Chapter 14

ALTERNATIVE WATER SUPPLY OPTIONS

14.1 Deep Tubewell

The aquifers in Bangladesh are stratified and the deep aquifers are separated from the shallow ones by impermeable layers so arsenic-free groundwater is found in the deep aquifers except for a very few places in the north-western region. In the case of tested water samples collected from deep tubewells (strainer depth. 150m), only 1% and 5% samples (Table 14.1) exceed the allowable limits of 50mg/L and 10mg/L, respectively. These deep tubewells are more expensive compared to shallow tubewells, but they appear to be cost-effective compared to other options presented in Table 14.2.

Table 14.1: Arsenic contamination situation of tubewell in Bangladesh

Total number (million) of tubewells in the country	8.61 (100)
Total number (million) of tubewells tested for As	4.73 (55)
As affected shallow tubewells above 0.05 mg/L	27%
As affected shallow tubewells above 0.01 mg/L	46%
As affected deep tubewells (strainer depth . 150 m) above 0.05 mg/L	1%
As affected deep tubewells above 0.01 mg/L	5%

Table 14.2: Installation, operation and maintenance costs of selected presently operating water supply options

Technological option	Unit cost (US$)	Population served	Installation cost (US$/person)	Operation and maintenance cost (US$/person/yr)
Rainwater harvesting	106	5	21.2	.34
Dug well	560	120-150	4.0	.01
Manikgonj AIRP including overhead tank	223,534	60000	3.7	-
PSF	560	150-200	3.2	.04
Small-community type AIRP	140	40-50	3.1	.07
Deep tubewell	775	250-300	2.8	.05
Shrouded tubewell	175	100-120	1.4	.10
Shallow tubewell	105	120-150	.8	.06

Source: Rahman et al. 2003

14.2 Shallow Shrouded Tubewell and Very Shallow Shrouded Tubewell

In many areas of Bangladesh, groundwater with low arsenic content is available in shallow or in very shallow aquifers composed of fine sand. The particle sizes of the soil are not suitable for installing a normal tubewell. An artificial sand packing is required around the screen of the tube well to get water through these very fine-grained aquifers (Figure 14.1). This artificial sand packing is called shrouding. Shrouding increases the yield of the tubewell and prevents the entry of fine sand into the screen.

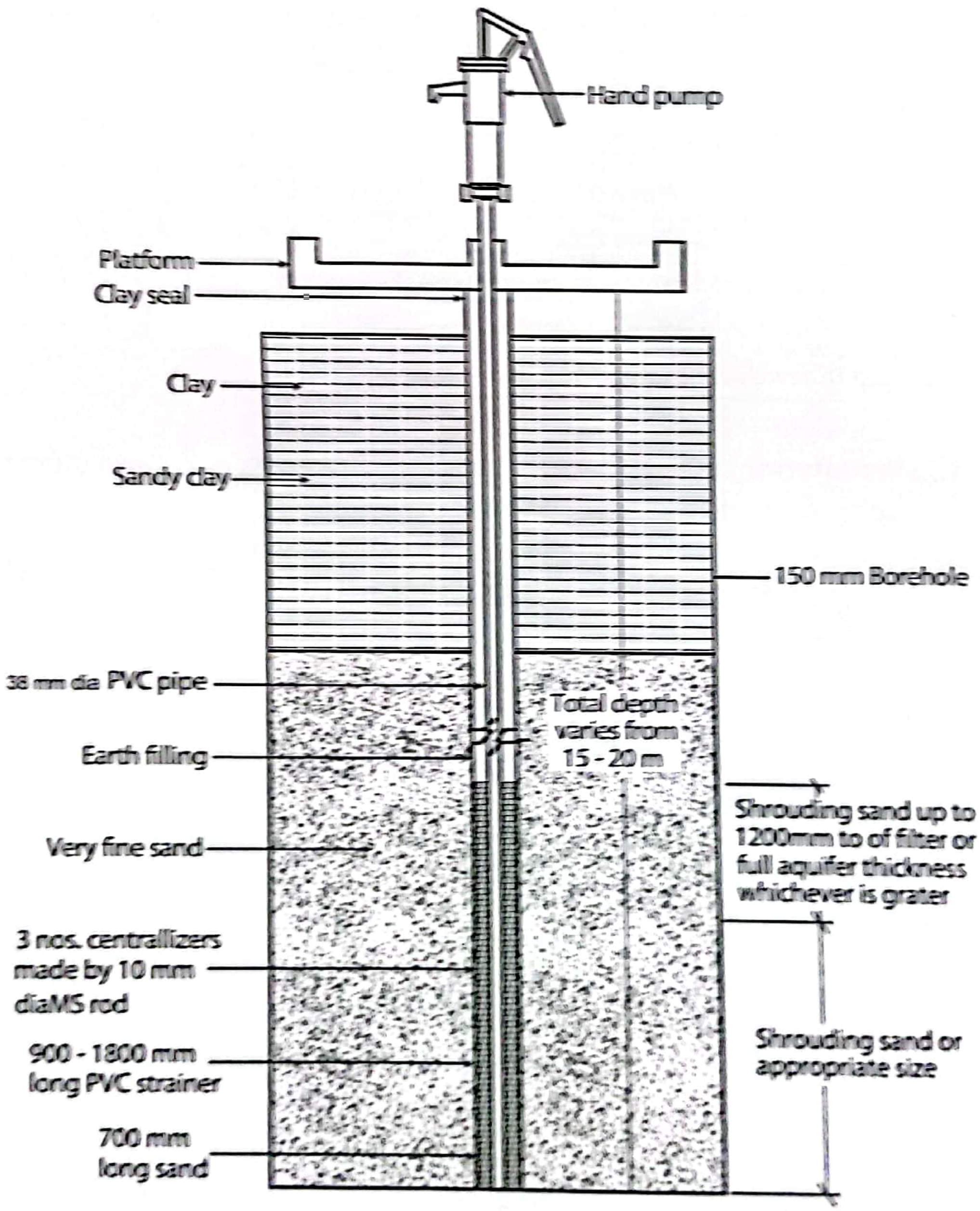


Figure 14.1: Shallow shrouded tubewell.

14.3 Infiltration Gallery/well

In this technology water is allowed to infiltrate through a layer of soil/sand and so it is significantly free from suspended impurities including microorganisms usually present in surface water. Infiltration galleries can be constructed near perennial rivers or ponds. Surface water being the main source of water in the gallery/well, it is free from arsenic. If the soil is impermeable, well-graded sand may be placed in between the gallery and the surface water source for rapid flow of water. Improvement of water quality requires good sanitary protection and disinfecting by chlorinating. This technology is also discussed in the article 4.12.

14.4 Dug Well

The dug well is the most traditional method of withdrawal of groundwater in many countries of the world for domestic water supply. But degradation of dug well water quality by bacterial contamination is very common. Percolation of contaminated surface water is the most common route of pollution of well water. Satisfactory protection against bacteriological contamination is possible by sealing the well top with a watertight concrete slab (Figure 14.2). Water may be withdrawn by installation of a manually operated hand pump rather than the conventional bucket and rope, and then the system becomes more expensive (Table 14.2)

14.5 Construction

Dug wells are lined with brick or stone masonry, cast-in-situ concrete or pre-cast concrete rings. Lining provides protection against caving in and collapse of soil during construction, and a seal against polluted water seeping from the surface into the well during operation. The most common and low-cost method of construction of dug wells is manual excavation from the inside. Removal of soil beneath the well allows the well to sink down due to its own weight. A circular wedge-shaped concrete shoe under a pre-cast concrete ring or masonry work as shown in Figure 14.3 prevents uneven settlement and a slightly larger shoe facilitates sinking without friction along the outside faces of the rings or masonry works. The sinking of the well is continued until the desired level is reached. The construction of a well under the water table requires drying of the well by pumping. The wall below the water table may have perforations for entry of water

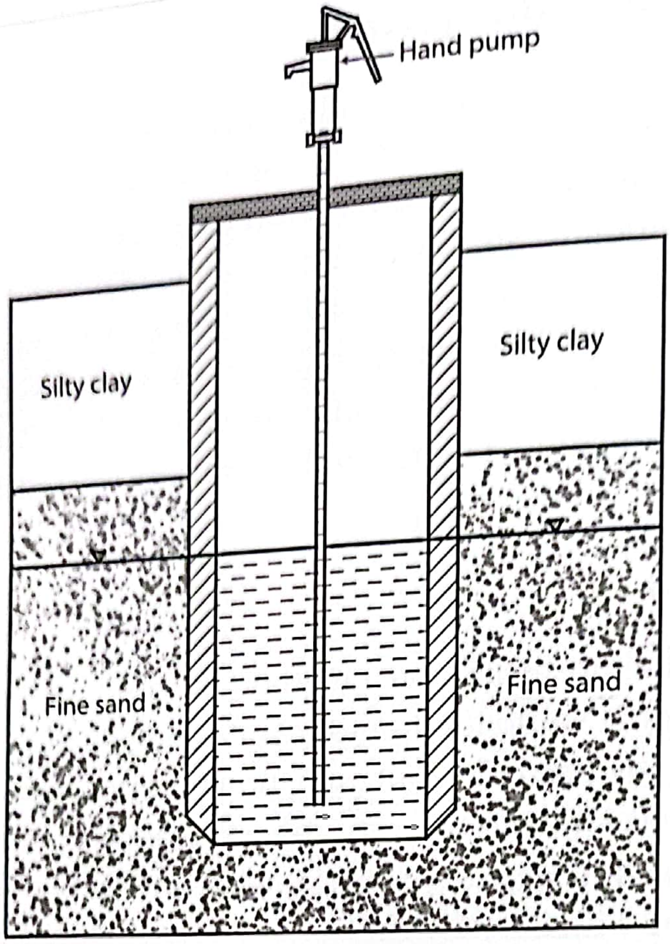


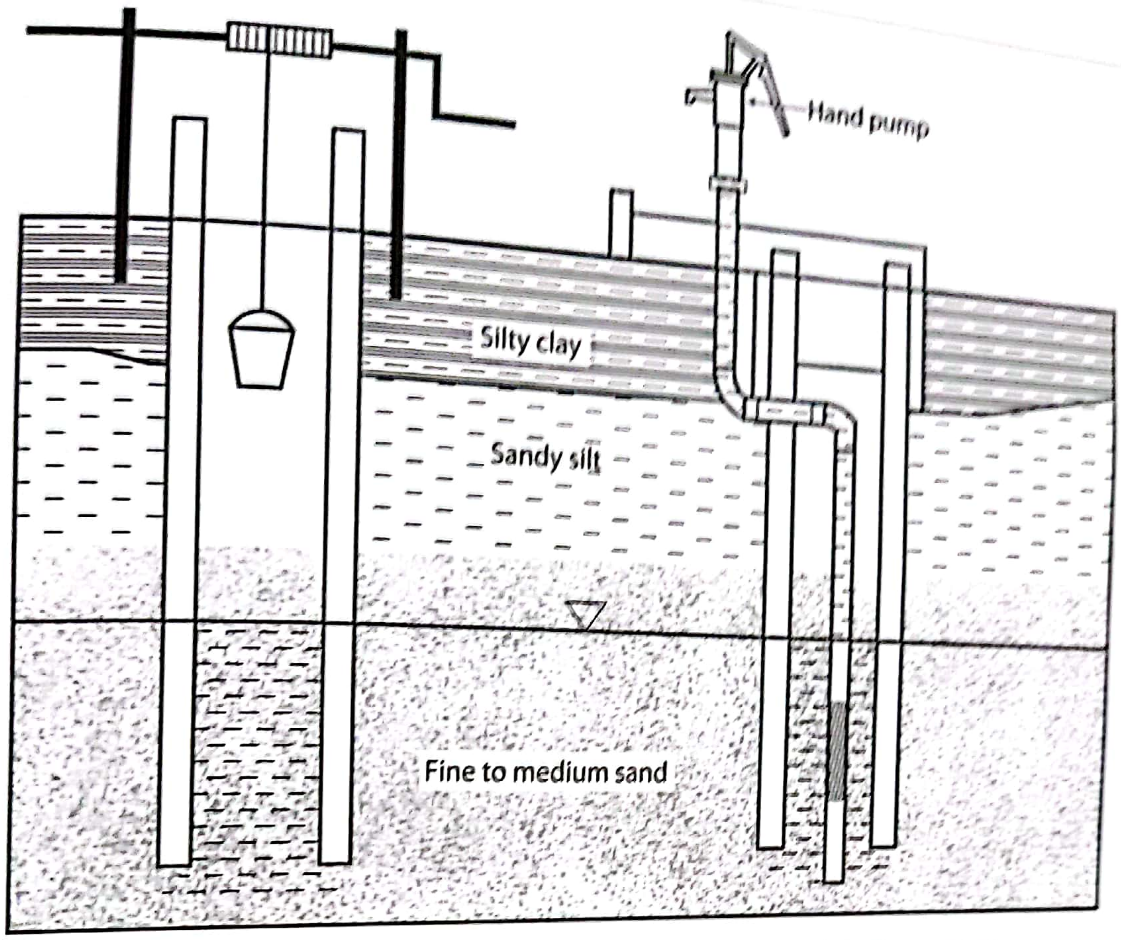
Figure 14.2: Dug well

in the well. The dry season, having the lowest water table, is the ideal time for construction of a well.

In case of loose materials, the space between the outer wall of the well and the soil is filled by itself, but in cohesive soil the space is to be filled by appropriate materials. If the walls are made perforated for the entry of water, the space should be filled with coarse sand up to the height of the perforated wall. The upper part of all wells must be filled with impermeable clay to prevent entry of contaminated surface water. Placement of 100 mm of coarse sand below 100 mm of gravel at the bottom of the finished well will provide clear water even during turbulent conditions.

14.6 Sanitary Protection

It is very difficult to protect the water of the dug well from bacterial contamination. Percolation of contaminated surface water is the most common route of pollution of well water. The upper part of the well lining and the space



(a) Conventional Dug Well

(b) Well with Sanitary protection

Figure 14.3: Conventional dug well and dug well with sanitary protection

between the wall and soil should be properly sealed. The well lining should be extended at least 0.5 m above the ground to form a 'head wall' around the outer rim of the well. A concrete apron, about 2 m in width, should then be constructed on the ground surface extending all around the outer rim of the well. The apron prevents entry of contaminated used water at the well site by seepage into the well. Water in a dug well is very easily contaminated if the well is open and the water is drawn using bucket and rope. Satisfactory protection against bacteriological contamination is possible by sealing the well top with a watertight concrete slab. Water may be withdrawn by installation of a manually operated handpump. Water in the well should be chlorinated for disinfection after construction. Disinfecion of well water may be continued during operation by pot chlorination as stated. In a completely closed dug well, the inflow of water may be actuated by suction created due to withdrawal of water from the well.

In the Chittagong hilly areas, Sylhet and northern parts of Bangladesh, construction of handpump tubewells is not always possible due to adverse hydrogeological and stony soil conditions. Construction of protected dug wells can be a good option for water supply in these areas. Dug well water is free from iron and arsenic, hence dug wells are a potential source of groundwater in acute arsenic and iron problem areas in Bangladesh.

14.7 Pond Sand Filters

Pond sand filters (PSFs, Figure 14.4) are basically scaled-down slow sand filters for community water supplies. They were initially developed in Bangladesh to treat low-saline pond water for domestic water supply. Slow sand filters are

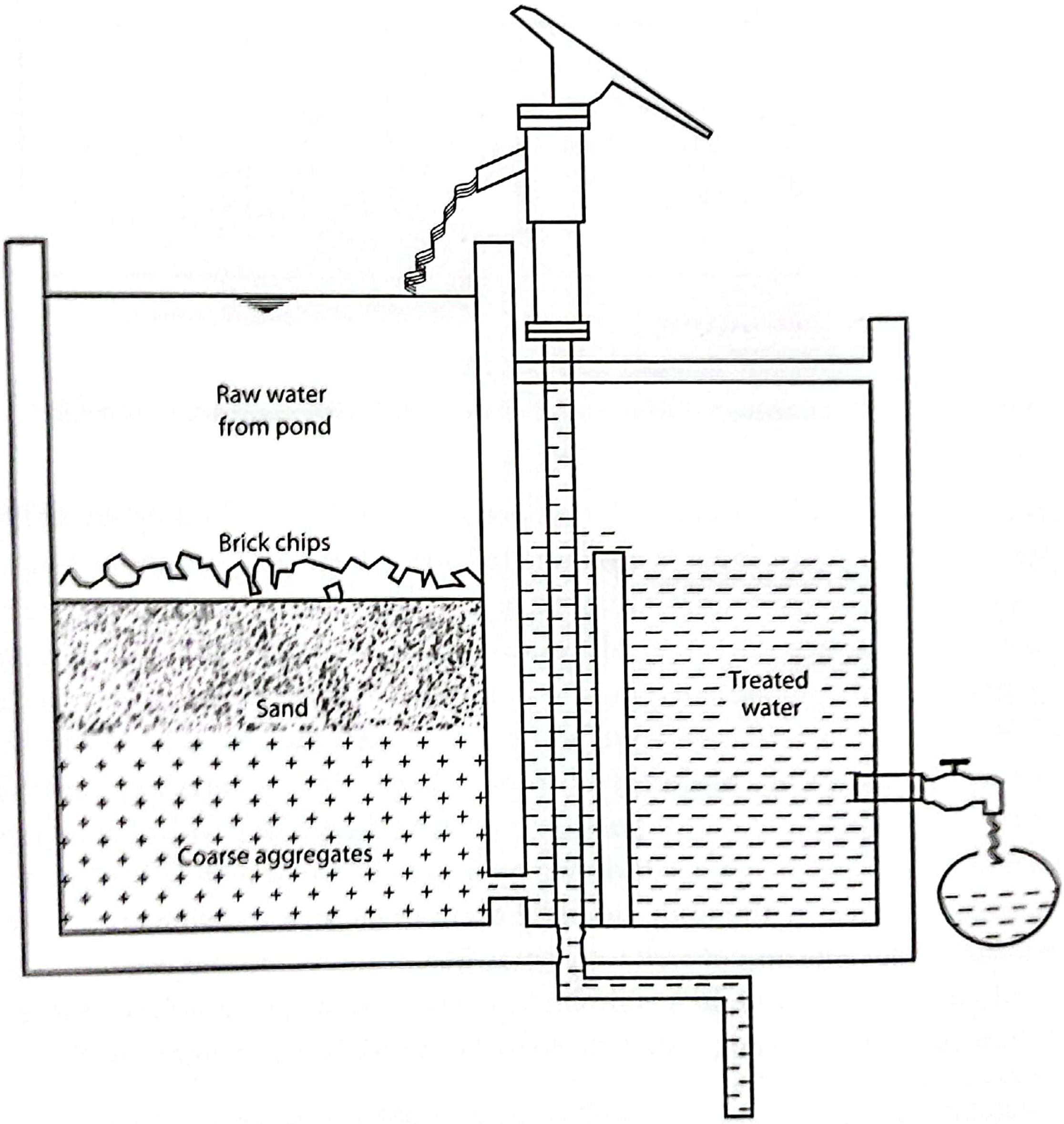


Figure 14.4: Pond and sand filter

installed near or on the bank of a pond, which does not dry up in the dry season. The water from the pond is pumped by a manually operated hand tubewell to feed the filter bed, which is raised from the ground, and the treated water is collected through tap(s). It is tested and found that the treated water from a PSF is normally bacteriologically safe or within tolerable limits. On average, the operating period of a PSF between cleaning is usually two months, after which the sand in the bed needs to be cleaned and replaced. The treated water may require chlorinating to meet drinking water standards. The average installation, operation and maintenance costs of a typical PSF are shown in Table 14.2.

14.8 Conventional Surface Water Treatment Plant

This may include slow sand or rapid sand filtration process. Surface water is arsenic-safe but often contains pathogenic organisms of immediate health concerns, and perennial water sources are not available in many places in Bangladesh and the investment cost is also high.

14.9 Household/pitcher Filters

Pitcher filters are constructed by stacking a number of pitchers (Kolshis), one above the other, containing different filter media as discussed earlier. Raw water is poured in the top Kolshi and filtered water is collected from the bottom one. Full effectiveness of the filtration process is obtained if the media remain in water all the time. Experimental units constructed in Bangladesh and in other countries show that the residual coliform bacteria present in the filtered water may vary from a few to several hundred (Rahman, Rahman et al. 2003). However, improvement in general water quality by household filters is remarkable.

14.10 Solar Disinfection

This is a natural process of elimination of disease-producing microorganisms using solar energy. If solar radiation is allowed to penetrate the water in a thin layer, the water is disinfected by the combined action of ultraviolet rays and temperature. If water in a transparent bottle is exposed to full sunlight for about 5 h the water is completely disinfected (EAWAG-SANDEC 1998). This method is not suitable for treatment of large volumes of water containing high turbidity.

14.11 Rainwater Harvesting

In some areas of the coastal region in Bangladesh with high salinity problems, about 36% of households have been found to practise rainwater harvesting in the rainy season for drinking purpose (Hussain and Ziauddin 1989). In the present context, rainwater harvesting (Figure 14.5) is being seriously considered as an alternative option for water supply in Bangladesh in arsenic-affected areas. In the context of Bangladesh there are a number of advantages in favour of considering rainwater harvesting as an alternative technology. The quality of rainwater is

Figure 14.5: Rainwater harvesting

usually good. Water is available at the point of demand and is suitable for scattered settlements. Locally available manpower and physical resources can be utilised for the development and construction of the plants. Since the water stored in the plant is situated at a higher elevation, no additional cost is involved for distribution or to send it to the users' end. There are, however, shortcomings regarding the quantity, which is limited by the rainfall, and the storage system is expensive (Table 14.2). There are two main constraints in development of a completely rainwater based water supply system:

- Available of suitable catchment area and
- The need for larger storage tank.

A large catchment for rainwater collection is needed if the total water supply is based on rainwater. Again a larger storage reservoir is required for unequal distribution of rainfall throughout the year. The advantages and disadvantages of rainwater collection systems over the other water supply schemes are presented in Table 14.3.

Table 14.3: Advantages and disadvantages of rainwater collection system

Advantages	Disadvantages
• The quality of rainwater is comparatively good • The system is independent and therefore suitable for scattered settlements • Local materials and craftsmanship can be used in construction of rainwater system • No energy costs are incurred in running the system • Ease in maintenance by the owner/user • The system can be located very close to the consumption points	• The initial cost may prevent a family from installing a rainwater harvesting system • The water availability is limited by the rainfall intensity and available roof area • Mineral-free rainwater has a flat taste, which may not be liked by many • Mineral-free water may cause nutrition deficiencies in people who are on mineral deficient diets • The poorer segment of the population may not have a roof suitable for rainwater harvesting

14.12 Rainwater Availability

Rainwater is available in adequate quantities in Bangladesh. The distribution of rainfall is that relatively higher rainfalls occur in the eastern part of the country and the highest rainfalls occur in the north-eastern region and eastern part of the coastal area. The lowest rainfall, less than 1500 mm per year, occurs in the western part of Bangladesh. In the coastal and hilly areas, with a greater fresh water source problem, rainfall is higher, which is favourable for rainwater harvesting.

A ten-year rainfall pattern based on the mean rainfall intensity recorded in 28 stations for the period from 1987 to 1996 is shown in Figure 14.6. It appears that the average yearly rainfall in the country during 1987-96 varied from 1950 to 2800 mm, i.e. 1.95 to 2.80 m^3 of rainwater was available per m^2 of catchment area each year for development of a rainwater based water supply system. However, there are some losses in the collection system. The available rainwater can be estimated by the equation

$$Q = CIA \qquad 14.1$$

Where Q is the total quantity of rainwater available in m^3/year, C is the coefficient of available runoff, I is the rainfall intensity in m/year and A is the catchment area in m^2.

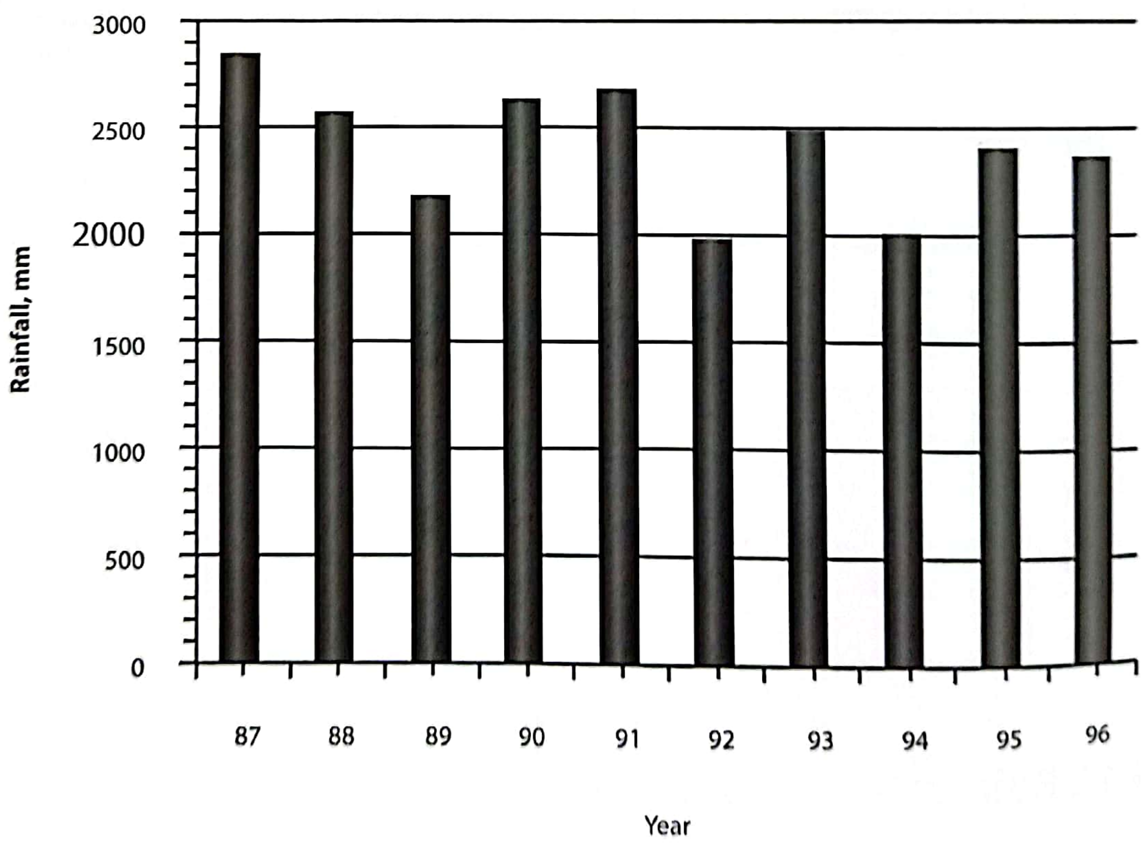


Figure 14.6: Variation of annual rainfall in Bangladesh

14.13 Rainwater Catchment

The catchment area for rainwater collection is usually the roof, which is connected to a gutter system to lead rainwater to the storage tank. Rainwater can be collected from any type of roof, but concrete, tiles and metal roofs give comparatively cleaner water. The GI sheet roofs commonly used in Bangladesh perform well as a catchment area. A thatched roof can also be used as catchment area by covering it with polyethylene, but it requires good skills to guide water to the storage tank. In coastal areas of Bangladesh, a cloth fixed at four corners with a pitcher underneath has been found to be used during rainfall for rainwater collection. The minimum catchment area *A*, required for the collection of rainwater for *N* number of people supplied with *q* litres per capita per day (lpcd) of water can be derived from equation 14.2

$$A = 0.365\,qN/CI \qquad 14.2$$

About 25% of the rainwater may be assumed to be lost by evaporation and by washing the catchment area. The catchment area is usually washed using first rain, which produces inferior quality rainwater. For an average annual rainfall of 2.4 m/yr, as indicated in Figure 14.6 and a coefficient of runoff of 0.75, equation 9.3 can be written in the following form:

$$A = 0.203qN \qquad 14.3$$

The poorer segment of the population is in a disadvantageous position with respect to utilization of rainwater as a source of water supply. This group of people has smaller thatched roofs or no roofs at all, to use as a catchment for rainwater collection. The use of land surface as a catchment area and an underground gravel/sand packed reservoir as a storage tank can be an alternative system of rainwater collection and storage. In this case, the water has to be channeled towards the reservoir and allowed to pass through a sand bed before entering into underground reservoirs. This process is analogous to recharge of underground aquifers by rainwater during the rainy season for utilization in the dry season.

14.14 Storage Tank

The unequal distribution of rainfall over the year requires storage of rainwater during the rainy season for use in the dry season. The minimum volume of the storage rainwater tank *V*, required for rainwater can be computed by the equation:

$$V = 0.365 fqN \quad 14.4$$

Where f is the fraction of total available rainwater required to be stored for consumption at a constant rate throughout the year. The total annual rainfall in 1996 as shown in Figure 14.6 is approximately equal to the average annual rainfall of the last ten years. The monthly distribution of average rainfall in 1996 shown in Figure 14.6 is assumed to represent the average condition. The rainwater availability mass curve in Figure 14.7 has been constructed assuming that the cumulative consumption/demand at a constant rate is equal to total available rainwater.

The mass curve has been prepared assuming that 75% of the rainwater would be available. It may be observed that there is a shortfall of 0.48 m^3 in the dry periods and an excess of 0.24 m^3 during rainy season. For full utilization of rainwater potential, a storage tank with capacity 0.72 m^3 (40% of the available rainwater) is required for uninterrupted water supply at a constant rate throughout the year. However, if only drinking and cooking water is harvested, the sizes of the storage tank and catchment area would be smaller and within an affordable range for a family. Substituting f = 0.4 in equation 14.4 for representative rainfall distribution of 1996, the minimum volume of the storage tank required for rainwater becomes:

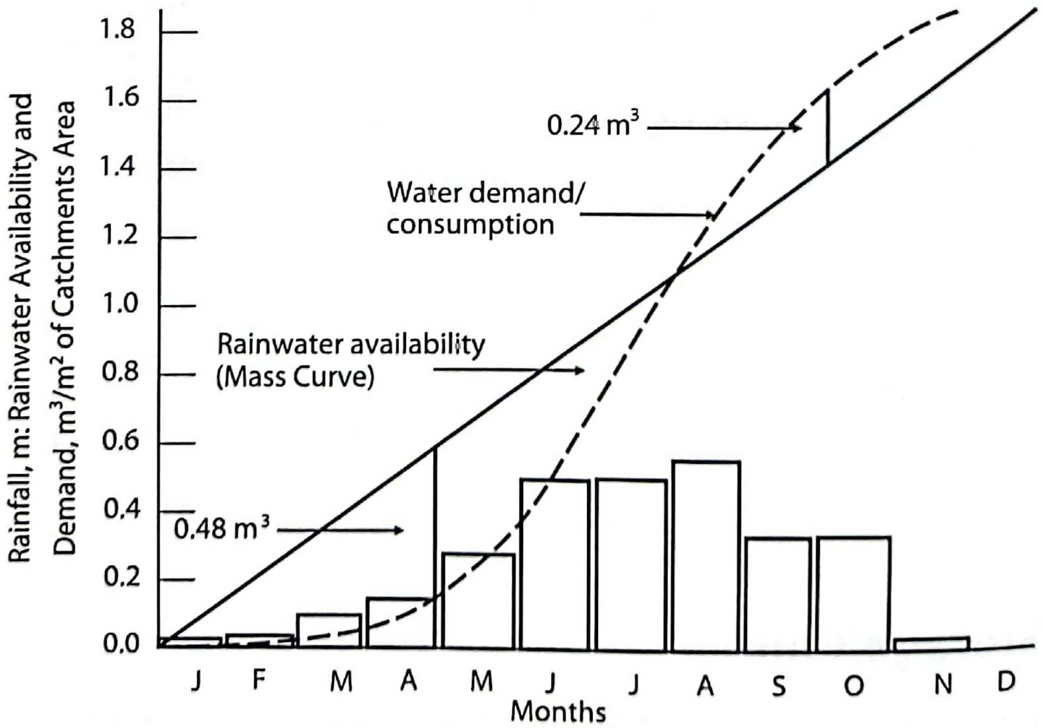


Figure 14.7: Rainfall intensity, cumulative rainwater availability and demand

14.15 Conclusion

This chapter contains the alternate water supply options mostly suitable for rural Bangladesh, as the climate change prone country suffers a lot on drinking water issue. The AILA cyclone prone area is still suffering from available drinking water where these alternate sources of water have immense value to the local people. However, these options need economic support from home and abroad to promote uptake.

Reference

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