Table 3 Generalised values for rural household water needs and potential recycling

Water use/water need	Typical quantities needed	Quality required	Recyclable portion and quality
Domestic water – safe for drinking			
Potable (drinking, cooking, dish-washing)	7 ℓ per capita per day	Safe for drinking	60% (mainly from dishwashing)
Domestic water – good for cleaning purposes			
Domestic non-potable (washing self, cleaning house, laundry)	65 ℓ per capita per day	Clear water	70% (good for most raw water uses)
Water for production			
Vegetable gardening	Max 20 ℓ /m²/week (summer)	Raw water, but without toxins	0%
Fruit trees	Min 20 ℓ/tree/week		
Poultry	200 ml/adult chicken/day		
Small livestock	5 ℓ/adult goat/day (10% of bodyweight)		
Large livestock	40 ℓ /adult cow/day (double if lactating)		
Cement-block making	20 ℓ per 20 large blocks or 40 maxi-bricks	Raw water (but with no traces of sugar)	
(Adapted from WRC 2009)			

RAINWATER HARVESTING POSSIBILITIES IN DEEP RURAL VILLAGES IN THE AREA

Lubala village (31°11'33.83"S; 29°29'53.45"E) has been earmarked as the War on Poverty village for the Eastern Cape. The DWA, through Umhlaba CG (Pty) Ltd, is currently implementing limited rainwater harvesting interventions in Lubala as part of the War on Poverty. Currently, Lubala households depend on a spring; the yield of a recently drilled borehole was disappointing (ORTDM 2009b). Lubala will benefit from the proposed Qaukeni Bulk Water Regional Scheme only in Phase 10: Zone 4 Secondary Pipelines, and rainwater harvesting options could provide immediate relief in the interim. Localised rainwater harvesting could also help improve groundwater levels.

Figure 8 shows the context for rainwater harvesting: a mixture of traditional thatch and corrugated roofs, relatively large open areas between dwellings, and vast areas of undeveloped space. In undulating terrain like this, fetching water from a stream could typically require a 30-minute walk down steep slopes.

Table 4 Rainwater harvesting for differentiated quality needs of rural households in Lubala

	[a] Domestic water – safe for drinking (roof runoff)	[b] Domestic water –cleaning purposes (surface runoff)	[c] Water for production (surface runoff)
Inputs			
Water capture area (m²)	40	3 000	3 000
Storage capacity (m³)	10	20	20
Initial wetting loss (mm rain)	1	10	10
Capture efficiency (%)	85	25	25
Water per capita per day (ℓ/c/d)	10	23	–
Number of people per household	5	5	–
Garden area – summer (m²)	–	–	40
Garden area – winter (m²)	–	–	40
Effective rainfall (%)	–	–	50
Results			
Mean annual water harvested (m³)	18,4	42,3	40,7
Average number of empty tank days per year	1	0	1
Highest number of empty tank days in a year	31	9	20
Average of annual maximum consecutive dry tank days	0	0	0
Highest number of consecutive dry tank days	20	8	19
Dry periods in 1950–1999: Year [number of dry tank days]	1953 [31 d]	1956 [7 d] 1999 [9 d]	1953 [20 d]

Notes
A conservative 40 m² roof size was used. A typical RDP house has a 60 m² footprint.
Effective rainfall was set at 50% because in high rainfall areas, rain often falls on already wet garden beds.

⑨ Evidence of pre-existing awareness of rainwater harvesting in Lubala. Lack of suitable roofing can be an impediment to some types of rainwater harvesting (photo: M de Lange 2009)
⑩ Combining "deep trenching" and "run-on" rainwater harvesting for food security, MaTshepo Khumbane harvested one ton of food off 220 m² garden beds in winter 2002 (photo: M de Lange 2009)
⑪ Landscape water harvesting: concentration and storage of rainwater for food production (M Botha 2009)
⑫ Urban rainwater harvesting in public rights-of-way (City of Tucson 2005)
⑬ Public building example: water collection and storage locations (City of Tucson 2005)

Rainwater harvesting potential for Lubala village

On the assumption that the overall rainwater harvesting yield potential for a village is a function of the average annual rainfall and the footprint area of the village (at a minimum), we can calculate the overall rainfall utilisation (including all collection inefficiencies such as initial wetting losses before runoff forms, evaporation, deep percolation and overflows due to inadequate tank and landscape storage) required to match local water demand.

The demand scenario adopted in the Qaukeni Water Master Plan is that water consumption would start at 25 ℓ/c/d and gradually rise to 75 ℓ/c/d by 2038. Population growth of 0% was assumed.

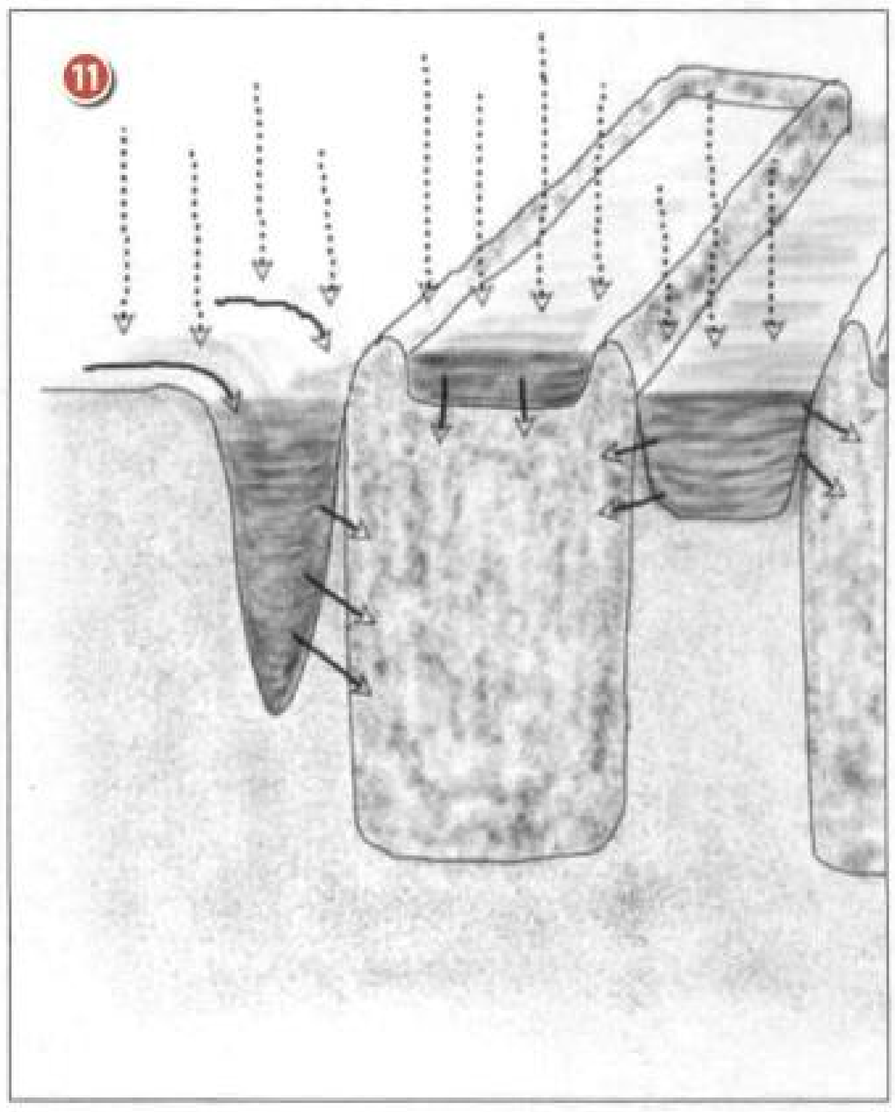
Table 2 shows that at 27% overall rainfall utilisation, the annual volume of rainfall within the village footprint would be sufficient to supply the 2038 target of 75 ℓ/c/d set in the Qaukeni Water Master Plan. By comparison, current water use where households fetch water from a remote source is normally below 10 ℓ/c/d.

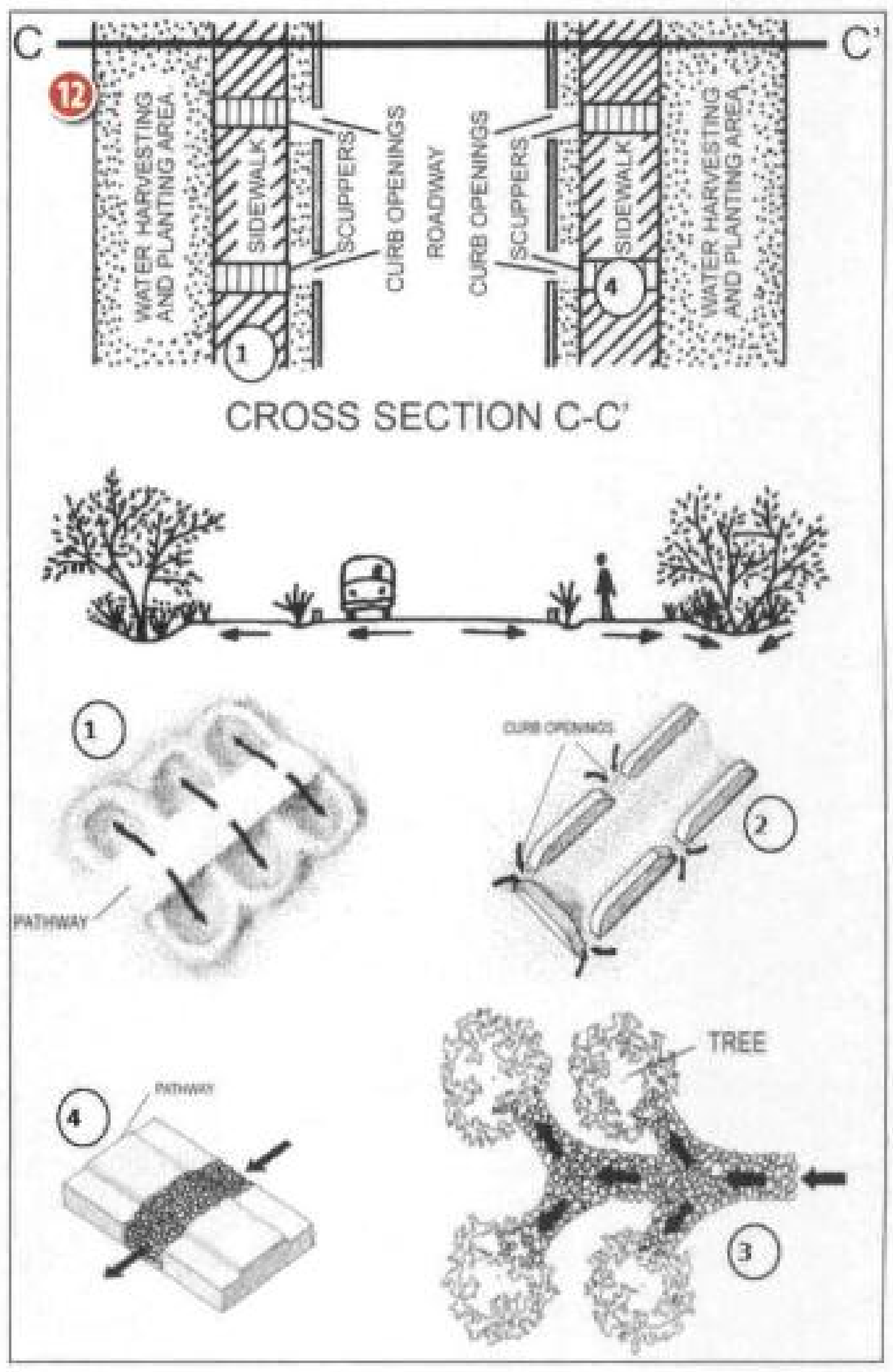
Further, T60 has a low total populated footprint (SA nightlights = 3,7% of surface area), meaning that we can expect the impact on MAR of 100% adoption of rainwater harvesting in all T60 villages to be insignificant (also see WRC 2008a).

Practical considerations

Theoretically, enough rainwater falls within the village footprint to supply Lubala's annual demand, but some practical questions remain:

- Is it possible to create enough **local storage** to balance demand and supply across the seasons?
- In practice, how can **rainwater harvesting techniques** be applied to provide water to Lubala?
- Can it be done **cost-effectively**?





Differentiating water quality requirements

A range of rainwater harvesting techniques can be applied if water quality requirements are differentiated, for instance, for drinking, cleaning and production uses (see Table 3).

Rainfall Harvesting Calculator

The new Rainfall Harvesting Calculator, developed by Charles T Crosby and Charles P Crosby, draws on the 50-year daily rainfall records and other weather data in Sapwat3 (WRC 2008b). Sapwat3 is the latest version of the planning program that is utilised by DWA and the irrigation industry for estimating the irrigation requirements of crops. Table 4 shows some results using the Rainfall Harvesting Calculator for Lubala.

Grey water use

Note that in Table 4 the same storage configurations have been tested for [b] and [c] (see Figure 4). However, recycling of 70% of the water used in [b] can support 50 m^2 of garden beds in winter. Recycled flows are continuous, therefore three-day storage of grey water (e.g. a number of 200 ℓ drums) should suffice for this purpose.

Some practical solutions

Individual homestead solutions

Where good-quality hard roof surfaces are available, conventional roofwater tanks and guttering can be installed. A first-flush system (see www.searnet.org/searnetfinal/demonstration.asp) ensures rinsing of the roof before water is allowed to enter the storage tank.

Water harvesting off thatched rondavels remains something of a challenge. The simplest approach is to treat thatch runoff as normal surface runoff (see Figure 9).

Low-cost silver-impregnated ceramic filtering is recognised as a viable home-based water treatment option, but as yet availability in South Africa is problematic. Other household disinfection options also exist, but there is room for further development regarding affordable and manageable solutions for poor households.

Communal solutions for drinking water

In the hilly terrain, one possibility that could be investigated for communal drinking water is to channel surface runoff through a permanent configuration of vegetative and sand filters into a communal storage tank within a walking distance of 200 m of the homesteads served. Such systems could be repeated throughout a village wherever topography and runoff permit. Many other innovations are possible.

Water for production

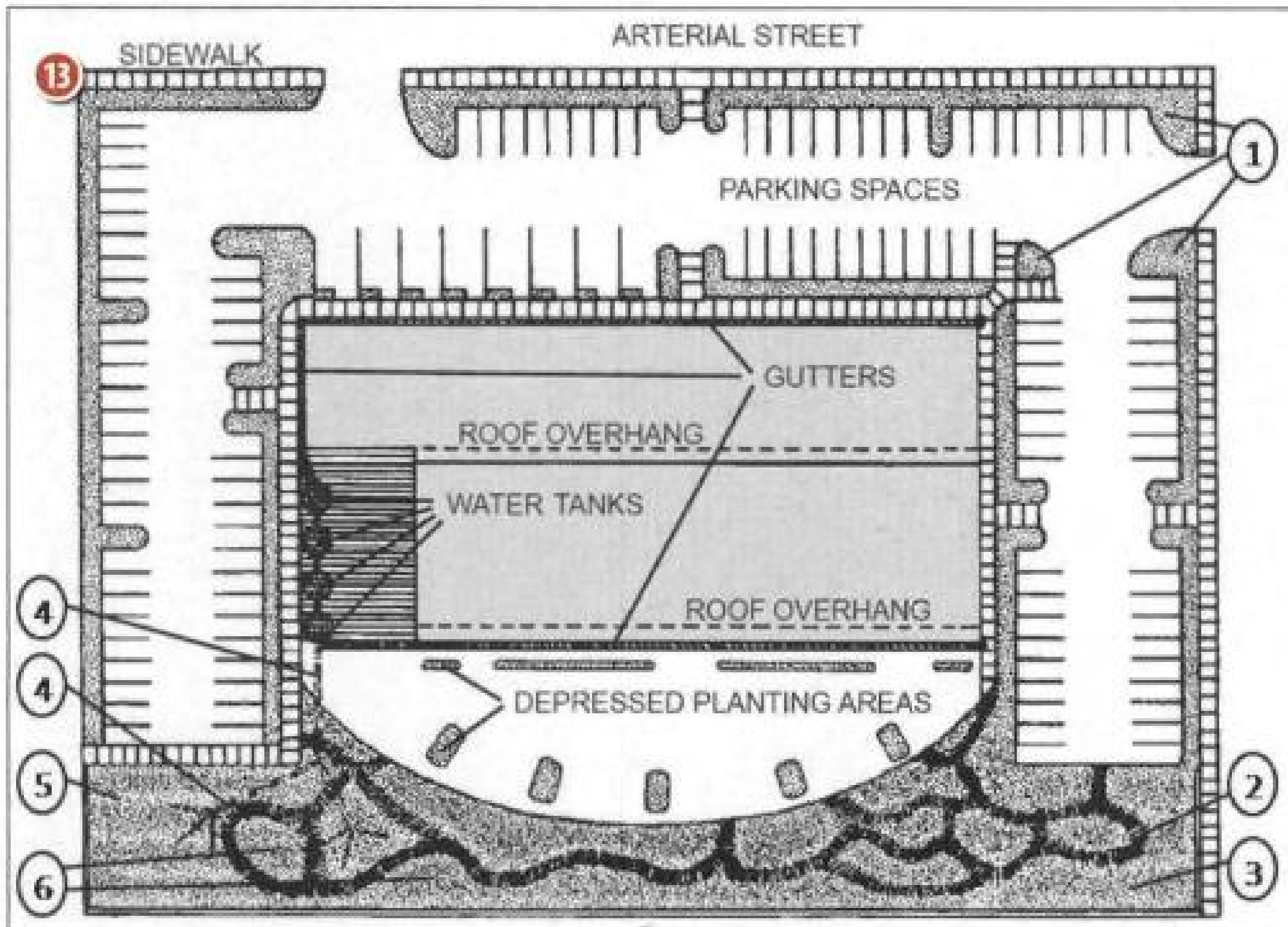
In contrast to water for potable and hygiene uses, water for production can also be stored in the soil profile. The following methods require no capital or operating costs other than the household's own manual labour (Figures 10 & 11):

- *Deep trenching* of planting beds provides the food gardener with a permanent solution to the limited soil water reservoir in the shallow soils that are typical of this area.
- *Run-on* is the practice of collecting and redistributing runoff to planting beds.

In effect, this is controlled passive irrigation. During a rainstorm, surface runoff is channelled to a cut-off ditch along the top contour of the garden and distributes – both underground and through a network of footpaths – among the permanent deep-trenched planting beds, which are soft and absorbent due to the very high amount of organic matter mixed into the beds during their construction.

In Sapwat3 data input to the Rainfall Harvesting Calculator, the effect of deep trenching is taken into account by setting the soil depth at a healthy 0,6 m and assuming an intensive high-yielding production regime – which is true of deep-trenched gardens. Further computing development is still necessary to recognise the considerable effect of run-on.

13



1. Depressed planting areas
2. Raised pathways
3. Detention area with overflow to storm drain
4. French drain receiving overflow from rainwater tanks
5. Detention area with overflow to storm water drain
6. Assorted swales and micro-basins in association with raised paths constituting a detention area

These practices could become particularly significant where municipalities are struggling to cope with the water demand of hosepipes used to water food gardens from municipal supplies.

RAINWATER HARVESTING IN URBAN CONTEXTS

The rainwater harvesting techniques identified above can also be applied successfully in urban settings such as Flagstaff and Lusikisiki Town (31°22'00.16"S; 29°34'59.91"E). There are various further techniques specifically developed for urban application.

Passive irrigation

In urban landscapes water supply infrastructure and energy requirements for landscaped areas can be reduced by:(1) creating depressed areas for planting; and (2) maximising runoff collection and storage capacity in the soil profile. In Figure 12 these principles are applied to a suburban street, and in Figure 13 to a public building (City of Tucson 2005).

Lawn

The Rainfall Harvesting Calculator also provides a routine for calculating water demand for lawn. By creating detention areas as described in Figure 13, the demand on municipal supplies for watering public and residential lawns can be reduced considerably.

CONCLUSIONS

Rainwater harvesting provides a range of innovative possibilities for improving life for poor rural and urban households, and for reducing municipal water demand in both urban and rural settings. South Africa has yet to investigate the potential gains to municipalities of incentivising citizens' adoption of rainwater harvesting practices.

Table 5 Some water harvesting techniques suitable for urban areas (adapted from City of Tucson 2005)

Goals for techniques and variations
Microbasins
Captures surface water from very small catchment areas and infiltrates it into the soil. ▪ in a series ▪ on-contour ▪ ① w/pathway/driveway ▪ local depression ▪ inside curbed areas ▪ ② in a parking lot
Swales on-contour
Captures surface water from small to moderate catchment areas and infiltrates it into the soil. ▪ large scale ▪ without berms ▪ adjacent to paths ▪ internal microbasins
Swales off-contour
Captures surface water from small to moderate catchment areas and slowly conveys it down-gradient while it infiltrates into the soil. ▪ pocket swales ▪ boomerang swales ▪ parking lot berms
French drains
Captures surface water and rapidly conveys it underground in a subsurface trench. Maximises infiltration while minimising evaporation. ▪ subsurface pipe ▪ as "curtains" ▪ ③ branched ▪ ④ across pathways ▪ for roof drainage ▪ general surface flow
Gabions
Slow surface water flow in very small drainages, capture detritus and sediment from water to fill in erosion cuts upstream of the gabion. ▪ wire basket wrapped around rock ▪ loose rock gabions
Water tanks/cisterns
Stores harvested water for later use. ▪ above-ground tanks ▪ below-ground tanks
Mulch
Aids water infiltration into soils, retards evaporation. Enriches soil nutrients, suppresses weed growth, helps reduce pollutants. Keeps soil temperature lower in summer and warmer in winter. ▪ organic ▪ inorganic

The Rainfall Harvesting Calculator, used in conjunction with the program Sapwat3, provides a useful tool for analysing the possibilities and impacts of rainwater harvesting for all quaternary catchments in the country.

A wealth of documentation has been generated in various parts of the world that can now be drawn on to develop South African guidelines, Best Management Practices, municipal regulations and incentives for the effective application of rainwater harvesting to the benefit of society and the environment. Indeed, rainwater harvesting should become an integrated component of all our water planning tools, such as reconciliation strategies, water services development plans and Water Master Plans.

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Rainwater harvesting provides a range of innovative possibilities for improving life for poor rural and urban households, and for reducing municipal water demand in both urban and rural settings. South Africa has yet to investigate the potential gains to municipalities of incentivising citizens' adoption of rainwater harvesting practices