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Rural Water Supply in Developing Countries

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Rural Water Supply in Developing Countries

Proceedings of a workshop on training held in Zomba, Malawi, 5–12 August 1980

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Contents

Rainwater Catchment in Botswana

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The Republic of Botswana, with an area of 561 800 km², lies at the centre of the Southern African Plateau, at a mean altitude of 1000 m above sea level. The climate is continental and semi-arid, with an average annual rainfall of 450 mm. The rainfall is erratic and unevenly distributed, ranging from 300 mm in the southwest to 700 mm in the northwest. Over 90 percent of the rain falls in the summer months between November and April, although some light rains occur as early as September. The country lacks perennial surface water, except in the northwest and a few springs, dams, and pools in the east. Mean maximum and minimum temperatures vary according to region, but the former seldom rises above 30° C and the latter seldom falls below 5° C.

About 84 percent of the land surface is covered with Kalahari sand, which supports low savanna-type vegetation. Rainfall is normally held in the top few metres and is largely lost through evaporation. Only 5 percent of Botswana has the combination of adequate rainfall and suitable soils necessary to provide for arable agriculture.

The population is estimated at 857 000, about 80 percent of whom live on the eastern side of the country, where there are suitable soils and sufficient rainfall to permit arable agriculture. About 15 percent of the population lives in towns and the remaining 85 percent lives in large villages, rangelands, and cattle posts. A peculiarity of life-style in Botswana is that most people have more than one home, i.e., the main village or town, where people reside from July to September; the rangeland area, where people reside from October to July; and in some cases, the cattle-posts area, where people stay for various lengths of time. This pattern of living makes it difficult to provide potable water to all the communities all the time.

One of the main constraints to productive arable agriculture is the lack of water, both for human consumption and animal watering, during the time prior to the main part of the rainy season. This causes plowing to begin late, which results in poor crop yield.

Rainwater Catchment Concept

Lack of water at the beginning of the rainy season has brought about the introduction of the rainwater catchment. It was felt that if water from the first light rains could be collected and stored, it could then be used for human consumption and draft-animal watering prior to the heavy rains; thus, plowing could begin earlier, resulting in a better crop yield.

Feasibility Studies

With cheaper alternative sources of water supply not available, the construction of rainwater cisterns becomes justified. This is particularly true at the beginning of the plowing season, when there are no other sources of water in many parts of Botswana.

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At Pelotshetlha, in the Southern District of Botswana, an integrated farming pilot project has engaged farmers in a new and alternative rainwater harvesting scheme. Advantage is taken of a traditional grain-threshing floor, which is used as a rainwater-collecting surface. The floor is surrounded by a low mud wall and is plastered with a mixture of clay and cow dung that provides a smooth, relatively hard surface. Plastering is done annually at the beginning of the crop-harvesting season.

These floors, which are common all over the country, slope gently toward one corner, where a small hole is usually made to allow the waste out. Under this pilot project, a shallow basin connected to a rainwater cistern by a short length of PVC pipe has been provided. This basin acts as both a collecting and sedimentation device.

The cistern is entirely underground, but has a brick curb to exclude surface runoff and to provide a bearing surface for a cover. In the initial cisterns, the cover was constructed of lengths of tree trunk. Because it is not easy to find long lengths of tree trunk, the width of these initial cisterns was restricted to 2 m. Also, because the surfaces of tree trunks are uneven, gaps occurred in the cover and permitted dust to enter the cisterns. This type of cover has, however, been found effective enough to provide shade against the sun and, thus, prevent algal growth in the water.

The cistern itself was waterproofed by a thin layer of cement plaster applied on a chicken-wire mesh that was pegged along the sides during plastering. The finishing plaster was smoothed over to render the surface waterproof. To date, no evidence of seepage loss has been noted.

Design and Construction Options

These initial rectangular cisterns have been criticized because the rectangular shape is structurally less strong due to differential stresses that will, in time, cause the plaster to crack at the corners and on the long sides, which are 8 m in the larger of the current cisterns. Also, the surface area to be plastered is about 25 times greater in a rectangular cistern than in a circular one of the same capacity. Thus, plastering costs are higher.

It is now recommended that circular tanks be used and that the rectangular ones be monitored to determine if they crack. If they do, they can be replastered and checked before the next rainy season. If the rectangular tanks fail, either they will be backfilled and circular tanks will be dug nearby, or an attempt will be made to convert them to an elliptical shape.

The roofing of circular tanks can take the form of precast concrete slabs incorporating a hole for drawing water in the same manner as for hand-dug protected wells. The slab can be cast in portions to facilitate handling, which can be eased through the use of pulleys. As tank size increases, the covering slab thickness will also increase. It can vary from 2 cm at the edge to 7.5 cm at the centre. The slab can be reinforced by five strands of barbed wire in the thick slabs and two strands in thinner ones.

Another alternative being tested is a domed cover, which is cast on a mound of earth that is carefully shaped and whose size is calculated to be larger than the outside diameter of the tank. The height of the centre of the dome varies with diameter (i.e., about 40 cm for a 10 m^3 tank and increasing to 1.5 m for a 25 m^3 tank). A well-shaped chicken-wire mesh is then pegged to the mound and plastered with cement mortar, which is then allowed to set for 5 days. In the case of domed covers, the hole for the dipping bucket should be toward the side so that people do not have to climb the dome to draw water. When the dome is set, it can be carefully lifted on poles and mounted on the tank.

Selection of Size

Table 1 gives the dimensions and estimated costs of four tanks ranging from 10–25 m^3 in capacity.

Operation and Maintenance

As mentioned earlier, the plastering of the traditional threshing floor is done annually

Table 1. Estimated costs (pula) of underground rainwater tanks of four different capacities (m^3). In all cases tank depth is 2 m.

	10 m^3		15 m^3		20 m^3		25 m^3	
	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Diameter (m)	2.52		3.09		3.57		3.99	
Floor area (m^2)	5		7.5		10.0		12.5	
Total plastered area (m^2)	20.8		26.9		32.4		37.5	
Man-days 1.27 m^2/day at P4.00/day	16	64	21	84	25	100	30	120
Supervised man-days (P12.5/day)	4	50	5	63	6	75	7	88
Cement bags (P2.84/bag)	7	20	9	26	11	31	13	37
Wire mesh (P1.44/m^2)	21	30	27	39	32	46	38	55
PVC inlet pipe		10		10		10		10
Contingencies, at 10% for transport		22		27		31		36
Transport of materials		50		50		50		50
Farm improvement grant		20		20		20		20
Total estimated cost		266		319		363		416
Cost per m^3 stored		26.6		21.3		18.2		16.6

Note: P1=U.S.$1.29.

at the beginning of the harvesting season. This is the only extensive maintenance required for the floor other than sweeping it time and again so that the first rain can find it clean and free from loose dust. The fact that the threshing floor will be used for collecting water means that all possible pollutants must be kept away from the floor.

Some silt will, obviously, be carried in the water and this may necessitate the provision of a simple slow-sand filter, which will require renewing of the filtering material once a year. By introducing a slow-sand filter the bacteriological content of the water will also be reduced.

The cistern will require cleaning before the beginning of the next rains. Plastering of the tank and cover may have to be done as cracks are noticed.

The entire unit must be fenced to prevent damage by livestock, particularly after the people return to their villages. The fencing itself is not a new innovation, nor is it expensive. It is common to have homesteads fenced with tree branches and gates blocked using newly cut branches at the end of the harvesting season.

Water must be drawn by bucket through the manhole and a trough should be available for watering livestock.

Water Quality

It has been feared that because the catchment area is plastered with a mixture of clay and cow dung, that nitrate and bacteriological pollution would be a serious problem. A sample taken from one of the existing tanks at Pelotshetlha showed a nitrate concentration of 1 ppm. The parameters tested were: nitrate 1 mg/litre; pH 7.2; conductivity 211 mmho; total dissolved solids 190 mg/litre; and chloride 8 mg/litre.

Further chemical and bacteriological tests of the water will be conducted, particularly because pathogens may also be found as a result of the use of cow dung. Such monitoring will be done while water from the previous rains is still in the tanks and also after the tanks have filled from the next rains.

Rainfall Analysis

Rainfall data for Pelotshetlha over the last 10 years were used to calculate the amount of water it should be possible to obtain with a catchment area of 150 m^2. Consumption figures of 20 litres per person per day for a community of 7 persons and 60 litres per ox per day for 6 oxen were used and the calculated water demand was 0.5 m^3 per day.

As mentioned earlier, the aim is to encourage early plowing by providing people and cattle with a safe water supply.

Today, people rely on water from pools. The oxen are often in poor health and as a result, when the first heavy rains come in November, plowing takes a long time.

Table 2 gives the amount of water that can be collected using water catchments and the earlier dates on which land preparation can begin as a result.

Table 2 indicates that an average of 17 days can be gained for land preparation before the start of plowing. (Normally, plowing begins with the first rainfall of >25 mm.) The following rainwater catchment data indicate the amount of rainfall it was possible to obtain in three different areas: Kanye: average, 8.0 m^3; 0–5 m^3, 4 years out of 19; 5–10 m^3, 10 years out of 19; > 10 m^3, 5 years out of 19. Mahalapye: average, 6.2 m^3; 0–5 m^3, 11 years out of 20; 5–10 m^3, 3 years out of 20; > 10 m^3, 6 years out of 20. Ghanzi: average, 3.4 m^3; 0–5 m^3, 15 years out of 20; 5–10 m^3, 4 years out of 20; >10 m^3, 1 year out of 20.

User Education

The experiments on rainwater catchment have been publicized in *Agrinews*, a bulletin

Table 2. Normal starting date for plowing vs. possible starting date of land preparation through the use of water catchments.

Normal starting date for plowing	Amount of water collected before plowing begins (m^3)	Possible starting date of land preparation with water catchment tank	Time gained (days)	Year
13 November	10.9	22 October	22	1971
7 November	5.6	7 November	0	1972
30 November	23.0	19 October	42	1973
18 November	9.0	5 November	13	1974
12 November	8.1	6 November	6	1975
7 November	19.9	14 October	24	1976
23 November	11.4	6 November	17	1977
29 November	13.7	6 November	23	1978
1 November	21.5	20 October	12	1979

of the Ministry of Agriculture. Agricultural demonstrators continuously take farmers in their areas of operation to Pelotshetlha to show them the rainwater catchment project run by the integrated farming pilot project. It is hoped that these measures, as well as others in the future, will prepare the farming community to accept and maintain these devices.

Today, the pilot project has about 10 underground tanks built and more are under construction. In all, it is hoped to have 80 completed by the end of 1980.

Conclusions

From rainfall statistics it is possible to state that in areas around Kanye and Mahalapye there is no need to construct tanks larger than 12–15 m^3. In the dry Ghanzi area, the tank volume can be reduced to 8 m^3. Before the heavy rains start in November, the average amount of rainwater it is possible to catch on a 150 m^2 threshing floor in these three areas is: Kanye, 8 m^3; Mahalapye, 6.2 m^3; and Ghanzi, 3.4 m^3.

Usually, the farmer is expecting enough rain for plowing in November and after the rain he takes his oxen out to the land. With the introduction of rainwater catchment tanks he can move with his family and oxen to the land 2–3 weeks earlier and be able to prepare for plowing so that he can start as soon as the rain comes.

In this way, the possibility exists that the farmer will be supplied with water during his entire stay at the land and when he comes back to the land for harvesting, his tank, in most cases, will again be filled with rainwater, which will last for a long time.

The quality of the water, although still not satisfactorily investigated, is a definite improvement over the water collected in pools, which is often contaminated by excreta from animals.