RAINWATER HARVESTING TECHNOLOGY FOR SMALL HOUSEHOLDS

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INTRODUCTION

Roughly, 97 percent of the earth water resources in the oceans are saline. Only 2.5 percent of the world's water is fresh and of that a mere fraction is available to man (Barrow, 1987). Fresh water is one of the most essential requirements for the existence of living beings. However, as reported by several researchers, South face (2002) Coelho and Reddy (2004) and Metro-water (2005), urban areas are experiencing a decline of fresh water availability due to the reasons of global climate change, population growth, urbanization, industrialization, pollution and lack of proper water resource planning and management techniques. In many areas of the world, owing to the increase of population number in urban areas, conventional water supply systems have failed to meet the needs of the people (DTU, 1999). On the other hand, study has shown that in urban areas whilst all water is treated to drinking water standards, as little as 1% of domestic water consumption is actually used for drinking and about 85% of bulk domestic water consumption goes to toilet flushing, laundry, and outdoor uses (Coombes, 2004).

Investment in large scale and modern water supply schemes in rural areas also remains a challenge due to unique and scattered settlement patterns in most developing countries (Alem, 1999). The potential for new large-scale water resource development in developing countries is declining due to financial constraints, which leads to a growing interest in improving household water availability through the development of small-scale water sources (Ariyabandu, 2003). Reviving the traditional practices of domestic water harvesting system using scientific methods is a potential option for the looming water crisis (Alem, 1999; Metro-water, 2005). Domestic rainwater harvesting is an ancient technology used for collecting and storing rainwater during the dry season for later use (Finkel and Michael, 1995; cited by Alem, 1999; DTU, 1999; Gould and Nissen-Petersen, 1999; GDRCL, 2005; Metro-water, 2005). Archeological evidence verifies that rainwater harvesting practice goes back 4000 years (DTU, 1999; Gould and Nissen-Petersen, 1999). Even nowadays, in many African countries, placing a small container under a roof to collect falling water during a rainy season is a common practice (DTU, 1999).

Domestic Rainwater harvesting is best known and practiced in the semi arid areas where annual rainfall is in the range of between 400 and 600 mm (Alem, 1999). In arid and semi-arid regions, where precipitation is low or infrequent during the dry season, it is necessary to store the maximum amount of rainwater during the wet season, especially for agricultural and domestic water supply (OAS, 1997). Ground water recharge and use of harvested rainwater for sanitary and drinking purpose is a simple and cost effective way to meet the ever-increasing water demand in urban areas (Metro-water, 2005). Rainwater is valued for its purity and softness for human consumption as well as for irrigation purposes (Gould and Nissen-Petersen, 1999). Furthermore, maintenance of the domestic rainwater harvesting system is likely to be undertaken regularly ensuring effective long-term system operation (Sutherland and Fenn, 2000; Southface, 2002). Aquaculture storage tanks for fish farming can be practiced and the nutrient rich water from these tanks may even support sustainable agriculture by reducing the use of inorganic fertilizers (Rajesh et al., 2003).

South Africa is not richly supplied with natural water resources and even the available water resources are not evenly distributed among the economic growth area (Zietsman et al., 1996). Owing to its location in the semi-arid part of the world; its climate varies from desert and semi-desert in the west to sub humid along the eastern coastal area, with an average rainfall of about 450mm per year (WRC, 2003; Backeber, 2004). As noted by WRC (2003), due to poor spatial and temporal distribution of rainfall, the natural water availability is highly variable and also in most parts evaporation exceeds rainfall.

Since traditional water supply technologies have been able to meet the needs of local populations for many centuries, the rainwater harvesting system is one of the options to ensure sustainability (Alem, 1999; Gould and Nissen-Petersen, 1999). Hence, it is necessary to take up measures to conserve and intensify the development of renewable water resources with all possible means at local and regional scale.

DOMESTIC RAINWATER HARVESTING TECHNOLOGY

The technology of domestic rainwater harvesting (DRWH) includes three main components, such as catchment surface, delivery system and storage facilities (Ariyabandu, 2003; Smet, 2003). Other possible components are filters or 'first-flush' diverters to reduce the quantity of debris entering the tank and other inlet and outlet devices to manage the water quality (Ariyabandu, 2003). As reported by Turner (2000) and DTU (2001a) the rain water harvesting reduces the time required to bring water to the household from supply points which are usually located far from the villages in many rural areas. Other benefits of rain water harvesting include reduction of soil erosion and reduced amount of valuable energy inputs as compared to the centralized water supply system.

As noted by Hailu and Merga (2002), the design work of DRWH system should take three levels of assessments into considerations such as social, technical and water demand assessments. The social assessment includes *inter alia* studying the domestic rain water harvesting practices in the community, opinion of the community on DRWH system use and the household's financial capacity to expend for DRWH system. The technical assessment looks into rainfall data, existing water sources, availability of construction materials and type as well as size of catchment surface area. The water demand assessment investigates the availability of water supply throughout the dry season in relation to the household demand.

The most common surfaces for rainwater harvesting system are the roof of the dwelling, courtyards, threshing areas, paved walking areas, plastic sheeting and trees (Ariyabandu, 2003). The roof of a building or a house is the first choice as a catchment to harvest rainfall, although additional capacity can be added by an open-sided barn (Qiang and Yuanhong, 1999; Waskom, 2004; TWDB, 2005). The roof can be made of corrugated iron sheet, asbestos sheet, tiles with a wide variety, slate, and thatch that may be made of variety of organic materials (DTU, 1999) Water quality from different roof catchments is a function of the type of roof material, climatic conditions, and the surrounding environment (Vasudevan, 2002;cited by TWDB, 2005). Water collected from crude thatch would be colored and turbid (Ariyabandu, 2003). Thatched roofs made from palm leaves such as Coconut and Anahaw palms with tight thatching are best to collect uncontaminated rainwater (Smet, 2003). Thatched roofs collection should be used only when no other alternatives are available (Hailu and Merga, 2002).

The natural soil, threshing yard and road have low efficiency in collecting rainwater (Qiang and Yuanhong, 1999). As reported by Smet (2003) and Waterfall (2004), paved catchments commonly have an overall runoff coefficient of 80%. Cement tiles about 75%, while clay tiles collect usually less and have a runoff coefficient of 50% depending on the production method. Plastic and metal sheets do best with an efficiency of 80-90%. As noted by DTU (2001a), 90% or more of the rainwater collected on the roof of corrugated iron sheet will be drained to the storage tank, if the gutter and down pipe system is properly fitted and maintained.

Gutters are part of the DRWH system that captures the rain falling on a roof and conveys it to a storage tank (Rees et al., 2000; Still and Thomas, 2002). There are wide varieties of shapes and forms of gutters ranging from factory made PVC to traditional bamboo, banana stem files, canvas and folded metals (Morgan, 1998; Rees et al., 2000; Lanka Rainwater Harvesting Forum, 2001). The most common materials for gutters and downspouts are half-round PVC, vinyl, seamless aluminum, and galvanized steel (TWDB, 2005). An ideal, gutter should be cheap to produce, efficient in capturing run-off water, easy to align and install, resistant to damage and simple to clean (Still and Thomas, 2002). Since the slightly acidic quality of rain could dissolve Lead and thus contaminate the water, Lead must not be used as gutter solders (DTU, 2001a). Canvas material is the most suitable for being waterproof and resistant to degradation by the sun and thus has a longer life than ordinary plastic sheeting (Morgan, 1998). Roof slope, roof type, roof length, roof area, intensity of rain fall, wind strength ,capacity of the gutter, inadequate number of downspouts, overhanging trees, excessively long roof distances from ridge to eave and inadequate maintenance affect the efficiency of DRWH system (Still and Thomas, 2002;TWDB, 2005). In adequate slope in gutters, leakage of joints and blockage by debris often result in spillage over the side of the gutters. Additionally, the gutter can be a breeding ground to mosquitoes and debris imparting extra bacteria and products of leaf decay to the water they convey (Still and Thomas, 2002;TWDB, 2005).

As reported by Still and Thomas (2002), the size of the gutter which gives best economy is the one that overflows when rainfall intensities reaches about 2 mm per minutes. Although intense rainfall requires guttering of relatively high flow capacity, 70 mm U or trapezoidal shape gutters are sufficient for most house roofs trapezoidal, semicircular and V-shaped gutters give somewhat similar economic performance in intercepting and conveying roof run-off water. Therefore, choice between them can be made on the basis of ease of manufacture or self-cleaning properties. V-shapes become blocked rather frequently and rectangular gutters however do not make efficient use of material. A trapezoidal or semi-circular shape gutter correctly sized for a roof slope of 22^0 will also be good for common roof slopes from 15^0 to over 30^0. The design of gutters for corrugated iron sheet (CI) roofs represents the worst case scenarios in gutter design and are adequate for other roofing types. Other components in addition to the horizontal gutters are the drop outlet, at least two 45-degree elbows, brackets, and straps to fasten the gutters and downspout to the fascia and the wall are necessary (TWDB, 2005). Gutters should be installed with slope towards the downspout and the outside face of the gutter should be lower than the inside face to encourage drainage away from the building wall.

As reported by Still and Thomas, (2002), generally, the roughness coefficients for PVC is given as 0.009~0.011. When the gutter has small slope, sediment may accumulate in the gutter itself that in turn increases the roughness. Hence, taking into account the effect of joints, 0.015 roughness coefficient is acceptable in sizing gutters. According to Gelt (2005), downspouts are located about every 6.10 m along the gutter, instead of the more common 12.20 m to ensures that heavy rains will not likely overflow the gutter.

According to Ariyabandu (2003), DRWH system must be designed with consideration of some water quality maintaining measures such as convenient first flush, covering lid, meshes and rapid water testing methods which indicate the presence of biological contamination in-situ. Leaf screen, leaf guards, funnel-type downspout filter, strainer baskets and filter socks are usually used to ensure protection of debris from entering into the storage (TWDB, 2005).

As noted by Waskom (2004) and Rees et al. (2000), first-flush devices ensure a certain degree of water quality in harvested rainwater. The first several litres of runoff from a gutter, roof, or other surface are likely to contain various impurities such as bird droppings and dust. A first-flush device prevents this initial flow from draining into the storage tank. While leaf screens remove the larger debris, such as leaves, twigs, and blooms that fall on the roof, the first-flush diverter get rid of the smaller contaminants, such as dust, pollen, and bird and rodent faeces (Rees et al., 2000). According to TWDB (2005), the quantity of first flush to be diverted determined by the amount and the nature of accumulated contaminants, intensity of the rain event, the slope and smoothness of the collection surface.

As reported by the TWDB (2005), roof washer, placed just ahead of the storage tank, filters small debris for potable systems and also for systems using drip irrigation. Usually, the box is placed on top of the tank and from which the owner can access via a ladder. Roof washers consist of a tank, usually between 113 and 189 liters capacity which can handle rainwater from 135 and 315 m^2 catchments respectively. The washer must be cleaned as it regularly becomes clogged and restrict the flow of water; and also clogged filters become breeding ground for bacteria as well.

STORAGE FACILITIES

According to DTU (2001a) and TWDB (2005), the storage tank accounts for a large fraction of the cost of DRWH system. The cost of storage construction has to be reduced either by reducing the material of construction or substituting cheaper materials as well as by mass production and make use of existing containers so that poor households will be able to have a storage structure. The variables, such as the amount of rainwater, the water demand, the projected length of dry spells without rain, the catchment surface area, aesthetics, personal preference, and economy or budget are some of the factors that determine the size of the storage tank (TWDB, 2005). Affordability is a strong function of tank size and tank design (Rees et al., 2000). Ideally, the DRWH collection system should involve basic construction techniques, be inexpensive to maintain, and have a long functional life span (Pacey and Cullis, 1985; cited by Turner, 2000). The storage tank has two parts such as a water store and a set of ancillaries to lead water into and out of the tank (DTU, 2001a). If the system is designed well, it should provide good safe source of drinking water at a relatively low cost when compared to the centralized water supply system (DTU, 2001a).

The storage facilities such as mortar jars, ferro-cement jars, cylinders and cuboid shapes of plastered brick, oil drums, corrugated iron cylinders, reinforced concrete tanks or for richer households plastic drums are commonly practiced in third world countries. Although, the choices of tank construction materials and storage size depends upon the space availability, soil condition and economical factors, a storage tank should be sufficient in size, strong, impermeable, durable and it should also have the ability to maintain the water quality (Gould and Nissen-Petersen, 1999;DTU, 2001a;Ariyabandu, 2003).

Generally, the basics of potable water storage tank must satisfy the following: It must be opaque so that algae growth inhibited; it should be free from toxic substances; should be covered to discourage mosquito breeding and be accessible for cleaning as well (TWDB, 2005). According to Turner (2000), the construction of tank may be above the ground or below the ground surface depending upon the choice of the beneficiaries and ease of construction. Generally aboveground storage are cheap or can be manufactured locally or can be purchased off the shelf; cracks or linkages are easily inspected; can be manufactured from a wide variety of materials and easy to construct using traditional materials. On the other hand, the aboveground storage requires a space, generally expensive, prone to weather attack, and failure can be dangerous as it can burst and damage the surrounding area. Underground water storage tanks (Cistern) are generally cheaper to construct and they are advantageous in using the surrounding ground as a support allowing thin wall thickness. It does not occupy space aboveground level. On the other hand, water extraction is more problematic often requiring a pump, leaks or failures are more difficult to detect, contamination from groundwater is more common, tree roots may damage the structure, and there is danger to children and small animals, if tank cover is left open. Flotation of the cistern may occur, if groundwater level is high and cistern is empty.

Surface tanks are commonly made of brick, ferro-cement, concrete blocks, plastics, wood, mortared stones and galvanized iron (DTU, 2001b; Motherearthnews, 2005). Brick is a locally manufactured, widely used, readily available material which is ideally suited to wall construction, but not quite so well suited to conventional larger volume tank construction (Rees, 1999). The suitability of brick for low cost tank manufacturing can be improved by using external steel reinforcing to give additional hoop strength to cylindrical brick tanks (Rees, 1999). The reinforced brick tank costs twice as much as the ferro-cement tank, although the cost per m³ reduces with increased capacity (Hasse, 1989). Example of brick tank is shown as in Figure 1.

Figure 1 Single skin externally reinforced burned brick tanks (Rees, 1999)

As reported by Hasse (1989), Turner (2000) and Motherearthnews (2005), ferro-cement is produced by applying cement mortar composed of fine aggregate and cement plastered over wire mesh reinforcement.

The wire mesh aperture typical size is 15mm x 15mm (Turner, 2000). The property of ferro-cement is more elastic than reinforced concrete while the durability is the same (Hasse, 1989). Ferro-cement is a low-level technology and is labor intensive; it is therefore ideally suited for water tanks in rural areas of developing countries (Turner, 2000). Ferro-cement is well suited for thin wall structures such as water tanks because the distribution and dispersion of reinforcement provides good cracking resistance, higher tensile strength-to-height ratio, ductility, and impact resistance (Turner, 2000). Figure 2 shows an in-situ construction of ferro-cement.

Figure 2 Ferro-cement tank under construction (Turner, 2000)

As reported by DTU (2000b), the stabilized soil block tanks (SSB) are one of the many ancient techniques that have been passed on from generation to generation. It is cheap and particularly suited to drier climates, although it is practiced in many humid areas. Suitable earth is mixed with a small percentage (5–10%) of cement and is compacted using a manual or hydraulically assisted ram or press. Soil varies widely in quality and content and so experimentation is required to find a suitable soil. The production of SSB and construction of semi-below ground tank using SSB are shown as in Figures 3 and 4.

Figure 3 Stabilized soil block manufacturing in Africa(DTU, 2000b)

Figure 4 Partially below ground SSB tank under construction (DTU, 2000a)

The jar, which is also used as a storage tank in many African countries, is shown as in Figure 5.

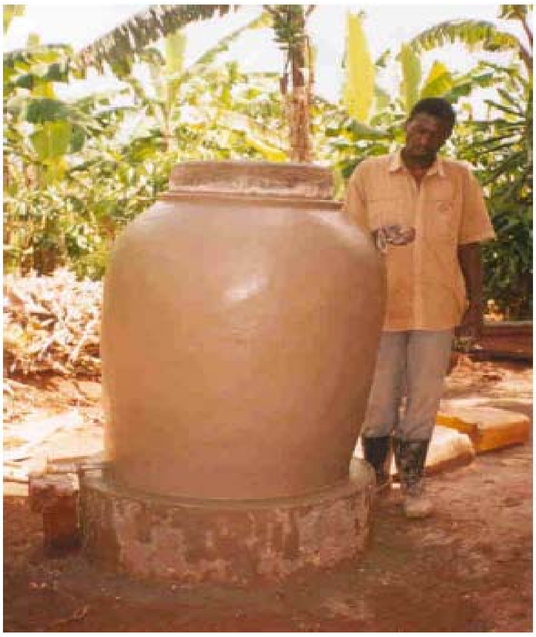
Figure 5 Water storage jar (DTU, 2000a)

The water storage tank requires the most careful design to provide optimal storage capacity while keeping the cost as low as possible (DTU, 1999). Usually, the main calculation when designing a DRWH system is to size the water tank correctly to give adequate storage capacity as the water demand varies widely with house occupancy, social calendar and season (DTU, 1999;Thomas, 2002). The storage requirement is determined by a number of interrelated factors, such as local rainfall data and weather patterns, catchment area, number of users and consumption rates (DTU, 1999). An adequate amount for a rural community is estimated to be 20 liters of safe water per person per day (National Council for Science and the Environment, 1993; WHO, 1996; cited by Whitehead, 2001).

As reported by DTU (2001b), the pressure exerted by the water stretches the tank walls. This is unfortunate as many of the materials traditionally used for tank construction are only 10% or 20% as strong in tension as they are in compression. The structure failures of storage tanks can be stated in three possible modes such as cracking and leaking, which probably progresses to failure, leaning over due to inadequate foundations and bursting with fragments flying some distance, hence damaging the nearby assets. The design consideration should include design to resist tensile stresses, whether vertical due to bending, radial hoop stresses and shear stresses acting through the wall and use of adequate wall thickness and adequate material of tensile strength. There is also a cyclic stresses due to the water rising and falling inside the tank and stress due to the material shrinking during construction. Either using dry mortar mix or low cement content reduce shrinkage, although these might have constrains by reducing the workability and the strength of the mortar. Spreading the cracks instead of having one big crack is advantageous to reduce the leakage. This can be achieved by putting a metal or fiber mesh inside the mortar so that splitting one wide crack into two narrow ones will reduce the leakage. Shrinkage has to be counter acted through modifying the render material adding slightly expansive components.

As described by DTU (2001b), renders of cement or lime mortar and plastic sheeting are commonly used in water tanks when the tank itself is constructed of rather permeable materials such as brick, stabilized or unsterilized soil. The render primary purpose is water-proofing, for which it should have a sufficiently low permeability to protect the main tank material and to reduce water loss through walls to a tolerable level. The render may have secondary functions such as reducing the roughness of a masonry surface so that it can be easily cleaned down, and providing a little stability to the wall behind it. Illustration of plastic sheeting is shown as in Figure 6.

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Figure 6 Lining tanks with plastic bags (DTU, 2001b)

LOW COST PUMPS

To lift up water from the cistern or aboveground storage into an irrigation field, an affordable and low cost pump is essential to replace manual lifting and carrying water (Kay and Brabben, 2000; Brabben, 2001). As reported by Whitehead (2001), many existing pumps may be regarded as over designed and too expensive to incorporate into a DRWH system. It is difficult to maintain because of the high cost of spares, and the spares may be stocked some distance from the pump location. Pumps for use on small scale irrigation farms need to be durable, endurable, high hydraulic efficiencies, sufficient lifting height, easy of manufacturing with minimum tools and skill and that the material be available in most local hardware outlets and markets.

As reported by EWW (2005), the labor-intensive rope and bucket method of lifting water for irrigation is the major production barrier for vegetable farmers in Africa. Irrigation time can be decreased by about a third or to 4 hrs per day, if the farmer uses Treadle pump while allowing the typical farmer to work on double garden size (Kedge, 2001; EWW, 2005). Therefore, a Treadle pump is gaining favor throughout Africa for rainwater harvesting and the reuse of gray water (EWW, 2005).

The Treadle pump is a human powered water pump that can lift irrigation water from the ground or the top surface (DTU, 1991). Treadle pump (TP) is simple, convenient for installation, suitable for irrigation of 0.5 ha of land for vegetables, cash crops and high value rice, easy foot operated, can extract water from 7 m depth, can lift up to about 12 m head and capable of pumping 5000 liters of water per hour (Sanmugnathan et al., 2000; SES, 2003; AOV International, 2005; EWW, 2005).

As reported by Chancellor and O'Neill (2000), the TP was invented in the late 1970s in Bangladesh. Since then, the technology has been disseminated in many parts of the world from south East Asia to West Africa. TP has been adapted for use in irrigation where much greater volumes of water are needed (Kay and Brabben, 2000; Bennet, 2002). This simple, human-powered device can be manufactured and maintained at low-cost in rural workshops, relatively easy to repair, spare parts are readily available and improvisation is possible in developing countries (Chancellor and O'Neill, 2000;Kay, 2001). As reported by Kay (2001), the experience of introducing TP into Africa serves as a useful model for the introduction of irrigation technologies such as sprinkler and drip irrigation as these give credit to increase crop yields as well as an increase in area of farmland.

The principle of TP is based on suction lift using a cylinder and piston to draw water from a source below ground level, two pistons are used, and each connected to a treadle (DTU, 1991; Kay and Brabben, 2000). The operator stands on the treadles, pressing the pistons up and down in a rhythmic motion as shown in Figure 7.

Figure 7 A farmer pumping pressure Treadle pump (Kedge, 2001).

There are two types of TPs, the suction pump and pressure pump (Kay and Brabben, 2000). Suction pump was made in Bangladesh to farmers who needed to lift large quantities of water through shallow lifts of 1-2 m and discharge it over a spout into a canal for gravity irrigation (Kay, 2001). The pressure pump works exactly on the same principles but the delivery ends was modified so that water could be fed into a pipe under pressure for sprinklers or hoses or storage tanks (Kay and Brabben, 2000). As noted by Kedge (2001) and EWW (2001), suction pumps can raise water up to about six to seven meters head at a flow rate of up to 2 liters per second, depending on the pump and the height above sea level. Pressure pumps can then add an additional seven meters to the head on the delivery side, giving a total lift of about fourteen meters. Although the flow rate of pressure pump is usually less and depends on the inlet and outlet pipe sizes and cylinder diameter, it is usually capable of pumping one liter per second (Kay, 2001;Kedge, 2001). The pressure pump can push up to a distance of about 150 meters depending on friction losses and also better at lifting water from deeper sources than the suction pump (Kedge, 2001). The development of pressure pump came from the needs of African farmers who often have to lift water from deeper sources and irrigate undulating land with sprinklers or hosepipes (Kay and Brabben, 2000). As noted by Whitehead (2001), the limits for suction lift pumps in theory is 10.4m at sea level, but in practice, 6.5m is a more practical limit. Suction head also affected by change in temperature. An increase of 10^0c in temperature decreases the suction head by 7%. Generally, for every thousand meters of elevation there is a loss of 1m suction head. As described by Chancellor and O'Neill (2000), the typical rural peasant can produce a sustainable power of 40 watt and a comfortable discharge rate would be around 50 liters per minute at a head of 3 m. At a head of 5 m, the discharge drops to 28 liters per minute.

In case of ground storage thanks low level hand pumps may also be used for DWRH systems to extract water for drinking and domestic use (Whitehead, 2000). Figure 8 shows hand pump while extracting water from partially buried storage tank.

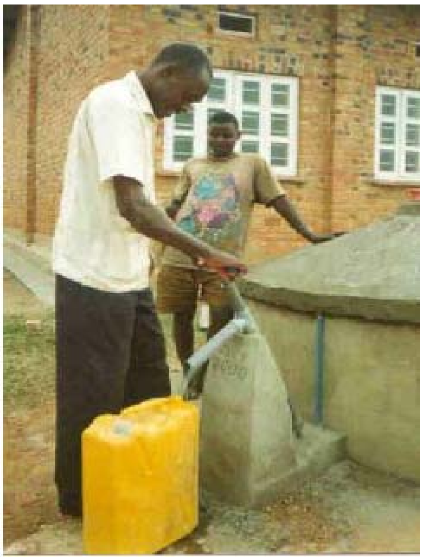

Figure 8 Hand pump (Whitehead, 2000)

AQUACULTURE FOR FISH FARM

The harvested rainwater may also be used for fish farm activities depending up on the availability of rainwater amount. Fish production is compatible with irrigation in integrated systems, which are based on dual use of the same water, first for fish production and afterward for irrigation (Dan Cohen, 1996). Rajesh et al. (2003) reported that the nutrient rich water from aquaculture tanks might even support sustainable agriculture by reducing the use of inorganic fertilizers. Species such as shrimp, Tilapia, Carp, Catfish, Salmon, Trout, Sea Bream, Cobia, Sturgeon, Arctic Char, Perch, Mussels, Clams, Oysters, Scallops, Conch and many other aquatic organisms are all being actively farmed today (AquaSol, 2003).

As reported by Dan Cohen (1996), the scale and output of the aquaculture facilities are designed according to water availability so as to cause no interference in the irrigation schedule. During dry season owing to withdrawn water for irrigation, fish biomass may increase in the reservoir, resulting in an increased concentration of nitrogenous compounds from fish excretion. This, in turn, may cause increased algal growth and creates problems both for irrigation (e.g. clogging of filters) and for the fish (growth inhibition due to anoxic conditions). Effective fish growth requires input of oxygen, removal of wastes, and elimination of ammonia excreted by the fish. The bacterial population are useful in the reservoir in such a way that they carry out heterotrophic decomposition of the organic waste, followed by nitrification, de-nitrification. The nitrate formed assimilated by the algae, which supplements the diet of the fish. Fish wastes become fertilizers for the irrigated crops and the reservoir serves as a natural biological filter, at no cost to the grower (Dan Cohen, 1996; Rajesh et al., 2003).

SUMMARY

DRWH technology is an ancient technology by which the scarce domestic water resource can be met in poor households. Adequate and cheap DRWH system may also encourage poor households to practice fish faming and irrigation of garden vegetables. Additionally, DRWH system is advantageous in recharging ground water and preventing soil degradation.

Poor households need cheaper yet adequate size of tank as they cannot afford to buy owing to their high cost and transportation difficulties. Since the large fraction of DRWH system is incurred on the storage facilities, the storage tank needs to be designed carefully. The design and the sizing should meet the available volume of water harvest from the catchment surface. In order to maximize the efficiency of rain water, adequate gutters, down spouts and storage tank should be designed in the system. Gutter and storage tanks should be maintained regularly so that blockage and bacterial breeding may be avoided. Clean and healthy water consumption can be maintained by installing water cleaning device both in the storage tank and in the downspouts. Algal growth, mosquito breeding and safety of children's should be insured in designing the storage tank. Low cost pumps are important in reducing the energy input to carry water to the irrigation fields. Fish farm activities can be augmented in rain water harvesting technology as it is important for protein production.

In designing DRWH system, the specific water consumption rate and size of irrigation plots should be studied. Material of construction, the easy of the skill required, durability of the tank are main factors considered to choose tank construction materials. Cheap storage construction materials should be identified in the villages so that inexpensive and community tailored DRWH system could be adopted.

Finally, the DRWH system can augment any other water supply systems and add towards the increase of water consumption that might be constrained by long distance walk. Hence, restoring the traditional practices of water harvesting system using scientific methods is an alternative resource to meet the looming water crisis.

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