Catching up — upgrading Botswana's rainwater catchment systems

by John Gould

The word 'upgrade' might not conjure up images of radical change – but the most effective designs often result from applying innovative ideas and approaches to age-old systems. This is happening in Botswana, where the proof can be seen in rainwater catchment replication in homes, farms and schools.

THE DEVELOPMENT OF rainwater catchment systems in Botswana has been an evolutionary process, with ideas for new designs being introduced, field-tested, modified and improved over many years. Many designs fail to catch on, but a few successful ones stand the test of time and are replicated, often in a form quite different from the original concept. Even after thorough field-testing, the only real proof of the worth of any new design or approach is whether the resulting systems can be replicated successfully and function effectively for most of their design life. Consequently, judging the success of any project or new technology can be a very long process, and often requires anything from a five to a 20-year perspective.

Botswana: climate and water resources

Botswana is a land-locked country straddling the tropic of Capricorn in southern Africa. The climate is semi-arid, with mean annual rainfall varying from under 250mm in the extreme south-west, to more than 650mm in the north-east (see Figure 1). Rainfall is highly erratic and, normally, limited to the wet season between October and April. Evaporation rates are high throughout the country, exceeding 2000mm/yr in many areas. As a result, water is a scarce and precious resource. Groundwater sources are limited, and often saline, and opportunities for developing surface-water resources are few and far between. The growing human and economic demand for water is putting considerable pressure on Botswana's limited water resources.

Most of the effort and resources for improving water supplies has been directed to the rapidly growing urban areas, and larger villages with populations of 500 and above. Smaller settlements and remote homesteads are difficult and costly to service with conventional technologies and it is here that rainwater catchment systems have the greatest potential.

Development of rainwater catchment systems

Traditionally, people have collected rainwater running off ground surfaces in excavated pits, and from the eaves of thatched roofs in pots and other small containers; to a degree, this practice survives today. The use of more formalized rainwater catchment systems such as roof catchment tanks dates back to the turn of the century, and many older buildings had rainwater tanks included in their original design; at Nata Primary School, tanks built in the 1940s are still in use.

ALDEP water-tank project

A number of current and proposed designs for rainwater catchment systems in rural Botswana which can be traced back to earlier models and traditional technologies which originate from both within and outside the country. The origin of the widely used ALDEP (Arable Lands Development Programme) tank designs date back to somewhere between 1966 and 1981.[1] The approach stems from the use of traditional excavated pits for collecting surface runoff to supply water for both cattle and human consumption.

The first documented development and upgrading of ground catchment systems in Botswana was the pioneering work of Vernon Gibberd and others in the mid- to late-1960s. This was based on the widely publicized polythene-filled, soil-cement, 'sausage-shaped' blocks used both to line the excavated sub-surface tanks and build 'beehive' structures within them.[2] This technology was developed in Sudan by Ionides, who traced the original idea back to the ancient Babylonian irrigation and water-supply systems in Iraq and Jordan which he had worked on in the 1920s and 1930s.[3]

Another important influence on the subsequent development of the design

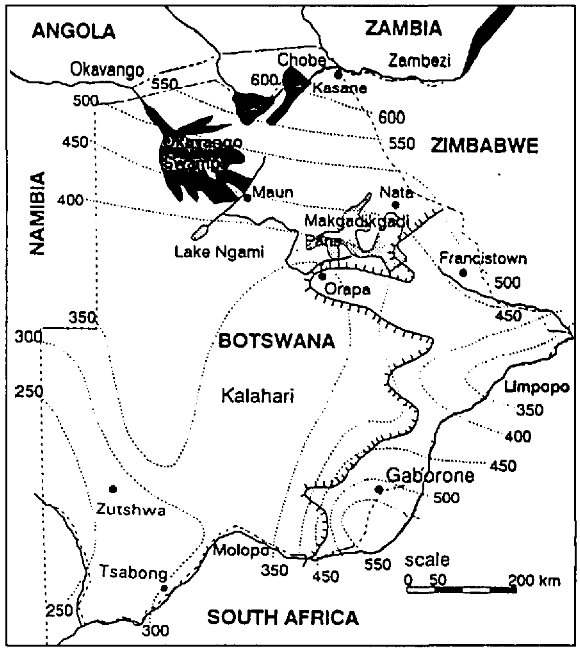

Figure 1. Map of Botswana showing rainfall isohyets.

was a local farmer's simple ground-catchment system which he constructed using a traditional threshing floor as a catchment apron, and an excavated pit as a tank. This design was subsequently upgraded by incorporating a $10m^3$ ferrocement and brick sub-surface tank design. The project offered eligible small farmers in remote areas a water-tank and catchment subsidy covering 85 per cent of the cost; between 1979 and 1991 more than 700 ALDEP ground tanks were built.

By the late 1980s, growing concerns over water quality led to a new ALDEP design; this consisted of a $40m^2$ corrugated-iron roof structure, and either a $7m^3$ PVC surface tank or $10m^3$ ferrocement or brick sub-surface tank. Since early 1991, around 300 of these systems have been installed, bringing the total number of tanks built under the scheme to more than 1000. But despite

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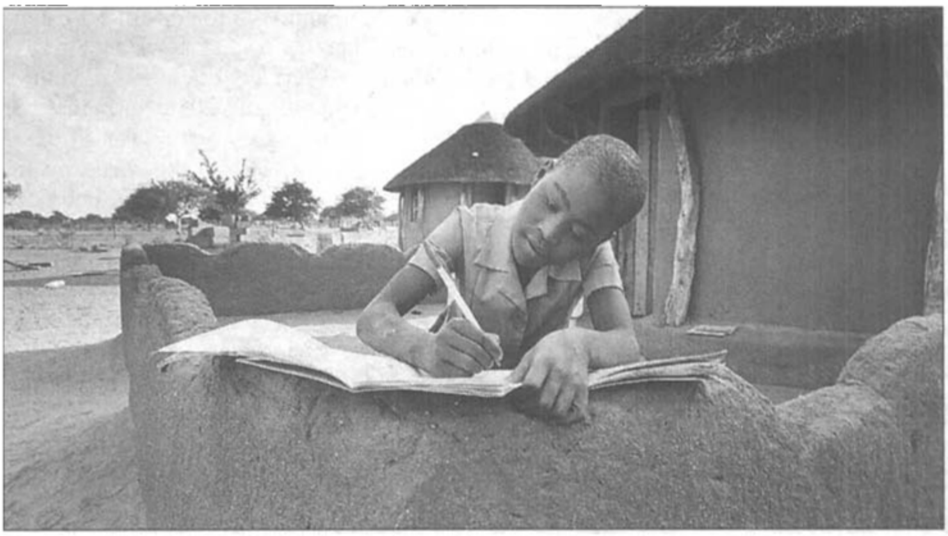
this generous assistance, some farmers find the 15 per cent down-payment — in cash terms averaging around US$200 (P800, the cost of a calf) — too costly and the project remains under-subscribed. Another problem is that the 40m^2 roof catchment is simply too small to collect sufficient rainwater to meet the average family's requirements.

A 1994-5 field survey revealed that the mean daily domestic water consumption amongst the ALDEP rainwater-tank owning households was 107 litres. A computer model and past rainfall data estimates of the mean annual yields from the 40m^2 ALDEP roof structures with 7 to 10m^3 of tank storage indicated that these systems could only provide between a third and a half of the average household's water demand. Clearly, these systems were not being used as a direct substitute for traditional sources and distant boreholes, but mainly as a supplementary source.



Bruce Paton/Panos Pictures

Doing homework in Mahalapye. Pupils and teachers in Botswana's schools stand to benefit immensely from improved rainwater catchment equipment.

Proposed combined roof-and-ground catchment system

Based on the findings of the field survey, and using the computer model as a design tool, a modified design for the ALDEP system was developed. In this design — illustrated in Figure 2 — the existing 40m^2 roof would be equipped with a 5m^3 surface tank and an additional ground-catchment system (similar to the original ALDEP designs) would be used; this would consist of a 100+m^2 ground catchment apron and a 15m^3 ferrocement or brick sub-surface tank. This combination should enable a rural houschold to collect between 20 000 and 50 000 litres of water in an average year (between 55 and 135 litres per day) in the driest and wettest part of the country, respectively. This is sufficient for most of a family's domestic water needs, and works out at between $2 to $5 per cubic metre, depending on location, and assuming a 20-year system life expectancy.

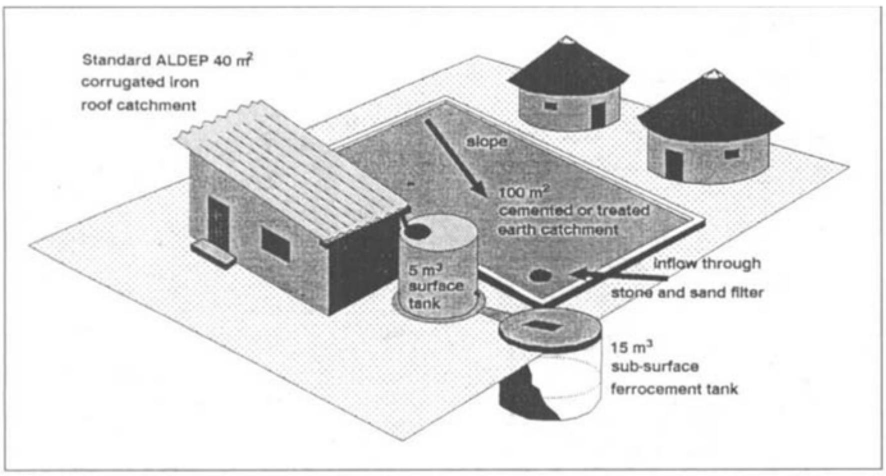


Figure 2. ALDEP's combined roof and ground catchment system proposal.

In the proposed combined roof-and-ground catchment system, the roof runoff stored in a surface tank should be used for 'higher quality' uses, particularly for drinking- and cooking water (treated if necessary); whereas the surface runoff stored in a sub-surface tank should be used for washing, cleaning, and watering animals or plants. In order to be workable, the dual scheme would probably need to be offered as a two-part Government-sponsored grant/down-payment package; the first half might enable the provision of a 40m^2 roof and 5m^3 surface tank. The second part of the package would allow for the construction of a 15m^3 ferrocement or brick sub-surface tank to which the householders would add a 100+m^2 ground catchment system. Householders should also be encouraged to upgrade the roof-catchment structure into an improved dwelling by adding walls, windows and doors as shown in Figure 2 above.

Upgrading school systems

Roof catchment tanks are a common sight at village primary schools throughout Botswana. A survey conducted by the Botswana Technology Centre in 1991 revealed that about half of the country's 800+ primary schools possessed rainwater tanks. Most were constructed from corrugated iron, and since these have an average life expectancy of five years or less, many schools had leaking or defunct tanks. The survey also found that, despite having average roof areas of around 1300m^2, with a mean annual roof runoff of 495m^3, the average, total, effective tank-storage volume was just 12m^3. Yet, despite the poor performance of their roof-catchment equipment, the majority of schools in Botswana were keen to have more tanks.

Because corrugated iron tanks are small and do not last long, the Botswana Technology Centre has, since the early 1980s, encouraged the implementation of ferrocement rainwater tanks. Initially, these were based on a 1978 design advocated by Watt which involved the use of corrugated-iron moulds.[4] Around 150 tanks of this type were constructed, ranging in volume from 10 to 30m^3 but, as a result of poor workmanship and inadequate training and supervision, there were a variety of problems and only a minority of tanks have stood the test of time. Since 1994, however, a ferrocement-tank construction and training pilot project has been in operation; this is based on larger tanks with a capacity of up to 46m^3 and using a design originally developed in Kenya.[5]

Other important innovations being developed for use on long school roofs are V-shaped gutters and splash guards. The V-shaped gutter can be made on

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A new 46m³ ferrocement roof tank at a primary school near Kanye.

site from galvanized iron sheets, and the 200cm² gutter can cope with the large quantities of runoff much better than conventional gutters, especially when splash-guards — made from a strip of sheet steel attached and bent over the full length of the eave — ensure that all the runoff is diverted directly into the gutter.[6]

The installation of these large ferrocement tanks makes sense for schools purely as back-up, or for supplementary supplies. Disruptions in standpost supplies are common as a result of breakdowns or because boreholes dry up in drought periods. Rather than relying on expensive trucked water supplies or having to close the school, large rainwater tanks could provide teachers with an invaluable stopgap. One full 46m³ tank could provide 500 pupils and staff with three litres of water per day for at least 30 days, even in the dry season; and for longer periods during the rains.

Upgrading in the Kalahari

This innovative project, pioneered by the Rural Industries Innovation Centre (RIIC), is located in the small, remote bushman settlement of Zutshwa, home to approximately 250 people. The project consists of a natural ground catchment apron and sub-surface tanks constructed for utilizing rainwater runoff from the side of a pan. The salt pan is a natural, low-lying depression encircled by a low ridge, which fills with water after heavy rains. Traditionally, local people have excavated large pits in the pan's calcrete surface to capture and store this water, as a source for their livestock.

The rills and gullies leading down the relatively steep sides of the pan provided the evidence of surface runoff which led RIIC — in conjunction with the community — to construct a catchment apron to direct water towards three sub-surface brick tanks with a total volume of 205m³ (Figure 3, below). During its first season of operation, the tanks were full by mid-February and considerable losses were incurred due to overflows. Prior to the construction of the rainwater catchment system, water had been trucked in from Hukuntsi, 65km away, at a cost of around US$65/m³. At this price, the rainwater collected in the full tanks would be equivalent to $12 000.

At a total cost of $20 000[7] the justification for the construction of the system seems obvious. There is one problem: the water contains very fine particles which remain suspended indefinitely, giving the water a turbid, milky appearance. A number of methods for dealing with this, including the use of natural coagulants — are currently being considered. A year after the completion of the project, a pipeline was constructed from a borehole 10km away where a sophisticated reverse osmosis system was installed to remove dissolved salts. While this system has the potential to provide Zutshwa's three standposts with virtually unlimited clean water, many questions have been raised regarding the appropriateness and sustainability of such a comparatively high-technology

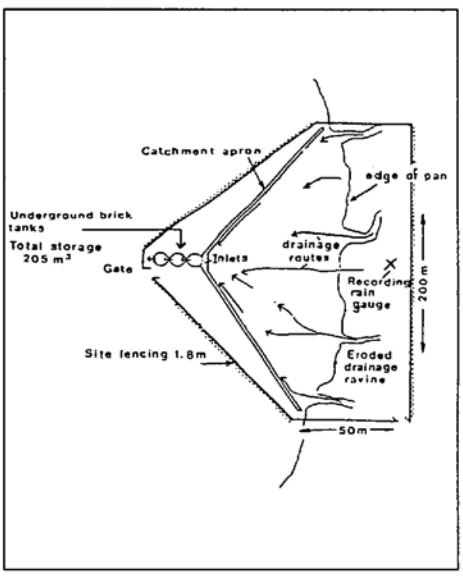

Figure 3. Plan of pan catchment system in Zutshwa, Botswana.

system. Indeed, when the author visited Zutshwa in July 1994, the standposts in the settlement were dry, as the diesel-pump had broken down for the second time since its inception; as a result, people were again forced to use rainwater as the only alternative source.

At the time of writing, in late 1996, the system at Zutshwa has been working successfully for three seasons, and Botswana's Ministry of Agriculture is attempting to replicate the technology elsewhere. Whether a top-down approach based on central planning, government funding and heavy machinery will work very effectively remains to be seen, but the initial signs are not promising.

Why upgrade?

Traditional technologies for water supply have evolved; they have been tried and tested over generations. As a rule, these technologies are in tune with local conditions and cultural traditions. So it makes sense to look at ways of upgrading and improving these, by seizing on new ideas and the use of modern materials and designs. This should result in the best of both worlds, exploiting the advantages of both the traditional and the modern.

The same argument applies to upgrading conventional technologies or approaches to water provision already familiar to the community. Ignoring tradition — whether in relation to technology choice, cultural preference or other aspects of water provision — may, in some cases turn out to be a costly mistake. Rural Botswana, like much of Africa, is littered with the rusting remains of inappropriate, modern water-supply technologies which have failed to stand the test of a rather short period of time.

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