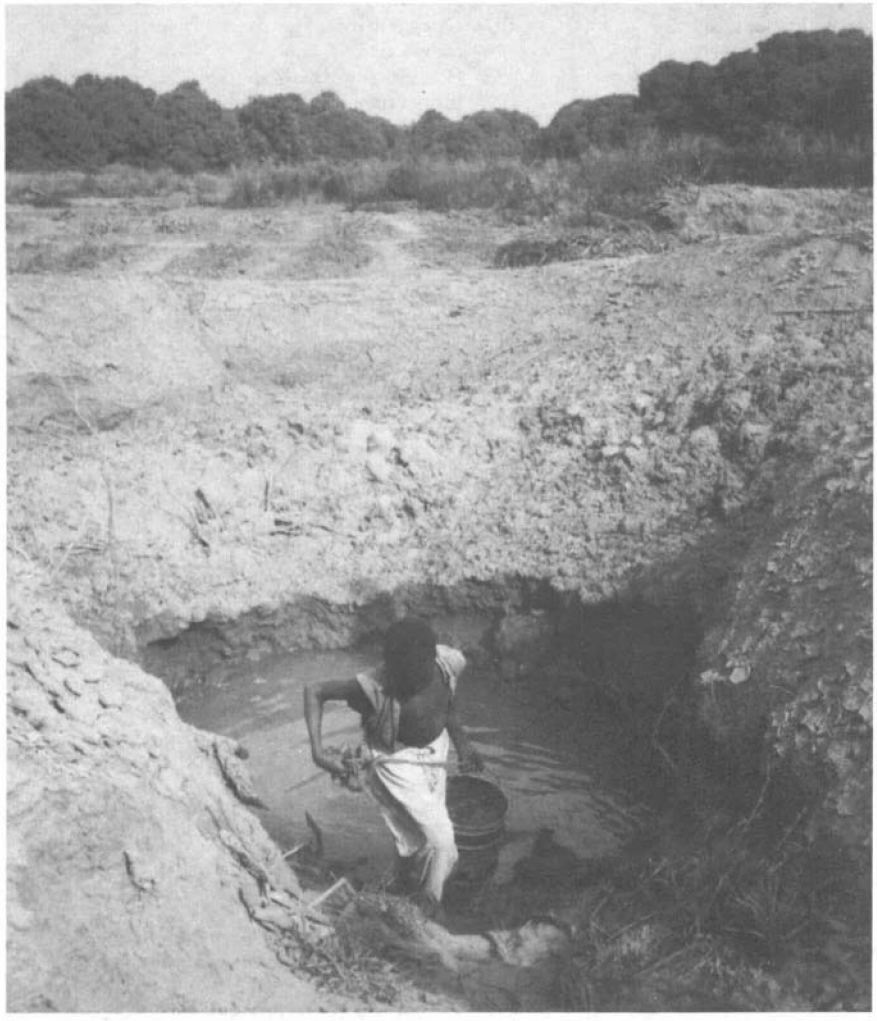
by Jonathan Naugle

A revolution in the design and installation of shallow garden wells has meant efficient and affordable irrigation for dry season gardeners in Niger.

NIGER IS A Sahelian country with a population of about 8.1 million people. The northern three-quarters of the country lie within the Sahara Desert, where annual rainfall is less than 200mm. Three-quarters of the population live in the southern tenth of the country, a zone with an annual rainfall ranging from 500 to 800mm. Subsistence farming is the primary activity for the rural population in this zone.

Niger has suffered from declining rainfall and recurring drought over the past 30 years. Severe droughts were experienced in 1968-73 and 1983-4, when crop failures were virtually country-wide. In other years there have been regional crop failures, caused either by insufficient total rainfall during the growing season, or poorly timed rainfall patterns. Regions often experience from three to six weeks without any rainfall during the growing season, and this can spell disaster for the crop.

Because of the frequency of these localized or widespread crop failures, many rural people have turned to dry season gardening as a hedge against disaster. Lutheran World Relief (LWR) started working with gardeners in Niger in 1978, and since then has been actively involved in developing methods to provide gardeners with adequate irrigation water at an affordable cost.



A traditional well occupies a large area of the garden, because the sides are continually collapsing and eroding.

Since the 1983-4 drought the Government of Niger has been promoting dry season gardening through the agricultural extension service.

Concrete ring wells

In many of the suitable gardening areas of Niger there is abundant water less than 10m from the surface, but traditional hand-dug, unlined wells need to be large in diameter with long sloping sides to prevent them from collapsing in the unstable sandy soils. Traditionally, some of these wells were lined with tree branches, but because of the increasing scarcity of this resource, the government has placed severe restrictions on the cutting of live wood. In addition, these wells cannot penetrate very far into the aquifer, resulting in a low recharge capacity.

The prevailing system of improved hand-dug wells in 1978 was a capital-intensive system designed for deep village wells of more than 20m. This system used several specialized teams of well-diggers and required mechanized lifting equipment to lower precast concrete rings into the well. Needless to say, the resulting well was extremely expensive, about US$1000/m, and while suitable for deep wells, it was over-engineered for shallow garden wells and not cost effective. These wells were beyond the financial means of gardeners in Niger. Recognizing a need for a more affordable yet durable well for irrigation, LWR began the development of a low-cost reinforced concrete ring well. Several years of testing and modification resulted in the now nationally accepted LWR or PMB (Puits Maraîcher en Béton) well, which is the standard for gardening projects throughout Niger. The advantages of the system are its low cost (about $80/m), simplicity, and transportability. The LWR system does not require mechanical lifting devices, since the forms are lightweight and the reinforced concrete rings are cast in place and do not need to be lowered into the well. The overall system is relatively simple and can be mastered by village-level well-diggers after several weeks of training. At last count LWR had constructed more than 3000 of these wells throughout Niger, and at least that many have been constructed by other organizations which have adopted the method.

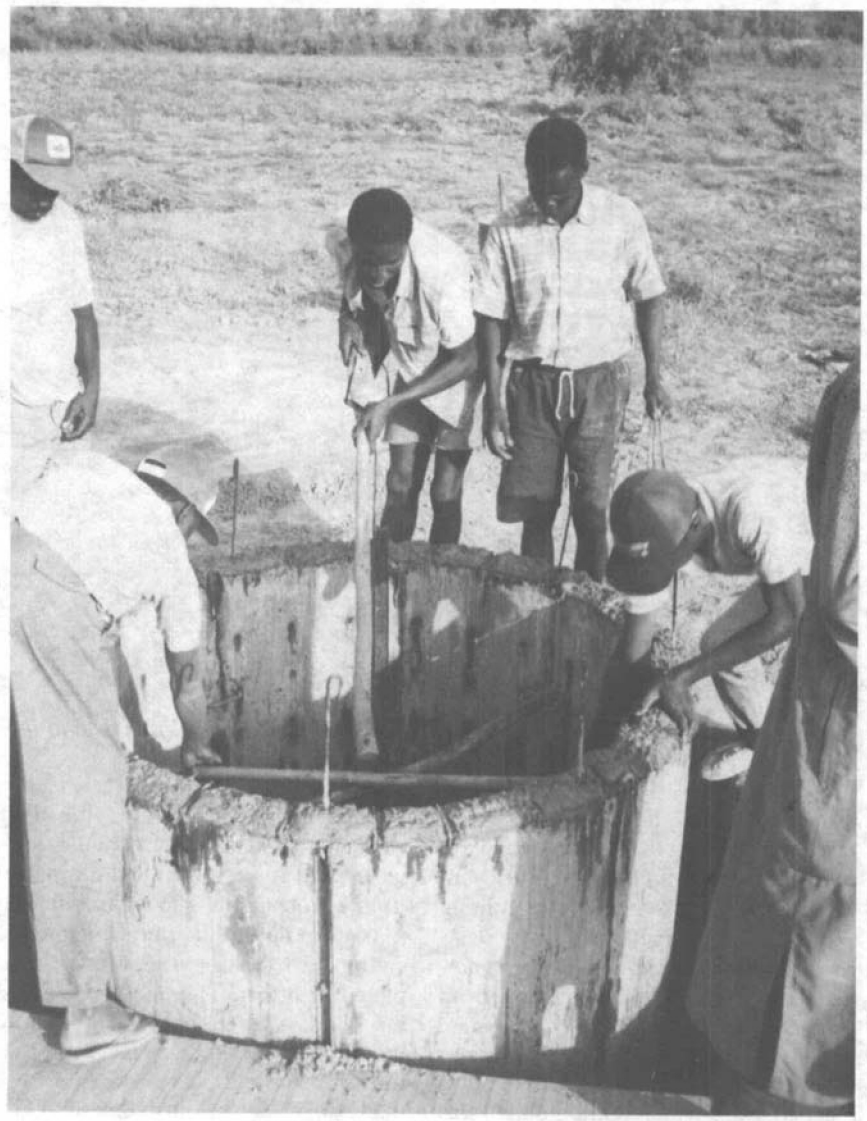
Dissemination

The original idea behind the introduction of this less-expensive system of permanent wells was to enable gardeners to build improved wells themselves, thus eliminating the need to redig traditional wells annually while reducing the pressure on the local forest resource. Initially, LWR projects introduced the method to a region by training local well-diggers, who then constructed 20-100 wells during the project. The forms and necessary hand-tools were then left in the village to be used for further construction. Unfortunately, with a few notable exceptions, the construction of individual wells stopped at the end of the project. It became obvious that the average gardener would not be able to save enough money to construct his or her own well without a system of rural credit.

The design of the LWR projects was then modified so that individuals had only to contribute 50 per cent of the cost of the materials to a village-controlled fund. This fund could later be used to provide credit for future well construction after the end of the project. The reimbursement rates for projects of this nature have been disappointing, with the best projects having reimbursement rates of less than 40 per cent of the required amount, or 20 per cent of the actual cost of the materials for the wells.

Gardeners insist that their priorities are wells and seeds. Why then are they so reluctant to pay for a well? When one considers the nature of gardening in Niger, the answer becomes clearer. In many places gardening is only a way of reducing the negative impact of a poor rainy season on the individual family's food supply, and as such is practiced more in years of drought than in years of abundant harvest. There are some regions which are exceptions: in these regions there is either a market for a speciality crop such as onions or hot peppers, or a nearby urban market for fresh vegetables. If the average annual per capita income in rural areas of less than $100 is considered, it can be seen that a well that costs almost this amount per metre and is not used primarily as an income-generating device will not be affordable.

Although the wells are technologically appropriate, and cost less than a tenth of the cost of the alternative type of concrete well, they still cost more than the average gardener is willing to pay. This means that without the intervention of outside funding the wells have little or no chance of being constructed privately, except by wealthier market gardeners. In 1987 LWR began to seek a less expensive means of providing irrigation water, something that would be affordable to the average gardener in Niger.



Introduced by LWR in 1978, the concrete ring well under construction here is now the standard for gardening projects in Niger.

Lower cost option?

It was noticed at the time that PVC well-casing was available in limited quantities in local markets. This material often consisted of sun-damaged or broken rejects from village water supply projects. While unacceptable for deep wells, it seemed likely that the undamaged sections could be salvaged for shallow garden wells. Once this source of appropriate material for lining wells was located, the next step was to find a simple way to install the pipe. Frustrated by the lack of references available in Niger, the 'wheel' was reinvented; it was different in some ways from those which have gone before, but similar to work done in other parts of the world. A brief history of the development of the system, including some of the dead ends that were tried and rejected, is presented in the following paragraphs.

The construction of the initial hand-augered well began with the augering of an 18cm-diameter hole as deep as

Hand-augering continues inside the PVC casing after the watertable has been reached.

Women are happy with the hand-augered wells: their gardens prosper and their children are safe.

possible, until unstable soil was reached. When the hole began to collapse a casing consisting of 1.5m lengths of 16cm-diameter steel tubing was installed. Augering continued inside the steel casing using a 15cm-diameter auger. As soil was removed from the inside, the casing descended under its own weight. This system worked well until the water table was reached, after which point a bailer was used to remove the soil and water as a slurry, and the casing continued to descend. Depths of 3m below the water table were obtained with this method, but more than that was not possible because of the rapid entry of water into the casing. When the steel casing refused to descend further, a 14cm-diameter PVC well-casing was placed inside it. The lower portion of the PVC asing was slotted and covered with a nylon filter cloth to prevent the entry of fine sand into the well, and the end of the PVC pipe was capped with a pointed metal cap. After the PVC casing was in place, hydraulic jacks were used to jack the steel casing out of the hole. This procedure initially took three days, but after some modifications a 10m-deep well was completed in a day. This method worked, but handling steel casing and jacking it out of the hole was tiring and time-consuming, so a decision was made to try direct installation of the PVC well-casing.

Direct installation

By going to direct installation of the PVC casing, some problems were eliminated but others were encountered. No longer was the tiresome task of handling steel pipe a problem, but the standard 3m-long lengths of PVC casing made drilling inside the casing difficult. Several different working platforms were tried, including a specially built tower, an ox cart, and a vehicle, but working several metres above the ground was found to be difficult and, more importantly, unsafe. The first solution to this problem was to make 1.5m-long sections of PVC casing with bell joints. The bell joints were made by heating the PVC pipe in hot oil and inserting another piece of pipe into the softened end to form the bell. These short sections made it possible to work at ground level or on top of two empty 200-litre drums. About 50 wells were installed using this method, and although most are still functional, several failures of glued joints have been encountered. At about that time the supply of used pipe in the market began to dwindle and new pipe was ordered from Abidjan in the Ivory Coast. The new pipe was ordered pre-cut and threaded in 1.5m lengths. This proved to be a major improvement in the installation procedure, although the new pipe was almost four times more expensive than used pipe.

Another problem associated with the direct installation of PVC casing was how to close the open bottom end, which previously had been plugged with a metal cap. In areas where the bottom of the casing can be embedded in a clay layer the open bottom end can be effectively sealed. In areas where this is not possible, fine sand has got into the casing. This problem has been solved by placing a small sack of filter cloth in the lowest 30cm of the completed well.

Direct installation of the PVC casing has proven to be faster and easier than the earlier method of sinking a steel casing first. The procedure is similar to that used to install the steel casing and is fully described in a manual entitled *Hand-Augered Garden Wells* (published by Lutheran World Relief/ Niger and available directly from them). Currently, a well extending 4 or 5m below the water table with a total depth of 10 to 12m can be installed in less than five hours in sandy soils. The

The hand-augered well coupled with a 3000-year-old technology, the shadaif, *results in a hybrid system that can raise about 60 litres per minute.*

cost of the well is essentially the cost of the PVC casing, which in Niger costs about $15/m. Labour costs amount to one day's wages for two well-drillers, or about $15.

A variety of augers have been built locally and each is suited to different soil conditions. The fabrication of the tools requires a skilled welder but no precise machining. The materials needed are locally available, namely: galvanized-steel pipe, square steel tubing, sheet steel, and reinforcing rod. A set of augers can be made for a total cost of about $200. Several of the sets have been used to construct more than 50 wells each with only minor repairs being necessary.

The hand-augered well is adaptable to a variety of methods of drawing water including a bailer, a handpump, and a motor pump. The simplest method is the bailer, which has been used successfully by gardeners for small plots. The bailer is made from a 110mm-diameter PVC thin-wall pipe and is 830mm long with a capacity of 7.5 litres. The advantage of the bailer is that it is simple and can be manufactured in the village. But once garden size increases beyond about 0.1ha it becomes impractical.

Water lifting

Currently field trials are underway using a 2m-long bailer supported by a lifting frame and raised with a winch. Another system is also being tested which raises the long bailer using a *shadouf*. The long bailer has a capacity of 18 litres but retains the simplicity of the smaller one. A locally manufactured lift pump has been used on several wells with good results. The flow rate from a 6m-deep well was measured to be 60 litre/min or 3.6m^3/hr. The frequently encountered problems with the lack of maintenance of handpumps in rural areas of Niger have made LWR reluctant to pursue this option for the majority of the wells constructed for subsistence gardeners. Recent tests using a motor pump indicated that flow rates of 150 litre/min or 9m^3/hr are possible from a 7m-deep well. The combination of a hand-augered well and a motor pump may be a viable alternative for commercial gardeners producing high-value cash crops, while more labour-intensive water lifting methods will be more appropriate for the subsistence gardener producing food to feed his or her family. Further research is needed to find affordable water-lifting devices which are able to supply irrigation water from depths of 8 to 15m.

This system combines low-cost tools ($200), rapid installation (1 day), and low cost installation (<$20/m),and has the potential to provide irrigation water to gardeners at a price they can afford.

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Jonathan Naugle is a Project Officer/Technology Specialist with Lutheran World Relief, B.P. 11.624 Niamey, Niger.

This 2m-long bailer and winch can lift 18 litres at a time, or 40 litres per minute.