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# Annex 6: Water Sector Fact Sheet – Rainwater Harvesting

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| **Sector** | Agriculture |
| **Category** | Infrastructure installation |
| **Adaptation needs** | Making use of water from other sources other than ground or surface water. Rainwater is easily collected and stored. More efficient use of water supply during periods of drought. |
| **Technology Name** | Rainwater harvesting |
| **How this technology contributes to adaptation** | Climate change is projected to increase the variability and intensity of rainfall. Variability is of particular concern close to the equator, where most developing countries are located (IPCC, 2007; Nicholls and Wong, 1990). Groundwater depletion due to excessive abstraction, land use change and population growth is likely to be exacerbated by these changing precipitation patterns.<br>Collection and storage of rainwater can provide a convenient and reliable water supply during seasonal dry periods and droughts. Additionally, widespread rainwater storage capacity can greatly reduce land erosion and flood inflow to major rivers (Liebe et al., 2005; Udawattage, 1985). Rainwater collection can also contribute greatly to the stabilization of declining groundwater tables (Stiefel et al., 2009; Sayana et al., 2010).<br>Lack of adequate water supply during drought and seasonal dry periods can halt economic development and hinder human health and well-being (Gleick, 2002). Access to a convenient supply of stored rainwater can decrease travel time to remote water sources, increase agricultural productivity and reduce depletion of groundwater resources. Increasing the availability of irrigation water during the dry season and even during short dry spells has been shown to yield large increases in agricultural production (Foster and Tuinof, 2004; Rockstrom et al., 2002; Ngigi, 2003). |
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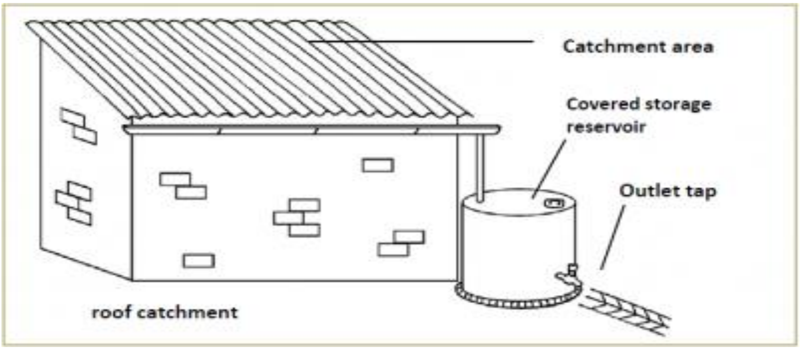
| **Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc** | Rainwater harvesting is defined as a method for inducing, collecting, storing and conserving local surface runoff (rain or surface water flow that occurs when soil is infiltrated to full capacity) for agriculture in arid and semi-arid regions (Boers and Ben-Asher, 1982). Both small and large-scale structures are used for rainwater harvesting collection and storage including water pans, tanks, reservoirs and dams. Commonly used rainwater harvesting systems are constructed from three principal components: The catchment area is the area where the rainfall or water runoff is initially captured and is in most cases either the roof-top of a house or building, ground surface or rock surface. Roof collection and ground surface would be suitable for Belize.<br>*Roof-top*<br>In the roof-top method (Figure 1) water from rainfall is collected in vessels at the edge of the roof or channeled to a storage system via gutters and pipes. Roofs can be constructed with a range of materials including galvanized corrugated iron, aluminum cement sheets, and tiles and slates. Thatch or palm leafed roofs can provide a low-cost alternative but can be difficult to clean and can taint the runoff. Tiled roofs, or roofs sheeted with corrugated mild steel or other materials are preferable, since they are the easiest to construct and give the cleanest water (WaterAid, no date). Health hazards can arise from roofs with asbestos sheeting, metallic paint or other coverings that can contaminate the water (Gould, 1992). Roof-top collection is suitable for household level application and can provide freshwater for domestic purposes and small-scale farming. For more information, see the article 'Rainwater harvesting from rooftops'.<br><br><br>Figure 1: Schematic of a typical rainwater catchment system (Source: UNEP IETC, 1998)<br>*Ground-surface*<br>In the ground surface method water flowing along the ground during the rains is usually diverted toward a tank below the surface (Figure 2). There is greater possibility of water loss than the roof-top system due to infiltration into the ground. The water is generally of lower quality than that collected directly from rainfall. Techniques available for increasing runoff within ground catchment areas include: i) clearing or altering vegetation cover, ii) increasing the land slope with artificial ground cover, and iii) reducing soil permeability by the soil compaction and application of chemicals (UNEP, 1982). Impermeable membranes can also be used to facilitate run-off. Ground catchment is applicable for low topographic areas and is suitable for large-scale agricultural production as it allows for in-situ storage and usage of fresh water for irrigation. |
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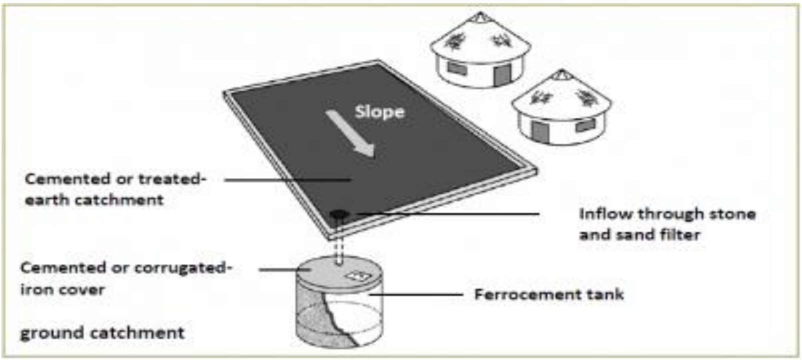
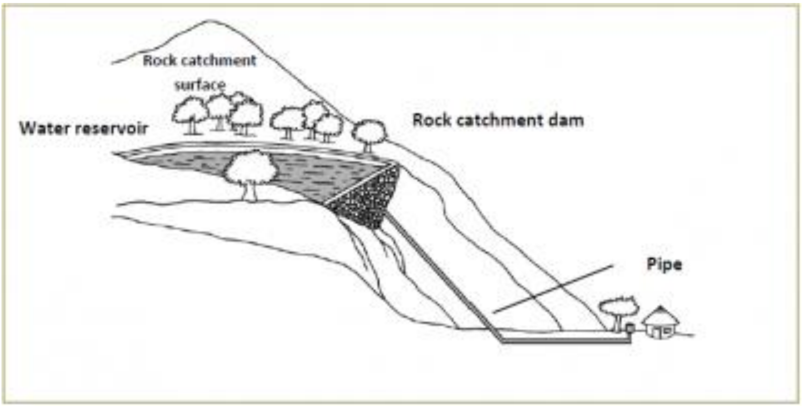
| | <br>Figure 2: Ground catchment system (Source: UNEP IETC, 1998)<br>*Rock Surface*<br>Rock surfaces can also be used as collection catchments. Bedrock surfaces found within rocky top slopes or exposed rock outcrops in lowlands often have natural hollows or valleys which can be turned into water reservoirs by building a dam (Figure 3). Developing a rock catchment area typically involves clearing and cleaning the site from vegetation and marking out the catchment area to be enclosed with gutters. Rock surfaces should not be fractured or cracked, as this may cause the water to leak away to deeper zones or underneath the dam. As with ground catchments, water is generally of lower quality than direct rainfall collection. Water quality can be improved if access to the area (for example, by animals and children) is limited (WaterAid, no date).<br><br>Figure 3: Rock catchment (Source: UNEP IETC, 1998)<br>Several types of conveyance systems exist for transporting water from the catchment to the storage device, including gutters, pipes, glides, and surface drains or channels. Larger-scale conveyance systems may require pumps to transfer water over larger distances. These should be constructed from chemically inert materials such as wood, bamboo, plastic, stainless steel, aluminum, or fiberglass, in order to avoid negatively affecting on water quality (UNEP, 1997). In the case of rock catchments, gutters can be constructed from a stone wall built with rough stones/hardcore and joined with mortar (Pace Project, no date). For household-level rainwater harvesting, gutters, down pipes, funnels and filters are required to transfer and clean collected water before it enters the storage device. |
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	Storage devices are used to store the water that is collected from the catchment areas and are classified as (i) above-ground storage tanks and (ii) cisterns or underground storage vessels. These facilities can vary in size from one cubic meter to up to hundreds of cubic meters for large projects. Common vessels used for small-scale water storage are plastic bowls, buckets, jerry cans, clay or ceramic jars, cement jars, and old oil drums. Devices can be made cheaply with locally available materials such as bamboo and steel and coated with a sand and cement mix (WaterAid, no date). Increasingly popular are ferro-cement tanks in which mortar is applied to a cylindrical wire frame which helps to control cracking. These tanks are feasible up to a size of 100 m^3. For storing larger quantities of water the system will usually require a bigger tank or cistern with sufficient strength and durability. Typically these tanks can be constructed out of bricks coated with cement. For water captured from a rock catchment, a dam is the more common form of storage device. Maintenance is required for the cleaning of the tank and inspection of the gutters, pipes and taps and typically consists of the removal of dirt, leaves and other accumulated materials. Such cleaning should take place annually before the start of the major rainfall season with regular inspections. In regions with unpredictable rainfall, more regular maintenance and cleaning will be required to ensure that the equipment is maintained in good working order. Cracks in the storage tanks can create major problems and should be repaired immediately to avoid water loss. In the case of ground and rock catchments, additional care is required to avoid damage and contamination by people and animals and to keep the catchment area free from vegetation. Climate change is disrupting global rainfall patterns meaning some parts of the world are suffering from a drastic drop in precipitation leading to a fall in water levels in many reservoirs and rivers. In Sub-Saharan Africa where two-thirds of the region is desert and dry land, the need for improving water management in the agriculture sector is particularly critical. Rainwater harvesting represents an adaptation strategy for people living with high rainfall variability, both for domestic supply and to enhance crop, livestock and other forms of agriculture (UNEP and SEI, 2009). Generally, the amount of water made available through rainwater harvesting is limited and should be used prudently to alleviate water stress during critical stages of crop growth. Supplemental irrigation is a key strategy and can help increase yields by more than 100 per cent. A small investment providing between 50 and 200 mm of extra water per hectare per season for supplemental irrigation, in combination with improved agronomic management, can more than double water productivity and yields in small-scale rain-fed agriculture (UNEP and SEI, 2009).

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| **Implementation assumptions, How the technology will be implemented and diffused across the subsector?** | Rainwater harvesting technology is simple to install and operate and does not imply any specific institutional or organizational requirements. However, governments and donors could play a key role in providing subsidies (none provided in Belize) for equipment purchases by making the technology accessible to a larger number of farmers, particularly small-scale farmers, who may have problems raising capital investment funds (UNEP and SEI, 2009).<br><br>Some key information for rainwater harvesting planning relates to the supply and demand of water as listed below:-<br>Knowledge Requirements for the Selection of Rainwater Harvesting Technology<br>• Rainfall quantity (mm/year)<br>• Rainfall pattern - the type of rainfall pattern, as well as the total rainfall, v determine the feasibility of a rainwater harvesting technology. A climate regularly throughout the year will mean that the storage requirement is lo cost will be correspondingly low and vice versa<br>• Collection surface area ($m^2$)<br>• Available storage capacity ($m^3$)<br>• Daily consumption rate (liters/capita /day)<br>• Number of users<br>• Cost – a major factor in any scheme.<br>• Alternative water sources – where alternative water sources are available significant difference to the usage pattern. If there is a groundwater sourc distance of the dwelling (say within a kilometer or so), then a rainwater h can provide a reliable supply of water at the homestead for the majority o significant impact to lifestyle of the user.<br>• Water management strategy – whatever the conditions, a careful water m always a prudent measure. In situations where there is a strong reliance o is a need to control or manage the amount of water being used so that it d expected.”<br><br>Source: Practical Action, no date |
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| **Costs** | The cost of rainwater harvesting systems will depend on the type of catchment, conveyance and storage tank materials used but in general the costs of rainwater harvesting systems is considered to be low (UNEP, 1997). The provision of the storage tank is the most costly element, and usually represents about 90 per cent of the total cost (WaterAid, no date). A review of 311 case studies on watershed programs in India, with rainwater harvesting and rainwater management as important components, found that the mean cost-benefit ratio of such watershed programs was relatively high at 1:2.14 (Joshi et al, 2005a).<br><br>In Bhutan, a three-year rainwater harvesting project aimed at safeguarding farmers from water shortages during dry periods and irregularities in the monsoon rainfall had a total budget of $850,000. Activities included:<br>• Small scale irrigation development based on rainwater harvesting technologies;<br>• Strengthening farmers involvement and research and extension services<br>• Vulnerability assessment<br>• Land survey<br>• Rural credit<br>• Project management<br>• Identification of areas vulnerable to dry spells and erratic monsoon rainfall<br>• Arial surveys and evaluation of remote sensing images/photographs to determine areas suitable for water harvesting<br>• Assessment of available and proven rainwater harvesting technologies for adoption<br>• Technological adaptation to fit the needs and requirements specific to each vulnerable locations<br>• Research new designs and package improved technologies (studying and modeling runoff behavior);<br>• Establish farmers' capacity to mobilize local resources for technology adoption and actual application<br>• Demonstration of emerging technologies like supplemental water system, dual purpose system, combined system, modeling<br>• Training farmers in the maintenance of their investments in RWHTs, and effective utilization of harvested rainwater<br>• Economic analysis of rainwater harvesting techniques.<br><br>In Burundi, a four-year project to install pilot rainwater harvesting units and train local technicians in their use totaled $100,000, as detailed<br><br>Rainwater harvesting from ground surfaces - It is difficult to find specific data on the construction and implementation costs of rainwater collection projects. Many factors, including the scale of the project, location, etc. will strongly affect costs. The program costs of foreign-funded rehabilitation and development of small reservoirs (locally known as "village tanks") in Tamil Nadu, India have been reported. The village tanks in that program were relatively large (40 ha or greater) and the average cost for each project was about $50,000 (Gupta, 2006). |
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| **Country social development priorities** | National Integrated Water Resources Management Policy (2009). This policy declared that the Government of Belize will promote and account for increased investment in the development of water storage infrastructure, which will include the use of "no regret" and other adaptation measures to respond to the predicted adverse effects of Climate Change on water resources. This policy also states that the GOB will make safe potable water supplies available in adequate quantities to the entire population by Year 2020. The policy provides opportunity to invest in water storage and conservation measures. |
| **Country economic development priorities – economic benefits** | The National Integrated Water Resources Management Policy (2009).<br>"Belizeans have a fundamental right to water and it is hereby declared that the policy of the Government is to bring about the planned development, coordinated management, sustainable use and protection of Belize's water resources consistent with the social, economic and environmental needs of present and future generations, and to ensure that all Belizeans have access to affordable, safe, adequate and reliable water."<br>Fundamental principles in the design of the policy include:-<br>1. Water is a finite and vulnerable natural resource, essential to sustain life, the environment, the economy and national development.<br>2. Access to safe and affordable water is a fundamental right of all Belizeans and water availability is directly correlated to levels of health and poverty.<br>3. Water has an economic value and the "user pays" principle is integral in ensuring the sustainability of the resource.<br>4. Global climate change, climate variability and land use will have impacts on the availability and use of water resources.<br><br>Formulation of this policy means that Government of Belize has set the stage for the introduction of measures to adapt to climate change in the water resources sector. |
| **Country environmental development priorities --environmental benefits** | The National Integrated Water Resources Management Policy, 2008 declared that it is the policy of the Government is to bring about the planned development, coordinated management, sustainable use and protection of Belize's water resources consistent with the social, economic and environmental needs of present and future generations, and to ensure that all Belizeans have access to affordable, safe, adequate and reliable water."<br><br>Belize's National Environment Action Plan – 2015-2020 promotes the "greening" of the productive sector by providing incentives for private companies to adopt superior environmental performance objectives to achieve strong international market positioning.. This could be interpreted to be referring to providing support to the agriculture sector for the use of technologies to increase competitiveness and sustainability while consuming less natural resources.<br><br>Rain harvesting can increase soil moisture levels and increase the groundwater table via artificial recharge.<br><br>Use of rainwater harvesting technology promotes self-sufficiency and has minimal environmental impact. Rainwater may be stored in plastic or concrete tanks which generates no GHG emissions. |
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| **Social benefits** | Rainwater harvesting systems, at the appropriate scale, can provide an element of water security at the level of the farm for both livestock consumption and irrigation purposes. This has not been applied for municipal purposes in Belize. One rice production company in Blue Creek uses rainwater harvesting as the source of water for irrigation of the fields. |
| **Other considerations and priorities (such as market potential)** | Running costs are reasonably low. Construction, operation and maintenance are not labor-intensive. Whether large or small, construction or installation is a one-time activity. Large plastic tanks can be handled by two or three men, while concrete tanks can be built by two or three men over a number of days. Water collected is of acceptable quality for agricultural purposes. Rainwater harvesting is also a viable options for locations /communities that are not connected to municipal or urban water supplies. |
| **Capital costs (per facility)** | Rainwater harvesting and storage systems can range from US$125.00 for a 200 litre plastic tank, up to US $2500.00 for a 4500 litre tank. A pump to deliver the water can add up to US $ 15000.00 to the system. The smaller tanks would be useful for a home garden. The industrial sized farm will require large storage ponds or reservoirs. |
| **Operational and Maintenance costs (per facility)** | Generally low, since the requirement is for cleaning of the catchment surfaces and collection pipes. The storage tanks need occasional emptying and cleaning to remove debris that has accumulated over the years. Operational cost is low since may only require occasional use of pumps, and for periodic cleaning. The larger cultivations like rice irrigation require diesel engine pumps to flood the fields during the growing stage as required. Operating costs are derived from fuel consumption and the operator's time. Operating and maintenance costs for fifteen days/yr at US$100.00/day was estimated using labour costs at 25.00/day, transport at 25.00/day, and fuel at 50.00/day. |
| **Daily supply capacity per facility** | This depends on the storage capacity. Agricultural rainwater storage systems can be built to provide thousands of gallons per day for short periods if required. |
| **Up scaling potential** | Agricultural storage systems would require construction of additional tanks for increased capacity. In some cases the catchment (roof or concrete slab) could also be increased through construction. Up scaling is considered moderately difficult since it may constrained by availability of land for the additional storage, if other land use is underway in the area. It might require new construction of the reservoir. If the storage tanks are located near enough to each other, they may be linked for pumping purposes; otherwise additional equipment has to be installed. |
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