



# WATER CONSERVATION TECHNICAL BRIEFS

## TB 2 - Rain Water Harvesting & Artificial Recharge to Groundwater

SAI Platform

August 2009

*This document has been produced for internal information purposes only among SAI platform members. It represents a collection of information that is freely available on the internet, and that we believe to be accurate. Nevertheless, it is by no means an exhaustive document and no guarantee is provided about the content. The views expressed herein do not reflect the official opinion of SAI platform, nor its members.*



# 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 RWH: Lined underground reservoir, contour ridges, contour stone 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 .....	2
Section 2: Contour Ridges .....	3
Section 3: Contour Stone Bunding.....	5
Section 4: Terracing Contour bunds.....	6
Section 5: Permeable rock dams.....	8
Section 6: Recharge Pits / Trenches.....	9
Section 7: Dried up well .....	11
Section 8: Check Dam.....	12
Section 9: Gabion Structure.....	14
Section 10: References.....	16
Section 11: Useful Websites and tools.....	18

## TB 2 - Rain Water Harvesting

### SECTION 1: LINED UNDERGROUND RESERVOIR

<b>Description</b>	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).
--------------------	---



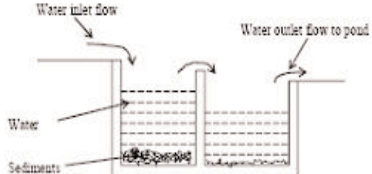
<b>Purpose</b>	Providing water for livestock use and / or crop irrigation.
----------------	---

<b>Cost</b>	Very variable
-------------	---------------

<b>Dimension</b>	<ul style="list-style-type: none"><li>• Ponds will generally be square or rectangular shaped.</li><li>• 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<sup>3</sup>.</li></ul>
------------------	---

<b>Recommendation</b>	<ul style="list-style-type: none"><li>• Close off the open water pan with live fence to keep children and livestock out.</li><li>• Tanks, ponds, dams and reservoirs all need to be lined to stop water from seeping out.</li><li>• 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.</li><li>• 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.</li><li>• Subsurface reservoir in concrete can also be built.</li><li>• Construct a silt trap along the inlet channel to filter excess sediment load (especially for subsurface reservoir).</li></ul>
-----------------------	---

## TB 2 - Rain Water Harvesting

Pictures		
		
<p>Plastic lined tank anchored trap with sand bags</p>	<p>Subsurface reservoir with a silt trap</p>	<p>Schema of a silt</p>

## SECTION 2: CONTOUR RIDGES

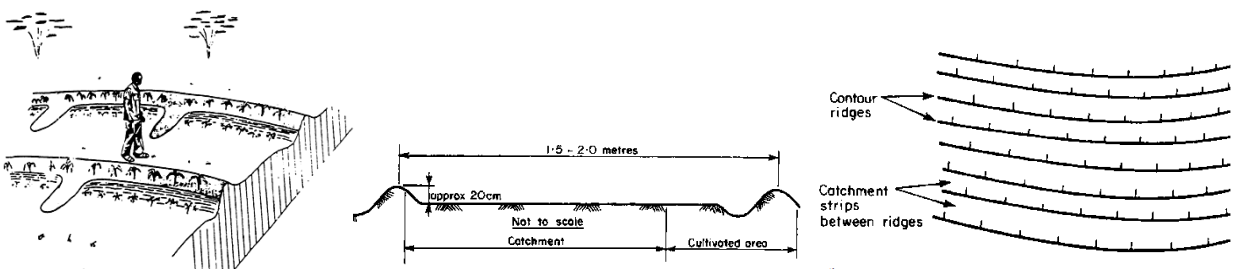
<p><b>Description</b></p>	<p>Contour ridges, sometimes called contour furrows or micro watersheds, are used for crop production. Ridges follow the contour at a spacing of usually 1 to 2 metres. Runoff is collected from the uncultivated strip between ridges and stored in a furrow just above the ridges. Crops are planted on both sides of the furrow.</p>
<p><b>Purpose</b></p>	<ul style="list-style-type: none"> <li>• To conserve soil moisture for crop production.</li> <li>• Reduce soil erosion</li> </ul>
<p><b>Cost</b></p>	<p>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.</p>
<p><b>Dimension</b></p>	<p>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</p>

## TB 2 - Rain Water Harvesting

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

<b>Recommendation</b>	<ul style="list-style-type: none"> <li>Contour ridges for crop production can be used under the following conditions:             <ul style="list-style-type: none"> <li>Field from flat up to 5.0%.</li> <li>Field Rainfall 350-700 mm.</li> <li>Area with rills or undulations should be avoided.</li> </ul> </li> <li>The distance between the ridges should be adapted depending on rainfall amount.</li> </ul>
-----------------------	---

<b>Maintenance</b>	Minimal maintenance is required if the ridges are properly constructed initially. Maintenance involves reconstruction of any lines and ridges that might have collapsed.
<b>Advantage / Disadvantage</b>	<ul style="list-style-type: none"> <li>This low cost technology has the potential to increase food security in below normal rainfall years.</li> <li>The relatively low planting density discourages farmers, especially in a good year, and the technique does not work well on steep slopes.</li> </ul>

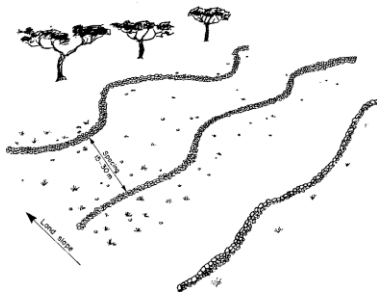
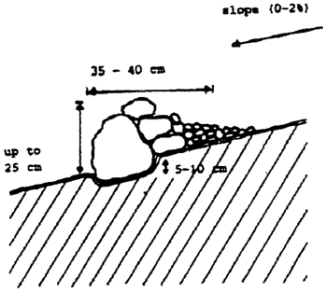
<b>Pictures</b>		
		
Contour ridges in Kenya layout)	Contour ridge dimension	Contour ridge (field

## TB 2 - Rain Water Harvesting

### SECTION 3: CONTOUR STONE BUNDING

<b>Description</b>	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,
<b>Purpose</b>	<ul style="list-style-type: none"><li>• To conserve soil moisture for crop production.</li><li>• To reduce soil erosion.</li></ul>
<b>Cost</b>	Where stones are in short supply, there are increased costs associated with their acquisition and transport.
<b>Dimension</b>	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.
<b>Recommendation</b>	<ul style="list-style-type: none"><li>• The technology is particularly suited to semi-arid lands, where stones are available.</li></ul>
<b>Maintenance</b>	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.
<b>Advantage / Disadvantage</b>	<ul style="list-style-type: none"><li>• The technology is simple to implement at the local level.</li><li>• Stone bunds do not readily wash away and, therefore, the technique is not vulnerable to unusual and variable intensity rainfall events.</li><li>• The popularity of the technique can result in shortages of stones and, therefore, a higher cost for latecomers.</li></ul>

## TB 2 - Rain Water Harvesting

Pictures	
 <p data-bbox="326 699 626 730">Contour stone bunding</p>	 <p data-bbox="898 699 1162 730">Detail of stone bund</p>

## SECTION 4: TERRACING CONTOUR BUNDS

<p><b>Description</b></p>	<p>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.</p>
<p><b>Purpose</b></p>	<ul style="list-style-type: none"> <li>• To conserve soil moisture for crop production.</li> <li>• To reduce soil erosion.</li> </ul>
<p><b>Cost</b></p>	<p>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.</p>
<p><b>Dimension</b></p>	<p>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</p>

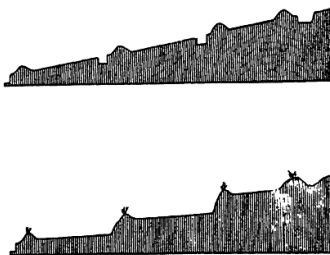
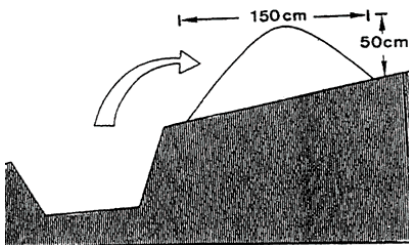

## TB 2 - Rain Water Harvesting

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

<b>Recommendation</b>	<ul style="list-style-type: none"> <li>• Use this system if moderate slopes field (5-30%) with light or medium soil texture.</li> <li>• Suitable in low rainfall areas (&lt;700mm per year) where monsoon runoff can be impounded by constructing bunds.</li> <li>• The bunds should be stabilised with planted fodder grasses.</li> <li>• Surveyed the system to see if it needs a cut-off drain to be installed in order to protect the terraces from surplus rainfall.</li> <li>• Compact the soil bund well and reinforce it with stones.</li> </ul>
-----------------------	--

<b>Maintenance</b>	Regular maintenance is required to maintain and repair the bunds.
--------------------	---

<b>Advantage / Disadvantage</b>	<ul style="list-style-type: none"> <li>• Simple to build.</li> <li>• The technology generally results in a reliable increase in crop yield.</li> <li>• The system is costly in term of labour.</li> <li>• May create some waterlogging problems in heavy soil.</li> </ul>
---------------------------------	---

<b>Pictures</b>			
			
	General view of terraces contour (with and without ditches)	Construction of the bund	Crop field with terraces bunds in South Africa

## TB 2 - Rain Water Harvesting

### SECTION 5: PERMEABLE ROCK DAMS

<b>Description</b>	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.
--------------------	---

<b>Purpose</b>	<ul style="list-style-type: none"><li>• Spread and retain floodwater runoff for improved crop growth.</li><li>• Control gulley erosion.</li></ul>
----------------	---

<b>Cost</b>	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.
-------------	---

<b>Dimension</b>	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.
------------------	--

<b>Recommendation</b>	<ul style="list-style-type: none"><li>• This system is generally used across relatively wide and shallow valleys.</li><li>• This technology is appropriate for regions with less than 700 mm annual rainfall, where gullies are being formed in productive land.</li><li>• 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.</li></ul>
-----------------------	--

<b>Advantage / Disadvantage</b>	<ul style="list-style-type: none"><li>• Increased crop production and erosion control as a result of the harvesting and spreading of floodwater</li><li>• Improved land management as a result of the silting up of gullies with fertile deposits</li></ul>
---------------------------------	---

## TB 2 - Rain Water Harvesting

	<ul style="list-style-type: none"> <li>• Enhanced groundwater recharge</li> <li>• Reduced runoff velocities and erosive potentials.</li> <li>• High transportation costs</li> <li>• Need for large quantities of stone</li> </ul>
--	---

<b>Picture</b>	
	
Permeable rock dams	

## SECTION 6: RECHARGE PITS / TRENCHES

<b>Description</b>	<p>Recharge pits and trenches are constructed for recharging the shallow aquifers and / or avoiding runoff damages.</p> <ul style="list-style-type: none"> <li>• Pits are generally 1 to 2 m wide and 2 to 3 m deep.</li> <li>• 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.</li> </ul> <p>Both are filled with boulders, gravels &amp; coarse sand to filter and increase water infiltration (minimizing evaporation loss).</p>
--------------------	---

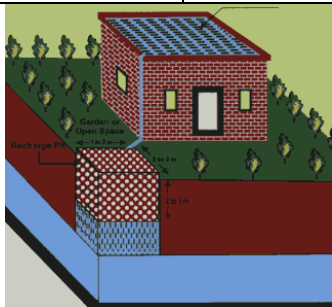


## TB 2 - Rain Water Harvesting

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

<b>Where to build?</b>	<p>Where water runoff are observed and in presence of a shallow aquifer.</p> <ul style="list-style-type: none"> <li>• In a garden next to a house to collect the roof rainwater. The gutter should convey the water directly to the pit.</li> <li>• Nearby a well to recover water loss through quick infiltration.</li> </ul>
------------------------	--

<b>Maintenance</b>	<p>Remove and replace the top sand layer periodically (generally every year after rainy season) to prevent blockage.</p>
--------------------	--

<b>Advantage</b>	<ul style="list-style-type: none"> <li>• This is an ideal solution of water problem where there is an inadequate groundwater supply or surface resources are either lacking or insignificant.</li> <li>• It will helps in reducing flood hazards.</li> <li>• To improve the quality of groundwater through dilution since rainwater is bacteriologically safe and free from organic matters.</li> </ul>
------------------	---

<b>Pictures</b>			
			
	Pit nearby a house pump	Trenches around an open well	Pit connected to a hand pump

## TB 2 - Rain Water Harvesting

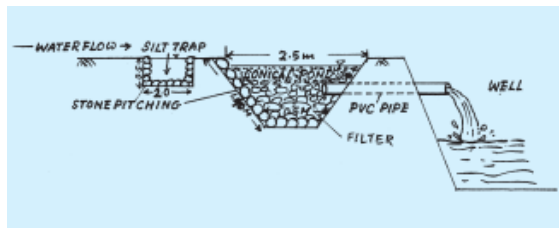
### SECTION 7: DRIED UP WELL

<b>Description</b>	When open well are dried up, it is possible to use them for recharging groundwater in diverting upstream runoff inside the well.
<b>Cost</b>	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)
<b>Dimension</b>	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
<b>Recommendation</b>	<ul style="list-style-type: none"><li>• Before entering the well, the water should be cleaned by passing the runoff through a silt trap and then filtrated in a pit.</li><li>• Dig a small diversion channel in the ground to allow the water passing through the cleaning unit.</li></ul>
<b>Maintenance</b>	Clean the silt trap at regular interval. Remove and replace the top sand layer of the pit periodically (every year after rainy season).

## TB 2 - Rain Water Harvesting

<b>Advantage</b>	<ul style="list-style-type: none"> <li>• Inexpensive (since it uses an existing well).</li> <li>• Easy to build.</li> <li>• Efficient harvesting runoff.</li> </ul>
------------------	---

<b>Pictures</b>	
-----------------	--



Diversion of runoff to a dried up well



A dried up well

## SECTION 8: CHECK DAM

<b>Description</b>	<p>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.</p>
--------------------	---

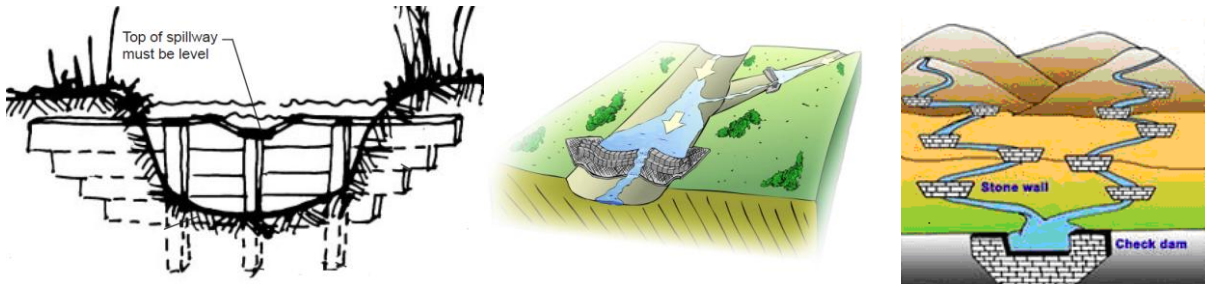
<b>Purpose</b>	<ul style="list-style-type: none"> <li>• To reduce runoff speed.</li> <li>• Reduce erosion and prevent gully formation during flood.</li> <li>• Allow groundwater recharge and sediment to settle out.</li> </ul>
----------------	---

## TB 2 - Rain Water Harvesting

<b>Cost</b>	<p>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).</p> <p>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.</p>
-------------	--

<b>Recommendation</b>	<ul style="list-style-type: none"><li>• 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.</li><li>• 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).</li><li>• Do not construct check dams in watercourses or permanently flowing streams without specific design (because of possible restrictions to fish passage).</li></ul>
-----------------------	--

<b>Maintenance</b>	<ul style="list-style-type: none"><li>• Check dams are inspected regularly and after significant rainfall.</li><li>• Check to ensure that the flow is over the centre of the dam and not either under or around the dam.</li><li>• Check that there is no erosion at the outfall.</li></ul>
--------------------	---

<b>Pictures</b>	 <p>The first diagram is a cross-section of a spillway with a stone wall. A label points to the top of the spillway with the text 'Top of spillway must be level'. The second diagram is a 3D perspective view of a check dam in a gully, showing water flowing over the dam. The third diagram is a plan view of a check dam in a gully, showing a stone wall across the gully and a check dam structure at the bottom. Labels 'Stone wall' and 'Check dam' are present.</p>
-----------------	---

## TB 2 - Rain Water Harvesting

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

## SECTION 9: GABION STRUCTURE

<b>Description</b>	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.
--------------------	---

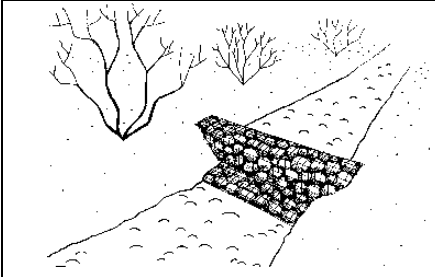
<b>Dimension</b>	The height of such structures is around 0.5 m and 1m wide, and is normally used in the streams with width of less than 10 m.
------------------	--

<b>Recommendation</b>	<ul style="list-style-type: none"> <li>• Gabions should be located within a straight reach of the watercourse, not on a curve nor immediately after a curve.</li> <li>• A poorly constructed gabion can do more harm than good by diverting water towards the bank. Consult a qualified professional.</li> </ul>
-----------------------	--

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

<b>Pictures</b>	
-----------------	--

## TB 2 - Rain Water Harvesting



Schema of a gabion



Gabion structure in a stream bed

## TB 2 - Rain Water Harvesting

### SECTION 10: REFERENCES

<b>Lined Underground Reservoir</b>	Action sheet 14: <i>Runoff Rainwater Harvesting</i> , Pan African Conservation Education Projects (PACE) <a href="http://www.paceproject.net/Userfiles/File\Water\Runoff%20rain%20harvesting.pdf">http://www.paceproject.net/Userfiles/File\Water\Runoff%20rain%20harvesting.pdf</a>
<b>Dried up well</b>	<i>Groundwater Recharging Techniques</i> , Central Research Institute for Dryland Agriculture (CRIDA), India <a href="http://www.crida.ernet.in/DFID/Groundwater.pdf">http://www.crida.ernet.in/DFID/Groundwater.pdf</a>
<b>Contour Ridges</b>	
<b>Contour Stone Bunding</b>	<i>Sourcebook of Alternative Technologies for Freshwater Augumentation in Africa</i> , United Nations Environment Programme (UNEP), Division of Technology, Industry and Economics <a href="http://www.unep.or.jp/ietc/publications/techpublications/TechPub-8a/">http://www.unep.or.jp/ietc/publications/techpublications/TechPub-8a/</a>
<b>Terracing Contour bunds</b>	<i>Water Harvesting: A Manual for the Design and Construction of Water Harvesting Schemes for Plant Production</i> , FAO, Rome, 1991 <a href="http://www.fao.org/docrep/u3160e/u3160e00.HTM">http://www.fao.org/docrep/u3160e/u3160e00.HTM</a>
<b>Permeable rock dams</b>	

## TB 2 - Rain Water Harvesting

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

## TB 2 - Rain Water Harvesting

### 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>