Drought management & water harvesting

Introduction

Drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. It is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry. Drought is a temporary aberration from normal climatic conditions, thus it can vary significantly from one region to another. Drought is different than aridity, which is a permanent feature of climate in regions where low precipitation is the norm, as in a desert.

Human factors, such as water demand and water management, can exacerbate the impact that drought has on a region. Because of the interplay between a natural drought event and various human factors, drought means different things to different people. In practice, drought is defined in a number of ways that reflect various perspectives and interests. Below are three commonly used definitions:

Defining a drought is difficult because of the word normal. In many areas, normal conditions generally mean conditions that do not deviate from long-term averages. However, these averages themselves can change over time.

Types of Drought

Meteorological Drought

Meteorological drought is usually defined based on the degree of dryness (in comparison to some “normal” or average) and the duration of the dry period. Drought onset generally occurs with a meteorological drought. A lack of precipitation is the most common definition of drought and is usually the type of drought referred to in news reports and the media. Most locations around the world have their own meteorological definition of drought based on the climate normals in the area. A normally rainy area that gets less rain than usual can be considered in a drought.

Agricultural Drought

Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, soil water deficits, reduced ground water or reservoir levels needed for irrigation, and so forth. When soil moisture becomes a problem, the agricultural industry is in trouble with drought. Shortages in precipitation, changes in evapo-transpiration, and reduced ground water levels can create stress and problems for crops.
Hydrological Drought

Hydrological drought usually occurs following periods of extended precipitation shortfalls that impact water supply (i.e., streamflow, reservoir and lake levels, ground water), potentially resulting in significant societal impacts. Because regions are interconnected by hydrologic systems, the impact of meteorological drought may extend well beyond the borders of the precipitation-deficient area. Many watersheds experience depleted amounts of available water. Lack of water in river systems and reservoirs can impact hydroelectric power companies, farmers, wildlife, and communities. Hydrological drought usually occurs following periods of extended precipitation shortfalls that impact water supply (i.e., streamflow, reservoir and lake levels, ground water), potentially resulting in significant societal impacts. Because regions are interconnected by hydrologic systems, the impact of meteorological drought may extend well beyond the borders of the precipitation-deficient area.
Causes Droughts

The cause of droughts is easily understood, but hard to prevent. Depending on the location, crop failures, famine, high food prices, and deaths can occur. One of the scariest parts of a drought is the onset time. Unlike other forms of severe weather or natural disasters, droughts often develop slowly.

Droughts are caused by a depletion of precipitation over time. Unlike a dry spell, prolonged lack of rain will cause regions around the world to slowly dry out. Because of the slow onset of droughts, their cost is often only estimated. Frequently, droughts are billion dollar weather events and are one of the top three threats to population in the world (along with famine and flooding).

Sometimes a drought takes decades to develop fully and predicting droughts is difficult. The frequency of droughts in the United States is literally every year. In other words, somewhere in the US in any given year, a drought is occurring. Droughts are completely natural, but their devastation can be far-reaching and severe. Atmospheric conditions such as climate change, ocean temperatures, changes in the jet stream, and changes in the local landscape are all culprits in the long story of the causes of droughts.

We already know that a drought occurs when not enough rain falls to the ground. However, water vapor condenses only if air rises into the colder regions of the atmosphere. If the air doesn’t rise, then no rain will form. When there is high air pressure, air falls instead of rising. With the air pressing down in a high pressure zone, no currents of water vapor are carried upward. As a result, no condensation occurs, and little rain falls to earth. In addition, high-pressure areas push clouds and air currents downward and away, resulting in sunny, cloudless weather. Low-pressure systems see more cloudy, stormy weather.

Usually, however, we experience both high- and low-pressure systems. It is normal for a high-pressure system to pass over an area and move on, being replaced by a low-pressure system. However, when a high-pressure system is stalled, the sunny weather can drag on for days. If it keeps on going, the result is a drought.

High-pressure systems can be stalled by jet streams, wide bands of fast-moving air (up to 335 miles per hour) in the upper atmosphere. Masses of air that usually move from place to place can be locked in one area by jet streams.

Unusual currents of cold and warm water in the ocean can also stall a high-pressure system. In the Pacific, a warm water current known as El Nino brings low-pressure systems that cause hurricanes and other violent storms to North America, while a cold water current known as La Nina brings drought. In Asia, the opposite occurs, with El Nino bringing drought and La Nina stormy weather.

Or droughts occur because water vapor is not brought by air currents to the right areas at the right times. Water that evaporates from the oceans is brought inland by wind to regions where it is needed. However, sometimes those winds are not strong enough. In the eastern United States, moisture is carried up from the Gulf of Mexico by northward blowing winds. This moisture is then pushed by other winds until it reaches the Midwest. This water then falls to the ground, supporting the farms in that region. However, if the winds don’t blow at the right time, in the right direction, or with enough force, the moisture falls in other areas and that Midwest region suffers from drought. A similar phenomenon occurs in southeast Asia. Usually, summer winds known as monsoons carry water vapor north from the
Indian Ocean inland, providing desperately needed rain. Sometimes, however, instead of blowing from north to south, they blow east to west. When that happens, the vapor doesn’t leave the Indian Ocean and many people suffer from the resulting droughts.

Mountains can prevent wind from blowing moisture to needed regions. As air is moving past a mountain range, it is forced to rise in order to pass over the peaks. However, as the air rises, it becomes colder and the vapor condenses into rain or snow. The rain then falls on that side of the mountain, known as the windward side (the side that is turned toward the wind). When the air mass finally makes it over the mountain, it has lost much of its vapor. This is another reason why many deserts are found on the side of a mountain facing away from the ocean. This phenomenon is known as the rain shadow effect.

**Impacts of Drought**

While droughts do not often cause deaths in the United States, the Dust Bowl in the US Midwest is one example of the devastation that can occur. This site has a great list of other famous droughts.

1. There are three main ways droughts impact lives and communities. First, the economic impacts of drought include losses in the timber, agricultural, and fisheries communities. Many of these losses are then passed on to consumers in the form of higher commodity pricing.
2. Next social impacts include increased chance of conflict over commodities, fertile land, and water resources. Other social impacts include abandonment of cultural traditions, loss of homelands, changes in lifestyle, and increased chance of health risks due to poverty and hygiene issues.
3. Finally, the environmental impacts of drought include loss in species biodiversity, migration changes, reduced air quality, and increased soil erosion.

Other parts of the world experience long periods without rains as well. Even during monsoon season, areas that depend on the seasonal rains will often experience drought if the monsoon rains fail. Once crops fail, famine can become a major problem. In some African countries, rain rituals are often used to try and thwart the dry seasons and bring on the rain. While it is no cure, modern technology has developed ways to help see potential famine situations as satellites see famine conditions from space.

**Why Conserve Water?**

Water conservation is an ongoing component of water resource management.

- The Washington State Department of Health’s Municipal Water Conservation Analysis and Recommendations states:

  Ensuring the efficient use of our limited water resources is a key component to the overall management of the state water resources and to salmon recovery efforts. Efficient water use benefits state natural resources by keeping as much water as possible in the natural environment. It also benefits water utilities and local governments by lowering water demands that may require costly new source development projects and by helping to ensure that water is available to meet economic and population growth consistent with local Growth Management Act planning efforts.
What is rainwater harvesting?

Rainwater harvesting is a technology used to collect, convey and store rain for later use from relatively clean surfaces such as a roof, land surface or rock catchment. The water is generally stored in a rainwater tank or directed to recharge groundwater. Rainwater infiltration is another aspect of rainwater harvesting playing an important role in stormwater management and in the replenishment of the groundwater levels. Rainwater harvesting has been practiced for over 4,000 years throughout the world, traditionally in arid and semi-arid areas, and has provided drinking water, domestic water and water for livestock and small irrigation. Today, rainwater harvesting has gained much on significance as a modern, water-saving and simple technology.

The practice of collecting rainwater from rainfall events can be classified into two broad categories: land-based and roof-based. Land-based rainwater harvesting occurs when runoff from land surfaces is collected in furrow dikes, ponds, tanks and reservoirs. Roof-based rainwater harvesting refers to collecting rainwater runoff from roof surfaces which usually provides a much cleaner source of water that can be also used for drinking.

Gould and Nissen-Petersen (1999) categorised rainwater harvesting according to the type of catchment surface used and the scale of activity (Figure 1).

Why rainwater harvesting?

In many regions of the world, clean drinking water is not always available and this is only possible with tremendous investment costs and expenditure. Rainwater is a free source and relatively clean and with proper treatment it can be even used as a potable water source. Rainwater harvesting saves high-quality drinking water sources and relieves the pressure on sewers and the environment by mitigating floods, soil erosions and replenishing groundwater levels. In addition, rainwater harvesting reduces the potable water consumption and consequently, the volume of generated wastewater.

Application areas

Rainwater harvesting systems can be installed in both new and existing buildings and harvested rainwater used for different applications that do not require drinking water quality such as toilet flushing, garden watering, irrigation, cleaning and laundry washing. Harvested rainwater is also used in many parts of the world as a drinking water source. As rainwater is very soft there is also less

![Diagram of rainwater harvesting systems and their applications](image-url)
consumption of washing and cleaning powder. With rainwater harvesting, the savings in potable water could amount up to 50% of the total household consumption.

**Components of a rooftop rainwater harvesting system**

Although rainwater can be harvested from many surfaces, rooftop harvesting systems are most commonly used as the quality of harvested rainwater is usually clean following proper installation and maintenance. The effective roof area and the material used in constructing the roof largely influence the efficiency of collection and the water quality.

Rainwater harvesting systems generally consist of four basic elements:

1. a collection (catchment) area
2. a conveyance system consisting of pipes and gutters
3. a storage facility, and
4. a delivery system consisting of a tap or pump.

Figure 2 shows a simple schematic diagram of a rooftop rainwater harvesting system including conveyance and storage facilities.

1) A **collection or catchment** system is generally a simple structure such as roofs and/or gutters that direct rainwater into the storage facility. Roofs are ideal as catchment areas as they easily collect large volumes of rainwater.

The amount and quality of rainwater collected from a catchment area depends upon the rain intensity, roof surface area, type of roofing material and the surrounding environment. Roofs should be
constructed of chemically inert materials such as wood, plastic, aluminium, or fibreglass. Roofing materials that are well suited include slates, clay tiles and concrete tiles. Galvanised corrugated iron and thatched roofs made from palm leaves are also suitable. Generally, unpainted and uncoated surface areas are most suitable. If paint is used, it should be non-toxic (no lead-based paints).

(2) **A conveyance system** is required to transfer the rainwater from the roof catchment area to the storage system by connecting roof drains (drain pipes) and piping from the roof top to one or more downspouts that transport the rainwater through a filter system to the storage tanks. Materials suitable for the pipework include polyethylene (PE), polypropylene (PP) or stainless steel. Before water is stored in a storage tank or cistern, and prior to use, it should be filtered to remove particles and debris. The choice of the filtering system depends on the construction conditions. Low-maintenance filters with a good filter output and high water flow should be preferred. “First flush” systems which filter out the first rain and diverts it away from the storage tank should be also installed. This will remove the contaminants in rainwater which are highest in the first rain shower.

(3) **Storage tank or cistern** to store harvested rainwater for use when needed. Depending on the space available these tanks can be constructed above grade, partly underground, or below grade. They may be constructed as part of the building, or may be built as a separate unit located some distance away from the building.

The storage tank should be also constructed of an inert material such as reinforced concrete, ferrocement (reinforced steel and concrete), fibreglass, polyethylene, or stainless steel, or they could be made of wood, metal, or earth. The choice of material depends on local availability and affordability. Various types can be used including cylindrical ferrocement tanks, mortar jars (large jar shaped vessels constructed from wire reinforced mortar) and single and battery (interconnected) tanks. Polyethylene tanks are the most common and easiest to clean and connect to the piping system. Storage tanks must be opaque to inhibit algal growth and should be located near to the supply and demand points to reduce the distance water is conveyed.

Water flow into the storage tank or cistern is also decisive for the quality of the cistern water. Calm rainwater inlet will prevent the stirring up of the sediment. Upon leaving the cistern, the stored water is extracted from the cleanest part of the tank, just below the surface of the water, using a floating extraction filter. A sloping overflow trap is necessary to drain away any floating matter and to protect from sewer gases. Storage tanks should be also kept closed to prevent the entry of insects and other animals.

(4) **Delivery system** which delivers rainwater and it usually includes a small pump, a pressure tank and a tap, if delivery by means of simple gravity on site is not feasible. Disinfection of the harvested rainwater, which includes filtration and/or ozone or UV disinfection, is necessary if rainwater is to be used as a potable water source.