

Lime — the great sealer: constructing low-cost, sub-surface rainwater tanks in Brazil

by Joao Gnadlinger

An extremely dry climate is hard enough to contend with; add to that little or no access to the existing water sources, and you have a recipe for desperation. A Brazilian NGO is promoting a neglected technology, and telling people about the possibilities for fundamental change.

About 12 per cent of Brazil is semi-arid land, most of which is covered with tree and shrub vegetation — *caatinga*. This dry zone in the north-east, which encompasses a total area of nearly one million km², and is home to 17 million people, has an annual rainfall of less than 1000mm; in the central section, this figure drops to below 500mm (see Figure 1).

The current government focus in the region is on big irrigation projects on the Sao Francisco river, which employ the local people as day labourers. The bulk of the land with easy access to water from rivers or wells is occupied by irrigation farmers or cattle-breeders, so most of the peasants in this region have problems obtaining sufficient water for the dry season. This — along with endemic social and political dependence and exploitation — has resulted in widespread migration to urban areas.

Working with the environmental conditions

The Regional Institute for Appropriate Smallholder Farming (IRPAA), an NGO based in Juazeiro, Bahai — right in the centre of the semi-arid region — puts the water-supply needs of the rural population in a wider context. IRPAA works to promote wider understanding of the north-east, not as a drought-afflicted disaster area — as it is usually described — but as a viable area in which to live and work, by using the existing rainfall, groundwater, and other natural resources in a sustainable way.

Three areas of IRPAA's ongoing work are of special interest to the local people:

- How to conserve water and how to cope during the six to eight month-dry season;
- how to raise small farm animals — especially goats and sheep which are

well adapted to a semi-arid climate and *caatinga* vegetation — and how to feed them throughout the dry season; and

- how to avoid soil erosion and grow crops which are appropriate for dry climates.

Conserving water for the dry season

The water problem can only be addressed successfully if the local community participates fully, and if all the available kinds of water supply (ground, surface, and rainwater) are used. The essential requirements are:

- Drinking-water for every family (supplied by cisterns, shallow wells, etc.);
- community water for washing, bathing, and for animals (supplied by

ponds, rock cisterns, shallow wells, etc.); and

- emergency water for drought years (supplied by deep wells and small dams).

Several different techniques are being used to resolve Bahai's drinking-water problem; this article looks in detail at low-cost sub-surface rainwater tanks, constructed with bricks and lime mortar.

Brick and lime-mortar cisterns

The Portuguese brought the technique of using lime to Brazil in the sixteenth century, and it was still in common use until about thirty years ago, when it was superseded by cement.

The brick lime-mortar cistern being constructed in the IRPAA project is a cylindrical underground tank with a semi-circular bottom. The shape of the cistern can best be described as looking like the 'bigger half of an eggshell' and it is important to dig out this shape to facilitate the construction of the wall. The plummet is needed when the cylindrical part of the hole is dug.

The size of the cistern depends on the particular water needs of each family. Assuming that the typical adult

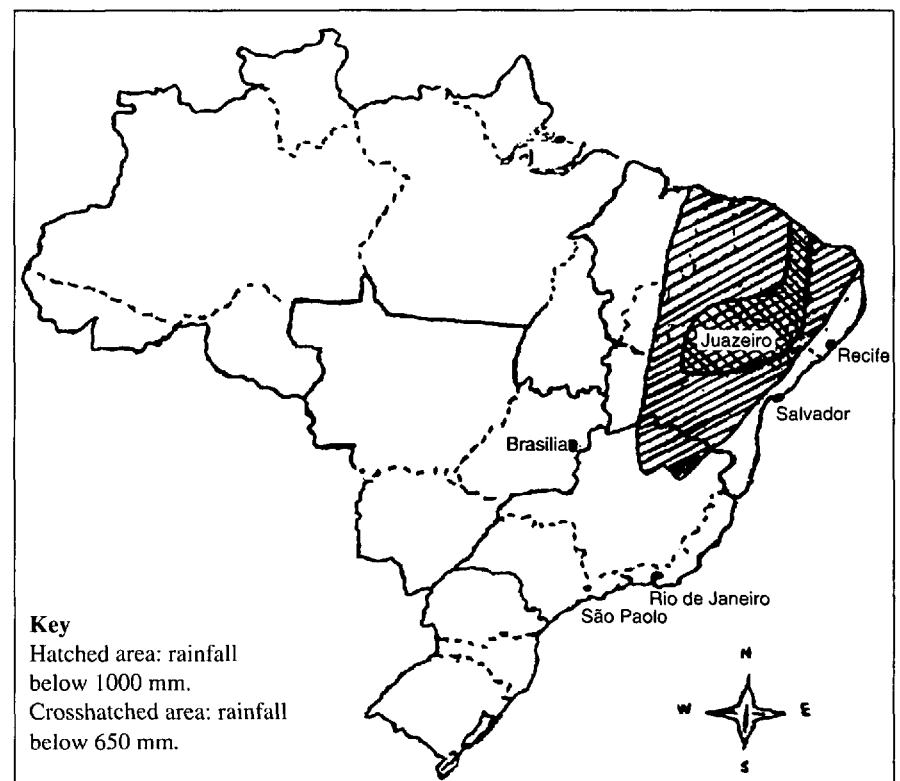


Figure 1. The semi-arid region of north-east Brazil, showing the city of Juazeiro.



Given the people of Bahia's dependency on seasonal employment, this labour-intensive method is not a problem.

requires 14 litres of water a day, over the eight months of the dry season, each person will use 3360 litres. To work out the optimum size of the tank needed, therefore, one should multiply the total number of the people in the house by 3360. For example, a family of six needs 20 160 litres of water ($3360 \times 6 = 20\ 160$). To ensure that the catchment area is big enough, one must calculate the probable runoff from the roof.

The construction materials consist of lime and burnt-loam bricks (measuring 20cm x 10cm x 5cm) — usually manufactured locally — and sand (see Table 1).

Working with lime

Bricklayers still know how to work with lime, and in several regions of north-east Brazil, limestone is still burned in community-owned lime kilns, and lime powder is widely available. For cistern construction, the lime powder is mixed with well-graded angular sand (which contains a little clay): three 18-litre cans of sand to one 18-litre can of lime powder (a ratio of 3:1). Before this, both the lime powder and the sand must be sifted; the mortar then has to be sifted well, and water added. The mortar must then be beaten with a wooden stick for 30 minutes, and the mortar mixed again. The whole

process should be repeated three times to ensure that no small lumps of lime remain. Then the mortar is left to cure for at least three days before use.

Building the cistern

1. Construct a 20cm-thick cistern wall. You must begin the wall in the middle of the semi-circular bottom,

otherwise, the wall will not be capable of supporting the weight of the water. For this reason, you must not build the wall more than 0.5m above the ground. NB When raising the wall, do not use a plummet (as in cement construction), because the bricks must be pressed to the earth-wall.

Table 1. Materials used to construct a brick and lime-mortar cistern

Family size	Water for 8-month dry season (litres)	Cistern diameter (metres)	Cistern depth (litres)	Number of bricks	Lime powder (18-litre cans)	Quicklime (18-litre cans)
3	10 080	3.2	2.6	3500	55	16
4	13 440	3.4	2.8	4200	70	21
5	16 800	3.8	2.9	5000	87	26
6	20 160	4.1	3	6000	107	31
7	23 520	4.2	3.2	7000	122	36
8	26 880	4.6	3.3	8000	140	42

Note: It is interesting to make a price comparison (values from 15 July 1995, at Juazeiro): For a cistern of 20 000 litres you need either: 31 cans of quicklime at US\$1.80 per can = US\$55.80; or: 105 cans of lime powder at US\$0.70 per can = US\$73.50; or: 18 bags of cement (US\$7.80 per bag) = US\$ 140.40.

2. When you come to the cylindrical part of the cistern, lay the bricks in alternating rows lengthwise and crosswise, leaning against the soil;

3. Leave the wall to dry for two months before you plaster the cistern.

This traditional Brazilian method is relatively easy to learn, but labour-intensive (not a problem in Bahia's dry season, however, when many peasants need work). And this method has one

Why choose lime?

Despite its declining popularity, lime is often preferable to cement!

- As a building material, lime requires less energy (to manufacture);
- lime is still fabricated and sold by small rural communities — not by international companies;
- lime is cheaper (by between 30 and 50 per cent);
- expensive materials like steel and wire are unnecessary;
- lime-mortar takes longer to dry than cement-mortar; so one does not need to hurry during the construction of a cistern;
- lime is more elastic and, unlike cement, does not crack easily;
- lime cisterns are easier to repair than cement-cisterns; and
- using lime, local communities retain control, and are responsible for both construction and subsequent maintenance.

major advantage for semi-arid regions: very little water is needed.

Using slaked lime

There is another way to work with lime, a method popularized in Europe. It is less labour-intensive, but more water is needed. In this case, quick-lime — burned in some rural communities — has to be slaked in an empty metal oil barrel and then run through a sieve (to remove any unslaked lumps) into a pit or a tank, where it is allowed to settle fully for at least four weeks. Slaked lime will keep indefinitely if covered with water. After four weeks, you can use the slaked lime to build cisterns. Make this mortar using a sand/lime ratio of 4:1, and use it as

described in the first method. If some lumps remain in the slaked lime, beat the mortar at least once.

Using lime without additives does not make the cistern waterproof because of the capillary absorption of lime and bricks.¹

Plastering the cistern from inside

To make the cistern waterproof, we successfully applied an impervious and semi-flexible coating based on acrylic modifiers, available on the Brazilian market, but too expensive for low-income communities. In the past, Brazilians used whale oil, but it is no longer available. We experimented

with castor oil, soybean oil, and the juice from the leaves of a cactus common in north-east Brazil (*Opuntia spp.*), but none proved satisfactory.

We also used a thin layer of cement-slurry spread over the plaster of lime-mortar for waterproofing. We plastered the cistern inside 1 to 1.5cm thick with lime-mortar (sand/lime ratio 4:1) by adding 5 per cent cement (by weight) to the lime. It was left to dry for two months; then we brushed on a layer of cement-slurry above the lime plaster. This resulted in a waterproof cistern. You must wet the plaster before applying the cement-slurry; keep it wet for a few days afterwards; and you must cover the cistern to avoid cracks.

A faster way of doing it is to use the cement-slurry together with the lime plaster. We plastered the cistern with a 0.5 to 1cm-thick layer of lime-mortar (sand/lime ratio 4:1, with 5 per cent of cement by weight as above). Then we added a layer of cement-slurry with a brush. Above the cement-slurry we added another 0.5 to 1cm-thick layer of lime-mortar. You must moisten the plaster every other day, and keep the cistern covered. Once the plaster has been left to dry for two months, you have a waterproof tank. IRPAA recommends this last method because the cistern is waterproofed effectively, and

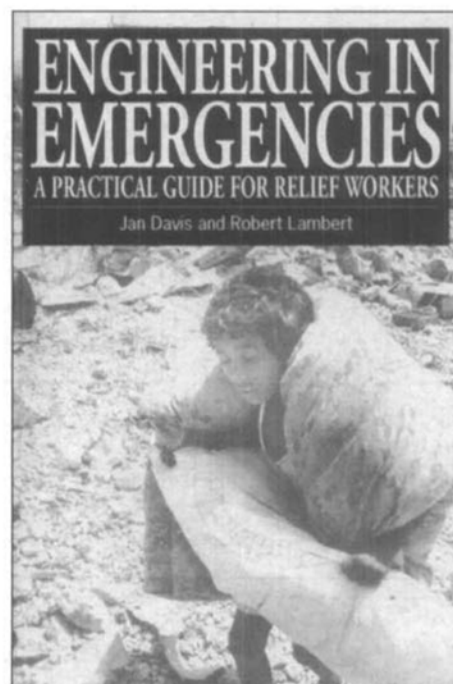
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However efficient the technologies, water-supply problems can only be tackled in the long-term if communities are fully aware of the benefits of storing rainwater in the dry season.

the cost of the small amount of cement needed is comparatively low.

Covering the cistern

Cover the cistern before it is plastered inside. A low rectangular house, with

that accumulates on the main roof. People with enough wood at their disposal cover the cistern with timber boards. The gutters and downpipes that channel the rainwater from the house and from the cistern roof are usually made of pvc tubing or zinc sheets but,

sometimes, people construct gutters out of sisal stems, palm-trees, and empty tin cans.

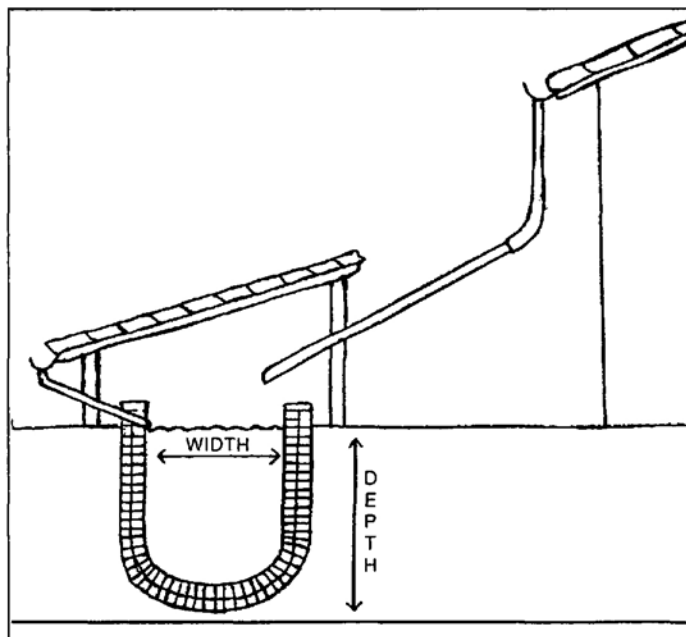


Figure 2. Side view of brick and lime-mortar cistern with family house.

walls made of lime-mortar and bricks, and a roof covered with laths and tiles, is particularly suitable, as it allows you to harvest the rainwater from the single-pitch roof in addition to the water

The advantage of this particular design is that the cistern is shut tight and the water remains clean throughout its storage period.

Cheap and sustainable

Brick and lime-mortar cisterns are popular in north-east Brazil, because lime is cheaper than other construction materials such as cement, and the technical know-how can be managed by the rural people. Most of the building materials are locally available, and members of the community participate fully — both in obtaining construction materials, and in providing labour. In this way, the need for external financial investment is reduced. Some communities are now constructing brick and lime-mortar cisterns independently, following a training workshop conducted for members of the rural workers' labour union. Before the problems of supplying clean water in rural areas are fully resolved, however, there must be much greater progress in making people aware of the benefits of storing rainwater in the dry season.

References

I. Santiago, C.C., and de Oliveira, M.M., 'Organic additives in Brazilian lime mortars', in Hill, N. *et al.* (ed.), *Lime and Other Alternative Cements*, IT Publications, London, 1992.

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