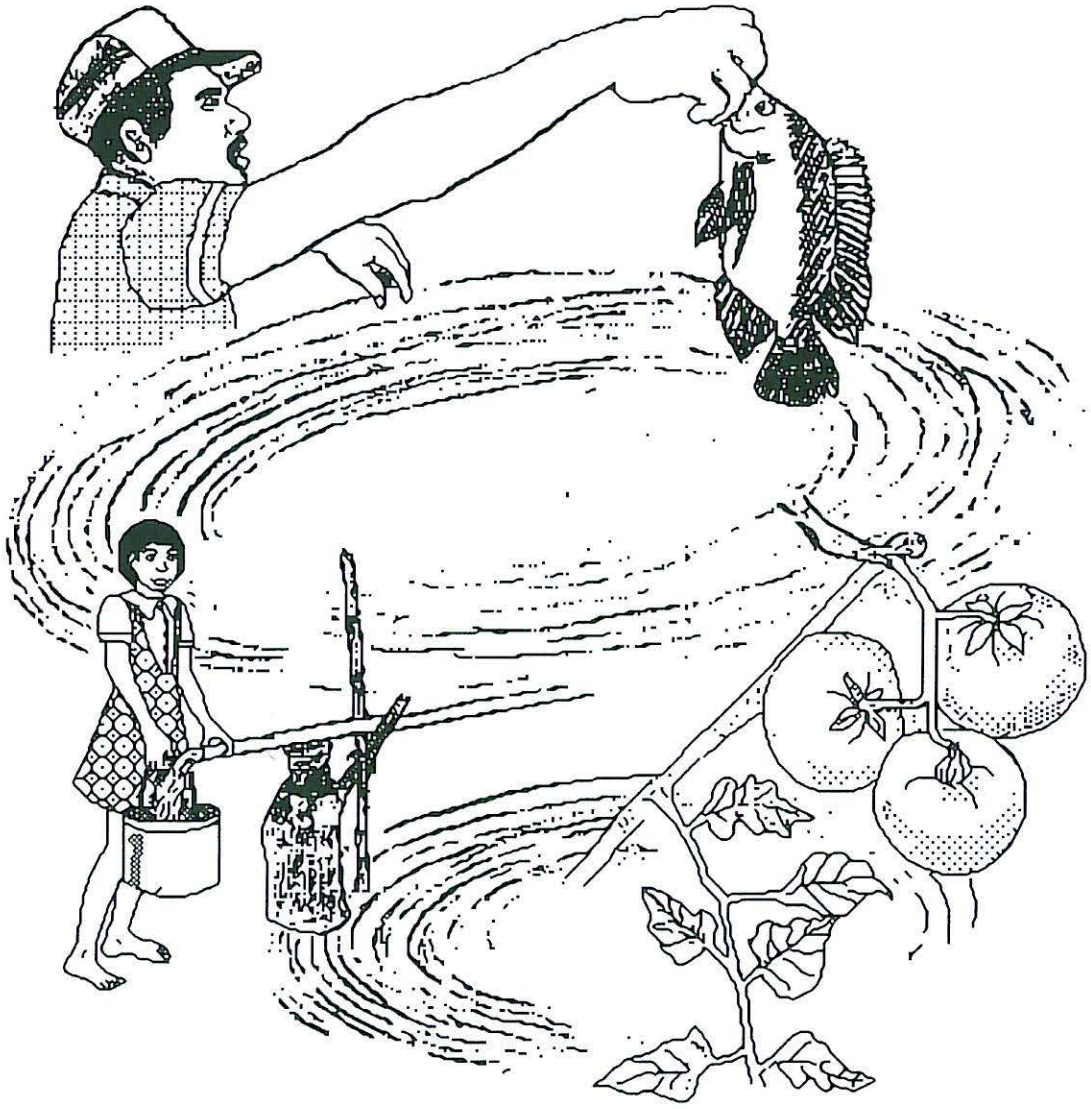
WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

INTRODUCTION TO WATER HARVESTING



INTERNATIONAL CENTER FOR AQUACULTURE
AND AQUATIC ENVIRONMENTS
AUBURN UNIVERSITY

INTRODUCTION

Throughout history, man has been dependent on an adequate water supply for his food, security and well being. Water is a universal need and is considered the principal limiting factor for human life. Destruction of natural watersheds has caused critical water shortages affecting vast areas and populations. Ways to help insure adequate water supplies for household, agricultural and other uses are available to farms and communities. The technology is called water harvesting.

Water harvesting is the practice of collecting and storing water from various sources for beneficial use. Water harvested from a watershed and conducted to ponds for storage can substantially increase available water for garden irrigation, livestock watering, aquaculture and other domestic needs.

THE HYDROLOGIC CYCLE

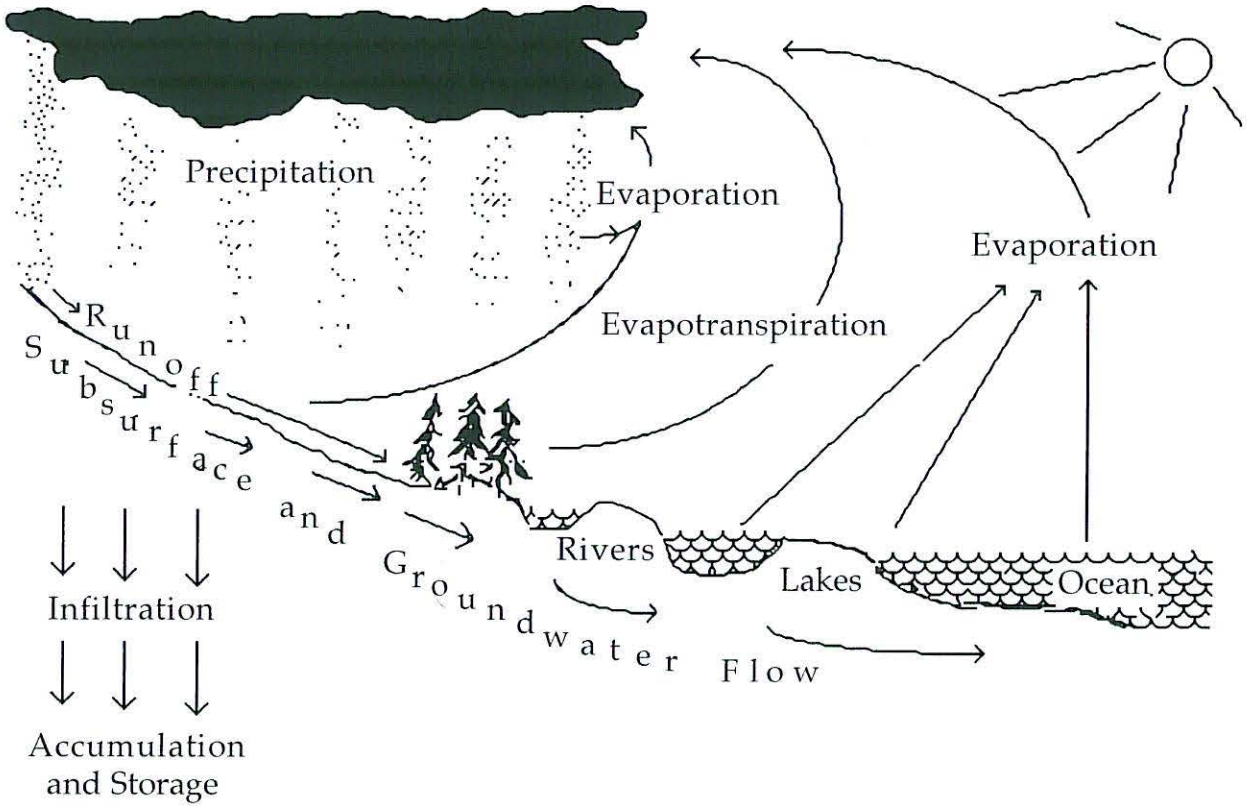


Figure 1: The hydrologic cycle.

The circulation of water in its various forms around the earth is called the hydrologic cycle. Water may be harvested effectively by man at certain points in the hydrologic cycle. An understanding of how water circulates around the earth will assist in the selection of an appropriate technology for harvesting it.

The sun heats water causing it to evaporate from the earth's surface. Water returns to the earth in the form of rainfall, snowfall, sleet, dew and hail. The higher the temperature of an air mass, the more water vapor it can carry. As air masses cool, water vapor changes to liquid forming droplets that fall of their own weight. Air cools due to expansion as it is lifted over mountains by collision with warm air masses and the heating of moisture-laden air close to the earth's surface (convection cooling).

The most important source of air moisture is water which evaporates from the oceans, but water may also evaporate from other open bodies of water and from the ground. Transpiration from plants (evapotranspiration) is another source of atmospheric moisture as water moves through plant roots, up the stem, through the leaves and to the atmosphere. For example, a corn field may transpire up to 7,000 to 10,000 gallons of water per hectare per day into the atmosphere.

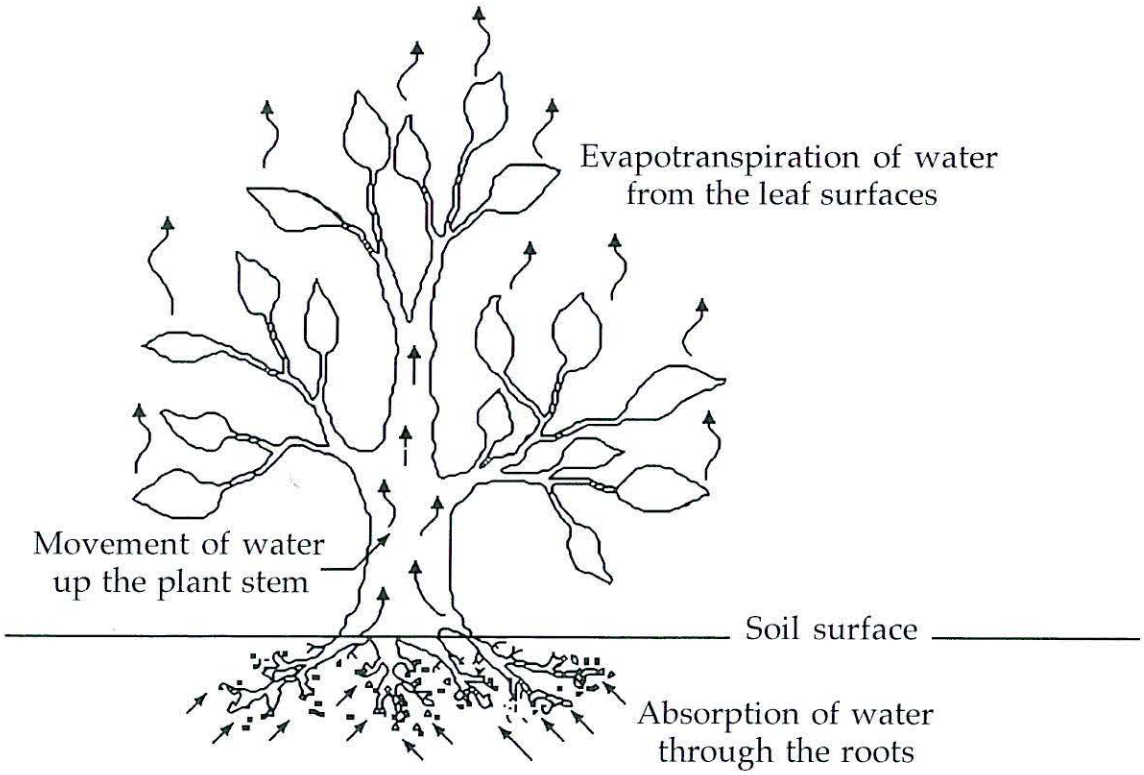


Figure 2: Transpiration of water by a green plant.

SURFACE WATER

Some precipitation runs overland by natural drainage channels where it eventually enters rivers, lakes and oceans. Most precipitation infiltrates the soil and becomes "ground water". Harvesting water on the earth's surface may be done only before it evaporates. Surface runoff, for example, can be intercepted and stored in impoundments for later use.

Water shortages in many areas of the world can be alleviated by harvesting surface runoff water. Criteria used to determine an appropriate harvesting method for a given location include: 1) the purpose for which the water will be harvested; 2) land slope; 3) soil properties; 4) construction costs; 5) amount, intensity and seasonal distribution of rainfall; 6) social factors such as land tenure and traditional water use practices. The following figures illustrate practical devices and systems used to harvest water.

Figure 3: Terraces are effective in harvesting surface runoff for cultivating rice and other crops.

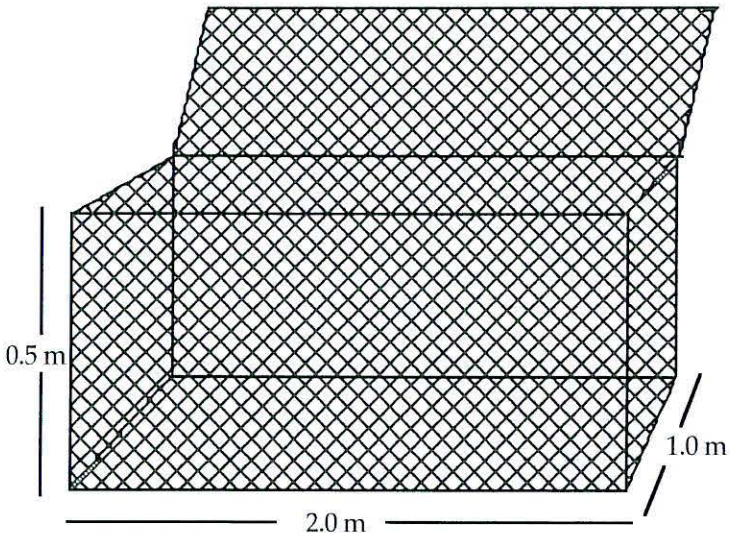


Figure 4: Gabions constructed of wire mesh and fashioned like a cage are gaining wide use in Africa.

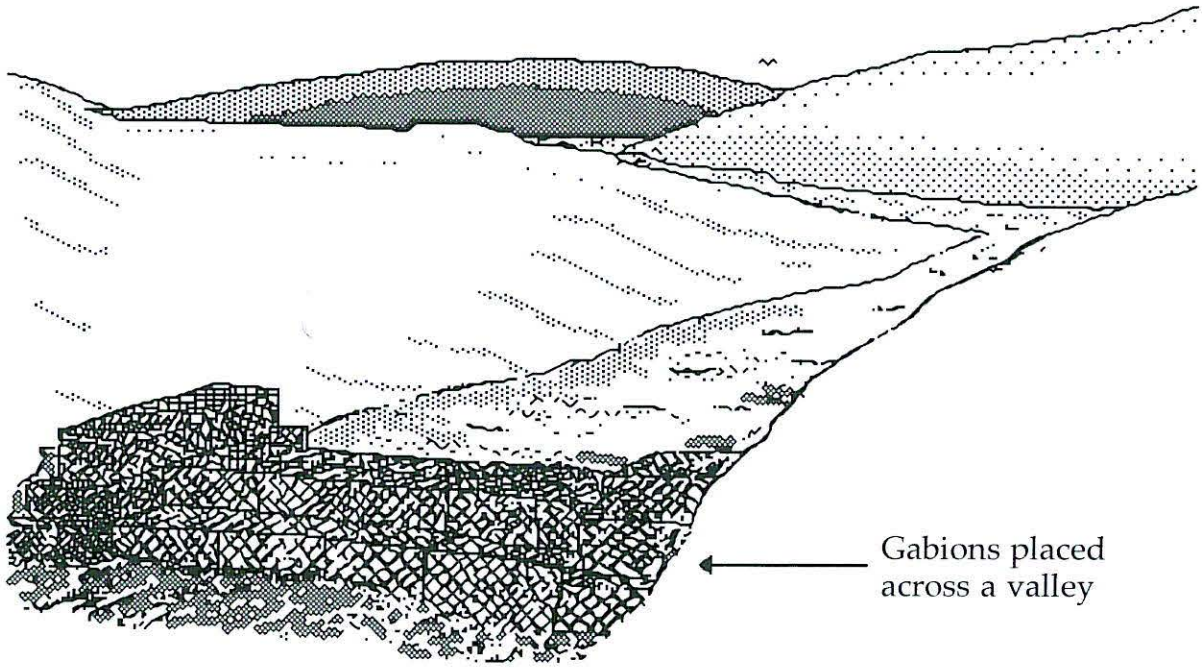


Figure 5: Gabions are filled with rock and placed across small valleys to act as barrages to retard runoff. Runoff water collected behind the barrage seeps into the ground. Resulting high soil moisture allows farmers to plant crops behind the barrage after rainy season.

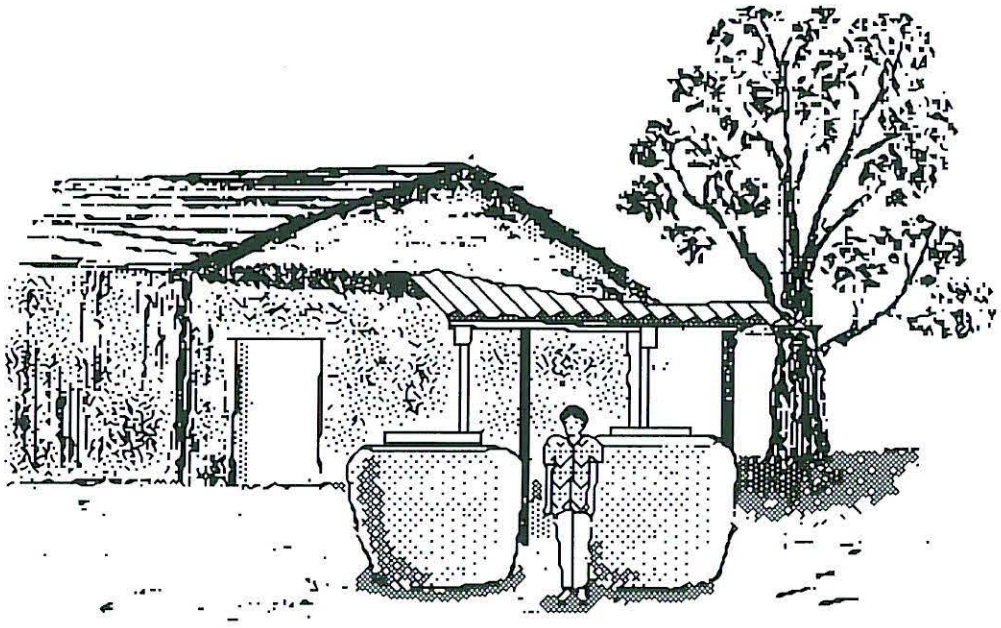


Figure 6: Large jars made of ferrocement are used in Thailand to harvest rainwater from roofs. These roof catchment devices may provide a family with enough drinking water to last through the dry season.

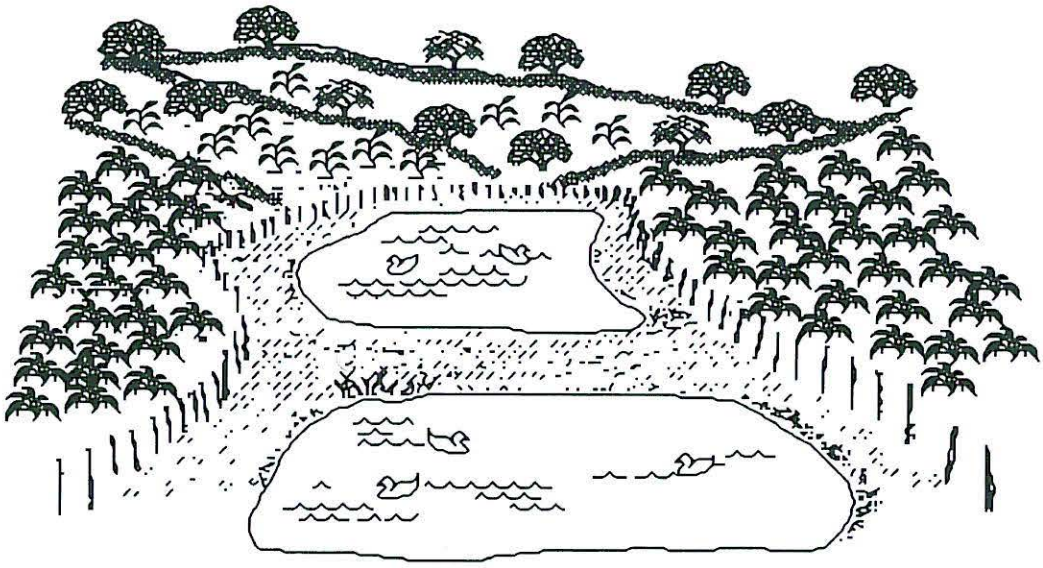


Figure 7: Small ponds provide opportunities for agricultural diversification. They are suitable for harvesting runoff water in rural areas, thus storing it for many purposes which include small scale irrigation, household uses, livestock watering and aquaculture. Ponds properly built and maintained have an indefinite life.

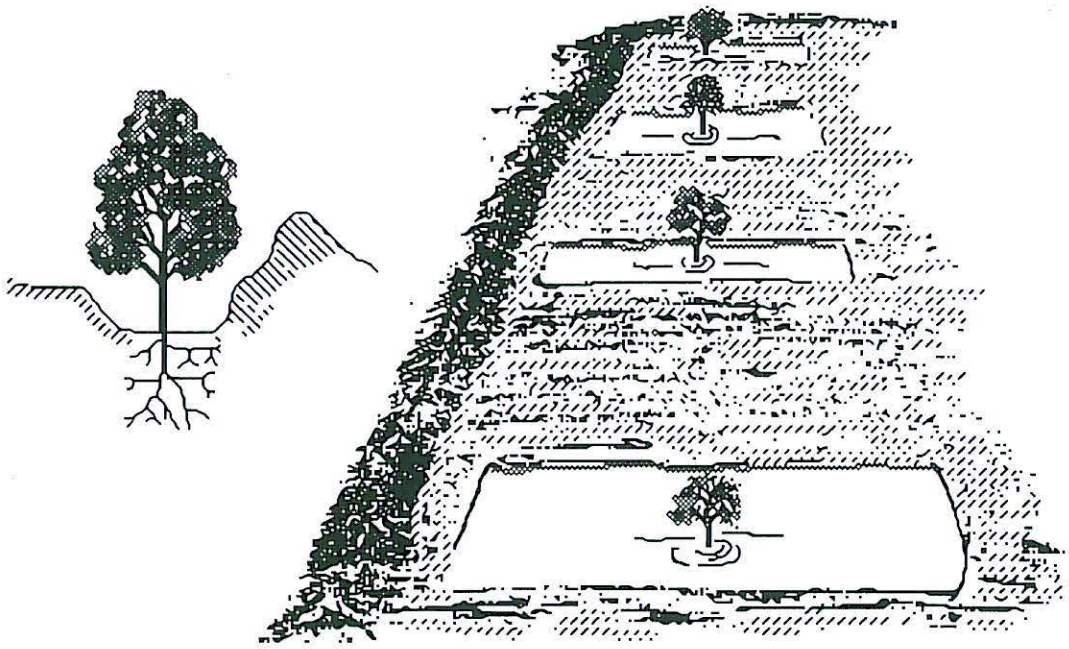


Figure 8: Microcatchment farming concentrates runoff water from a large area into a small basin. Fruit trees or other crops are planted in the basins.

Figure 9: A modification of microcatchment farming involves watershed modification to direct and concentrate runoff water into a designated area. Collecting ditches or low stone walls built on land contours can channel water to the point of use.

SUBSURFACE OR GROUND-WATER

Some rainwater infiltrates into the soil where living plants can take it up through their roots. Structures such as gabions and ponds, which harvest rainfall runoff, increase the amount of subsurface water available to plants. Water infiltrating into deeper soil layers beyond the reach of plant roots is called ground water. Ground water may be widely dispersed among particles of soil, sand, gravel or rock and be unharvestable. Soil type and moisture content determine the rate and amount of soil infiltration, which may vary from a fraction of a centimeter to several centimeters per hour. Eventually, water may reach a porous soil layer saturated with water. These porous soil layers are called aquifers. Water is typically harvested from aquifers by pumping or lifting from wells. The top layer of saturation is called the water table. Wells must be dug or bored down into this zone before water can be withdrawn from the aquifer.

An artesian aquifer is under natural pressure due to confinement between upper and lower impervious soil layers. (See Figure 10). At the lower elevation, pressure will push water upward if a well shaft penetrates the upper confining layer. Water in the shaft may rise considerably above the normal water table and even flow freely from the well due to pressure from the confining beds below. Figures 10 and 11 illustrate how water tables and aquifers are positioned relative to various soil layers.

Aquifers can become depleted by withdrawing water faster than the rate of recharge. When this happens, wells go dry and are often dug deeper as a temporary remedy. If a depleted aquifer is not recharged with new water, deepening wells only makes the problem worse. Aquifers are recharged as rain water infiltrates to the water table. Slow runoff rates enhance infiltration. High runoff rates and low infiltration typically occur in deforested areas. Many water harvesting practices retard runoff and encourage water to infiltrate deeply into the soil, thus aiding aquifer recharge. For example, a well dug downslope from a pond will be charged by seepage through the pond bottom and may never go dry.

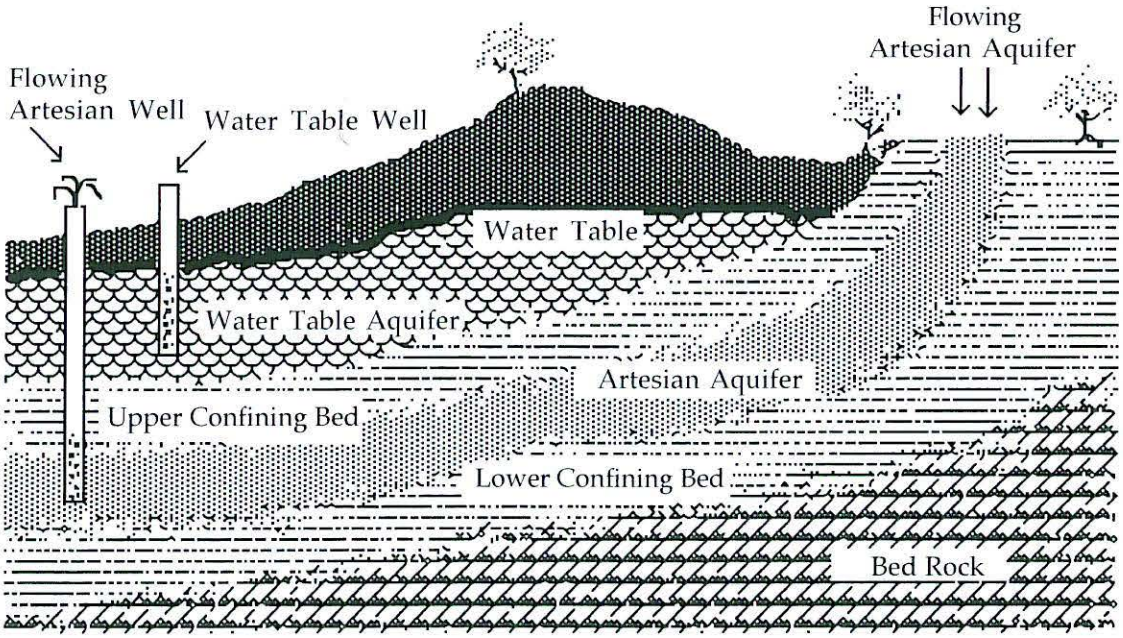


Figure 10: Subsurface and ground water phase of the hydrologic cycle.

Water seeping from springs may be harvested, and can be a source of good quality drinking water. Springs are often found in areas where a rock or clay layer surfaces on a hillside, as shown in Figure 11. Water that is perched above this impervious layer may flow from the hillside as a spring.

Springs may dry up when the watershed or recharge area is cleared of vegetation. Springs can be prevented from drying up by building water harvesting structures on the watershed to collect rainfall runoff and increase infiltration rates. Such water conservation measures help maintain an adequate water supply to rural families and villages.

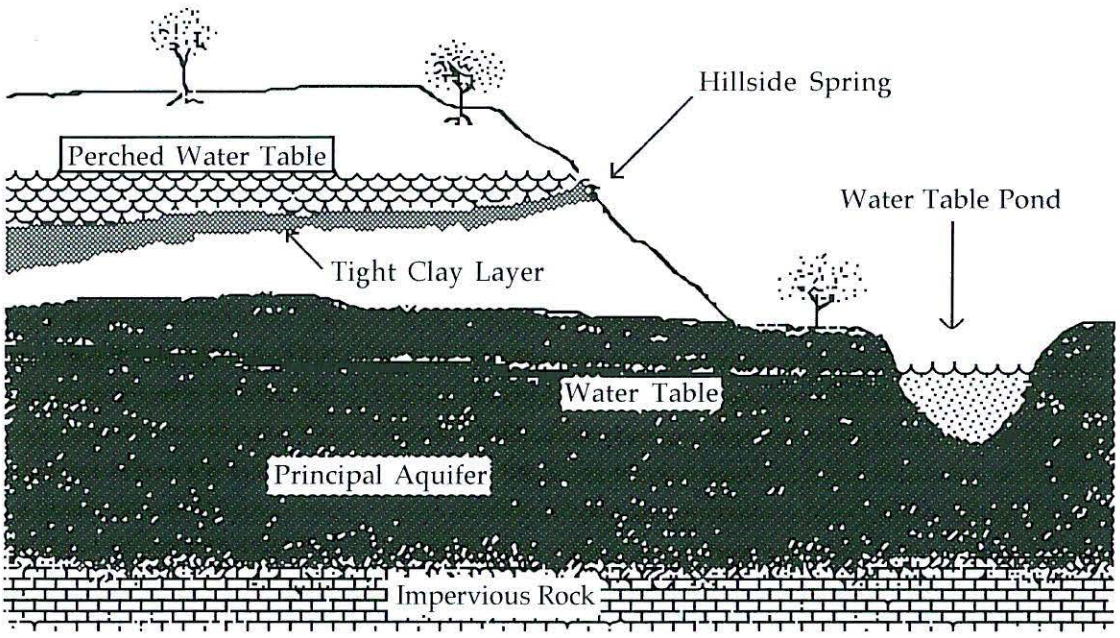


Figure 11: Perched water tables occur above impervious strata and above the main water table.

GLOSSARY OF TERMS

aquifer - a soil layer saturated with water.

artesian aquifer - an aquifer under pressure due to confinement between upper and lower impervious strata.

evaporation - the process by which water is changed from a liquid to a gas or vapor.

evapotranspiration - the passage of water through a plant from the roots, through the vascular system and to the atmosphere.

gabion - a wire cage that is filled with rock and earth and used to construct barrages for temporarily impounding water or preventing soil erosion.

ground water - water that has infiltrated soil beyond the root zone of plants.
hydrologic cycle - the natural sequence through which water cycles from the atmosphere to the earth and back to the atmosphere.

infiltration - seepage of water downward into the soil.

perched water table - a water table lying above a layer of impervious soil or rock which surfaces on a hillside as a spring.

permeability - the property of soil or rock which allows the passage of water through it.

roof catchment device - a device, such as a cement tank or cistern, that collects rain water falling from the roof of a building.

root zone - the depth to which the roots of plants penetrate the soil.

runoff - water that flows over the ground surface after a rain.

spring - a water source which flows up freely from the ground.

surface water - water, such as runoff, that stays on the ground surface and can be collected in ponds or other impounding structures.

subsurface water - water that has infiltrated soil to the root zone.

water harvesting - the practice of collecting and storing water from a variety of sources for beneficial use.

watershed - a region or area from which water flows to a single point.

water table - the top zone of water saturation in the ground.

zone of saturation - the layer or depth of soil which has become saturated with water that has infiltrated down through surface soil layers.

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