WATER CONSERVATION TECHNICAL BRIEFS

TB 2 – Rain Water Harvesting & Artificial Recharge to Groundwater

SAI Platform

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WATER CONSERVATION

TECHNICAL BRIEFS

TB 2 - Rain Water Harvesting & Artificial Recharge to Groundwater

This document provides a review of major technologies used in Rain Water Harvesting (RWH). RWH is the principle of collecting and using precipitation from a catchments surface. There are two main techniques of rain water harvesting:

1. Storage of runoff on surface for future use.
2. Recharge to groundwater & shallow aquifer.

This technical brief provides definition, detail of maintenance, cost, recommendations and dimensions of nine different types of RHW: Lined underground reservoir, countor ridges, countour stine bunding, terracing contour bunds, permeable rock dams, recharge pits/trenches, dried up well, check dam and gabion structure. Some references and tools can be found at the end of the document.

Contents

Section 1: Lined underground reservoir

Description	It is a hole dug in the ground, used to collect and store surface runoff from uncultivated grounds, roads or laggas (dry streambed of a river that flows only in the rainy season).

Purpose	Providing water for livestock use and / or crop irrigation.

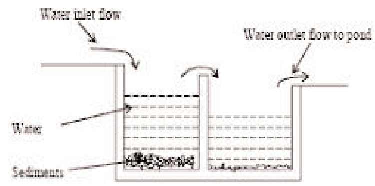
Cost	Very variable

Dimension	• Ponds will generally be square or rectangular shaped. • The capacity is variable and depends on site conditions (how much rain falls in the area during rainy season) and how much one wants to invest. Common ones are 400 to 1000m^3.

Recommendation	• Close off the open water pan with live fence to keep children and livestock out. • Tanks, ponds, dams and reservoirs all need to be lined to stop water from seeping out. • Materials used for lining include clay, rubber, plastic, bricks, stones or concrete. However in areas without clay, plastic (0.4 to 1.4mm) lining has proved to be appropriate mainly because of low cost and reliability of the material. • Design of the tank shape depends on the soil type, which dictates the maximum possible slope that will stay in place without falling in. For stable soil the side slope ratio can be 1:1 and 1:2 for unstable soils. • Subsurface reservoir in concrete can also be built. • Construct a silt trap along the inlet channel to filter excess sediment load (especially for subsurface reservoir).

TB 2 - Rain Water Harvesting

Pictures	



Plastic lined tank anchored Subsurface reservoir with a silt trap Schema of a silt trap

with sand bags

SECTION 2: CONTOUR RIDGES

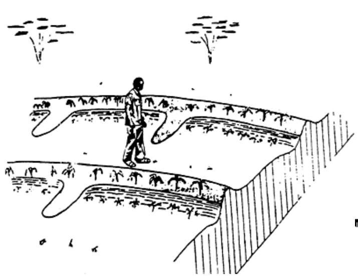
Description	Contour ridges, sometimes called contour furrows or micro watersheds, are used for crop production. Ridges follow the contour at a spacing of usually 1 to 2 metres. Runoff is collected from the uncultivated strip between ridges and stored in a furrow just above the ridges. Crops are planted on both sides of the furrow.
Purpose	• To conserve soil moisture for crop production. • Reduce soil erosion
Cost	With human labour, an estimated 32 person days/ha is required. Using machinery, the time requirement is reduced, but the costs are increased to an estimated $100/ha. This technology is considered low cost, although the rate of its adoption has not been high.
Dimension	Ridges need only be as high as necessary to prevent overtopping by runoff. As the runoff is harvested only from a small strip between the ridges, a height of 15

	-20 cm is sufficient. If bunds are spaced at more than 2 metres, the ridge height must be increased.

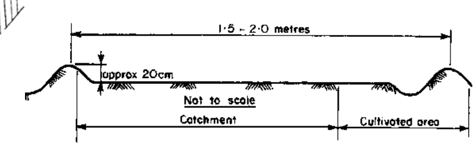
Recommendation	• Contour ridges for crop production can be used under the following conditions: - Field from flat up to 5.0%. - Field Rainfall 350-700 mm. - Area with rills or ondulations should be avoided. • The distance between the ridges should be adapted depending on rainfall amount.

Maintenance	Minimal maintenance is required if the ridges are properly constructed initially. Maintenance involves reconstruction of any lines and ridges that might have collapsed.
Advantage / Disadvantage	• This low cost technology has the potential to increase food security in below normal rainfall years. • The relatively low planting density discourages farmers, especially in a good year, and the technique does not work well on steep slopes.

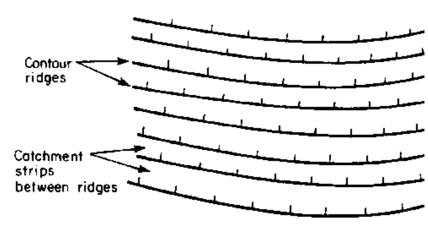
Pictures	



Contour ridges in Kenya



Contour ridge dimension



Contour ridge (field layout)

Section 3: Contour Stone Bunding

Description	A single line of stones, or a stone bund, depending upon the availability of stones, is laid along a contour. The contour stone bunds do not concentrate runoff but keep it spread. They also reduce the rate of runoff allowing infiltration,

Purpose	• To conserve soil moisture for crop production. • To reduce soil erosion.

Cost	Where stones are in short supply, there are increased costs associated with their acquisition and transport.

Dimension	Structures are up to 25 cm high with a base width of 35 to 40 cm. They are set in a trench of 5 to 10 cm depth which increases stability. The spacing between bunds varies but is usually between 15 to 30 m.

Recommendation	• The technology is particularly suited to semi-arid lands, where stones are available.

Maintenance	There is limited, ongoing repair required as the stones are not vulnerable to erosion. However, silting behind the stone bunds requires that the stones to be relaid from time to time. Care must be taken that overtopping of the bunds does not lead to erosion on the downstream face, with subsequent gully formation and undercutting of the bund.

Advantage / Disadvantage	• The technology is simple to implement at the local level. • Stone bunds do not readily wash away and, therefore, the technique is not vulnerable to unusual and variable intensity rainfall events. • The popularity of the technique can resulted in shortages of stones and, therefore, a higher cost for latecomers.

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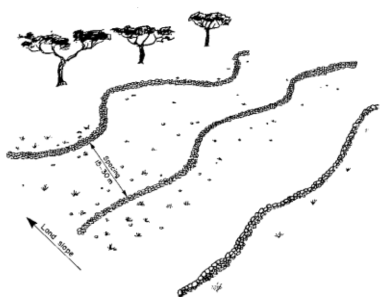
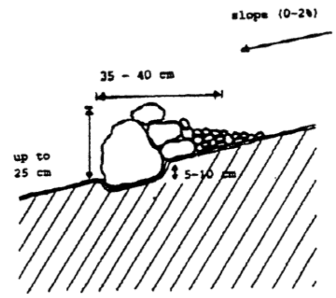
Pictures



Contour stone bunding



Detail of stone bund

SECTION 4: TERRACING CONTOUR BUNDS

Description	Terracing contour bunds are ridges and ditches made of soil, dug across the slope along the contour. They are used to prevent run-off and to conserve soil and water. Crops are planted on the land between the bunds.

Purpose	• To conserve soil moisture for crop production. • To reduce soil erosion.

Cost	The labour required for construction is estimated at 150 to 350 person days/ha for terraces and cut off drains. The cost of these structures is approximately $60-460/ha.

Dimension	The trench is 60 cm wide by 60 cm deep, and the bund 50 cm high by 150 cm across at the base. The distance between bunds depends upon the slope and

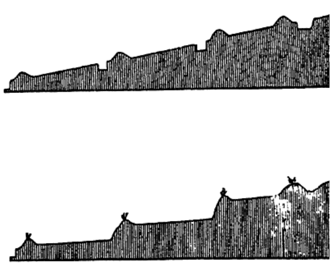
	may be from 5 m apart on steeply sloping lands to 20 m apart on more gently sloping lands.

Recommendation	• Use this system if moderate slopes field (5-30%) with light or medium soil texture. • Suitable in low rainfall areas (<700mm per year) where monsoon runoff can be impounded by constructing bunds. • The bunds should be stabilised with planted fodder grasses. • Surveyed the system to see if it needs a cut-off drain to be installed in order to protect the terraces from surplus rainfall. • Compact the soil bund well and reinforce it with stones.

Maintenance	Regular maintenance is required to maintain and repair the bunds.

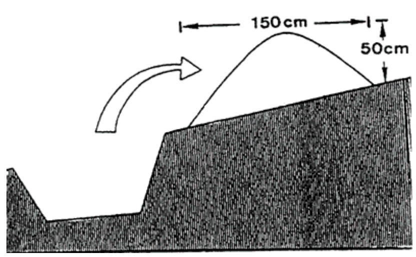
Advantage / Disadvantage	• Simple to build. • The technology generally results in a reliable increase in crop yield. • The system is costly in term of labour. • May create some waterlogging problems in heavy soil.

Pictures



General view of terraces contour

(with and without ditches)



Construction of the bund

Crop field with terraces

bunds in South Africa

SECTION 5: PERMEABLE ROCK DAMS

Description	Permeable rock dams consist of long, low rock walls with level crests along the full length across valley floors. This causes runoff to spread laterally from the stream course. This is a floodwater harvesting technique.

Purpose	• Spread and retain floodwater runoff for improved crop growth. • Control gulley erosion.

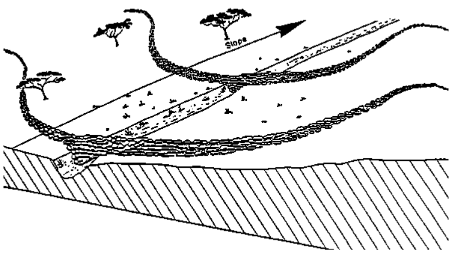
Cost	A typical rock dam providing erosion control and water supplies to plots of 2 to 2.5 ha costs about $500 to 650 for transportation of materiel and about 300 to 600 person days of labour.

Dimension	Each dam is usually between 50 and 300 m in length. The dam wall is usually 1 m in height within a gully, and between 80 and 150 cm in height elsewhere. The dam wall is also flatter (2:1) on the down slope side than on the upslope side (1:2), to give better stability to the structure when it is full. A shallow trench for the foundation improves stability and reduces the risk of undermining. Large stones are used on the outer wall and smaller stones internally.

Recommendation	• This system is generally used across relatively wide and shallow valleys. • This technology is appropriate for regions with less than 700 mm annual rainfall, where gullies are being formed in productive land. • This is particularly suited to valley bottoms with slopes of less than 2%, and where a local supply of stones and the means to transport them is available.

Advantage / Disadvantage	• Increased crop production and erosion control as a result of the harvesting and spreading of floodwater • Improved land management as a result of the silting up of gullies with fertile deposits

	• Enhanced groundwater recharge • Reduced runoff velocities and erosive potentials. • High transportation costs • Need for large quantities of stone

Picture	
 Permeable rock dams	

Section 6: Recharge Pits / Trenches

Description	Recharge pits and trenches are constructed for recharging the shallow aquifers and / or avoiding runoff damages. • Pits are generally 1 to 2 m wide and 2 to 3 m deep. • Trenches are generally 0.5 to 1m wide and 1 to 1.5 m deep and 10 to 20 m long depending upon availability of water. Both are filled with boulders, gravels & coarse sand to filter and increase water infiltration (minimizing evaporation loss).

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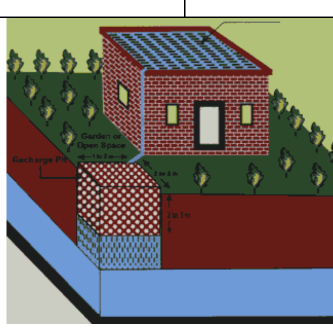
Cost	The cost will roughly depend on the cost of the filling material and labour. Approximative cost for a pit in India: 2500-5000 Rs (50-100 USD). Approximative cost for a trench in India: 5000-10000 Rs (100-200 USD).

Where to build?	Where water runoff are observed and in presence of a shallow aquifer. • In a garden next to a house to collect the roof rainwater. The gutter should convey the water directly to the pit. • Nearby a well to recover water loss through quick infiltration.

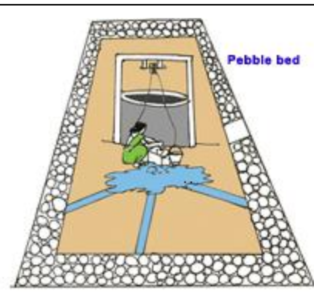
Maintenance	Remove and replace the top sand layer periodically (generally every year after rainy season) to prevent blockage.

Advantage	• This is an ideal solution of water problem where there is an inadequate groundwater supply or surface resources are either lacking or insignificant. • It will helps in reducing flood hazards. • To improve the quality of groundwater through dilution since rainwater is bacteriologically safe and free from organic matters.

Pictures	



Pit nearby a house



Trenches around an open well

Pit connected to a hand pump

SECTION 7: DRIED UP WELL

Description	When open well are dried up, it is possible to use them for recharging groundwater in diverting upstream runoff inside the well.

Cost	In India: Earthwork for silt trap, conical pit and diversion channel: 150 Rs Stone pitching for silt trap and pit: 150 Rs PVC pipe: 300Rs Total cost: 600Rs (12 USD)

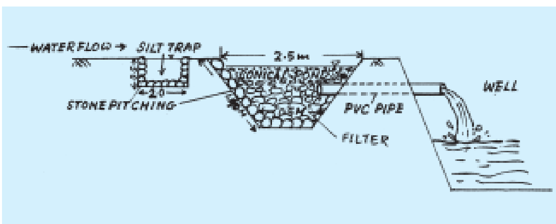
Dimension	Silt trap: 2 × 1 × 0.5m (length, wide, deep) Conical filter pit: 2.5 × 2.5m (top area) 0.5 × 0.5m (bottom area) 1m deep Length PVC pipe: depend on the site condition

Recommendation	• Before entering the well, the water should be cleaned by passing the runoff through a silt trap and then filtrated in a pit. • Dig a small diversion channel in the ground to allow the water passing through the cleaning unit.

Maintenance	Clean the silt trap at regular interval. Remove and replace the top sand layer of the pit periodically (every year after rainy season).

Advantage	• Inexpensive (since it uses an existing well). • Easy to build. • Efficient harvesting runoff.

Pictures	



Diversion of runoff to a dried up well

A dried up well

SECTION 8: CHECK DAM

Description	A check dam is a small, temporary or permanent dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows for a certain design range of storm events. A check dam can be built from logs of wood, stone, pea gravel-filled sandbags or bricks and cement.

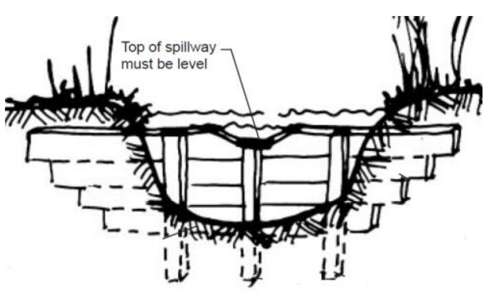
Purpose	• To reduce runoff speed. • Reduce erosion and prevent gully formation during flood. • Allow groundwater recharge and sediment to settle out.

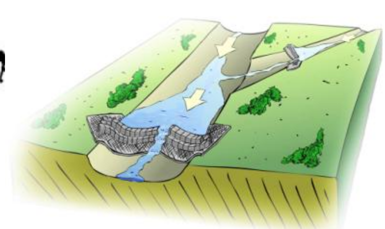
Cost	The cost of temporary structure is about US$ 200 - 400 depending on the materials used, the size of the gully and the height of the obstruction (dam). A permanent check dam constructed in using stones, bricks and cement can be much more expensive. Costs vary from US$ 1 000 - 3 000 depending upon the length and height of the dam.

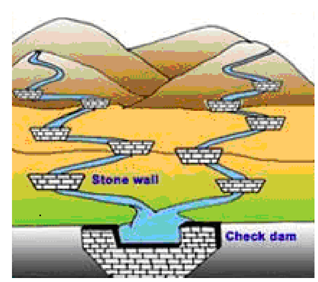
Recommendation	• Check dams should be checked for sediment accumulation after each significant rainfall. Sediment should be removed when it reaches one-half of the original height or before. • The sides of the check dam must be higher than the centre so that water is always directed over the centre of the dam (this avoids the dam being outflanked by the flow). • Do not construct check dams in watercourses or permanently flowing streams without specific design (because of possible restrictions to fish passage).

Maintenance	• Check dams are inspected regularly and after significant rainfall. • Check to ensure that the flow is over the centre of the dam and not either under or around the dam. • Check that there is no erosion at the outfall.

Pictures	







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Wood board check dams	Cement check dams	Check dam and gabion structures (stone wall)

SECTION 9: GABION STRUCTURE

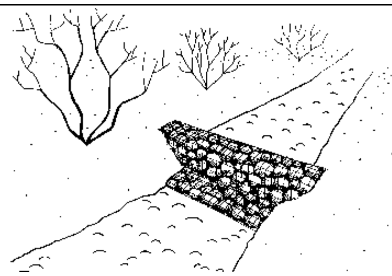
Description	A gabion is semi permeable barrier, made of boulders in a mesh of steel wires and anchored to the stream bank, to slow but not stop, the flow of storm water in a small watercourse so to favour water infiltration to groundwater and help prevent soil erosion.

Dimension	The height of such structures is around 0.5 m and 1m wide, and is normally used in the streams with width of less than 10 m.

Recommendation	• Gabions should be located within a straight reach of the watercourse, not on a curve nor immediately after a curve. • A poorly constructed gabion can do more harm than good by diverting water towards the bank. Consult a qualified professional.

Maintenance	Inspect gabions following major runoff events. Adjust apron size, gabion width, and gabion height as needed based on its performance.

Pictures	



Schema of a gabion

Gabion structure in a stream bed

SECTION 10: REFERENCES

<table>
<tr><td>Lined Underground Reservoir</td><td>Action sheet 14: Runoff Rainwater Harvesting, Pan African Conservation Education Projects (PACE)

http://www.paceproject.net/Userfiles/File\Water\Runoff%20rain%20harvesting.pdf</td></tr>
<tr><td>Dried up well</td><td>Groundwater Recharging Techniques, Central Research Institute for Dryland Agriculture (CRIDA), India

http://www.crida.ernet.in/DFID/Groundwater.pdf</td></tr>
<tr><td>Contour Ridges</td><td rowspan="4">Sourcebook of Alternative Technologies for Freshwater Augumentation in Africa, United Nations Environment Programme (UNEP), Division of Technology, Industry and Economics

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Water Harvesting: A Manual for the Design and Construction of Water Harvesting Schemes for Plant Production, FAO, Rome, 1991

http://www.fao.org/docrep/u3160e/u3160e00.HTM</td></tr>
<tr><td>Contour Stone Bunding</td></tr>
<tr><td>Terracing Contour bunds</td></tr>
<tr><td>Permeable rock dams</td></tr>
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</table>

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Recharge Pits /Trenches	*Rainwater Harvesting and Artificial Recharge to Groundwater (2000*, Unesco http://www.unesco.org/water/ihp/publications/water_harvesting.pdf
Check dams	*Check Dams*, Bagley College of Engineering Mississipi State University http://abe.msstate.edu/csd/NRCS-BMPs/pdf/water/erosion/checkdam.pdf *Check Dams*, The Hawke's Bay Regional Council (NZ) http://www.hbrc.govt.nz/LinkClick.aspx?fileticket=Dhz1RjigLa4%3D&tabid=248
Gabion Structure	*Water Harvesting Guidance Manual* (2005), City of Tucson, Department of Transportation, Storm water Management Section http://www.ci.tucson.az.us/water/harvesting.htm

SECTION 11: USEFUL WEBSITES AND TOOLS

International Rainwater Catchment Systems Association (IRCSA)

http://www.ircsa.org

Rainwater Harvesting Implementation Network TOOL Runoff calculator

http://www.rainfoundation.org

Smart Water Harvesting Solutions: Examples of innovative low cost technologies for rain, fog, runoff water and groundwater

http://www.waterland.net/showdownload.cfm?objecttype=mark.hive.contentobjects.download.pdf&objectid=1A6A3C6B-F37A-BF86-37BCD14A087EE1C9