The Water Forum | AN FÓRAM UISCE

Looking after Ireland's Water Resources

Factsheet:

DROUGHT

What is drought?

Both droughts and floods are related to extremes rainfall accumulations, but also to other atmospheric and surface conditions. Dry periods are classified by climatologists as *dry spells*, *absolute droughts* and *partial droughts*. The definitions of which depend on the spell duration and deficiencies in the total daily amounts of rainfall. Dry periods can occur any time of the year regardless of air temperatures.

- A *dry spell* is a period of 15 or more consecutive days to none of which is credited 1.0 mm or of precipitation.
- An *absolute drought* is a period of 15 or more consecutive days to none of which is credited 0.2 mm or more of precipitation. An absolute drought is often part of a more extensive dry spell and in prolonged droughts, two or all three categories may overlap and in some cases coincide. (See section Frequency of Dry Periods below.)
- A *partial drought* is a period of at least 29 consecutive days, the mean daily rainfall of which does not exceed 0.2 mm.

Figure 1, shows the occurrence of dry spells regionally. The meteorological record shows that the island of Ireland is prone to seasonal rainfall deficiencies resulting in dry spells; with records of major dry spells in the 1850s, 1880s, and 1970s. The likelihood of a continuous dry spell over 10 seasons (5 years) occurring the in the Dublin region has been identified by Met Eireann as being high.

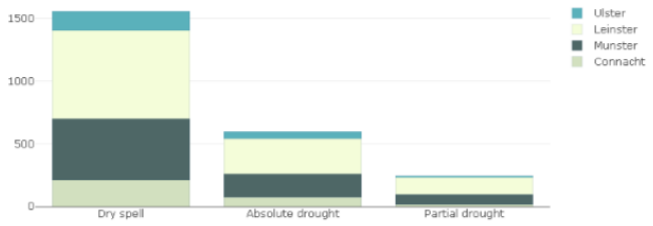


Figure 1: Dry spells, Absolute droughts and partial droughts regionally in Ireland in the Met Eireann digital record

Types of drought

The European Drought Observatory characterises 3 types of drought: *Meteorological, Agricultural* and *Hydrological*, this factsheet aims to describe these, their occurrence and impact in Ireland.

Two additional types of drought are also recognised: *Socioeconomic drought*, defined when the demand for economic goods and services exceeds supply as a result of a weather-related shortfall in water availability; and *Ecological drought* when ecosystems become stressed. These latter types of drought will not be explored further in this factsheet.

Meteorological Drought

A meteorological drought is defined as a period with an abnormal precipitation deficit, in relation to the long-term average conditions for a region.

This is measured using the Standardised Precipitation Index (SPI) that is precipitation anomalies based on long-term records, aggregated at different time-scales.

Therefore, SPI shows anomalies of observed precipitation at a given location over a period of time (months, seasons, years). The difference from the average (mean value) is a measure of the severity of the wet or dry event (Table 1). In this way, SPI indicators allow for estimating the potential impacts of meteorological drought. The lower (more negative) the SPI, the more intense the drought.

- SPI-1 to SPI-3: When SPI is computed for shorter accumulation periods (e.g., 1 to 3 months), it can be used as an indicator for immediate impacts such as reduced soil moisture, and flow in smaller streams.
- SPI-3 to SPI-12: When SPI is computed for medium accumulation periods (e.g., 3 to 12 months), it can be used as an indicator for reduced stream flow and reservoir storage.
- SPI-12 to SPI-48: When SPI is computed for longer accumulation periods (e.g., 12 to 48 months), it can be used as an indicator for reduced reservoir and groundwater recharge.

ANOMALY	*RANGE OF SPI VALUES*	*PRECIPITATION REGIME*
Positive	2.0 < SPI <= MAX	Extremely wet
	1.5 < SPI <= 2.0	Very wet
	1.0 < SPI <= 1.5	Moderately wet
None	-1.0 < SPI <= 1.0	Normal precipitation
Negative	-1.5 < SPI <= -1.0	Moderately dry
	-2.0 < SPI <= -1.5	Very dry
	MIN <= SPI <= -2.0	Extremely dry

Table 1: SPI Classification scheme used by the European Drought Observatory

However, the exact relationship between the accumulation period and the drought impact, depends on the natural environment (e.g., geology, soils) and levels of human interference (e.g., abstraction levels). In order to get a full picture of the potential impacts of a drought, the SPI should be calculated and compared for different accumulation periods.

Meteorological Drought occurrence on the island of Ireland

The Phoenix Park in Dublin has the longest continuous meteorological record in Ireland, dating back to 1837. Figure 2 is an illustration of that record, with red spikes showing lower than average precipitation whereas blue shows higher than average. The dashed horizontal line shows occasions of extreme drought (>SPI -2) over this period and it shows we are currently experiencing extreme drought conditions in Dublin.

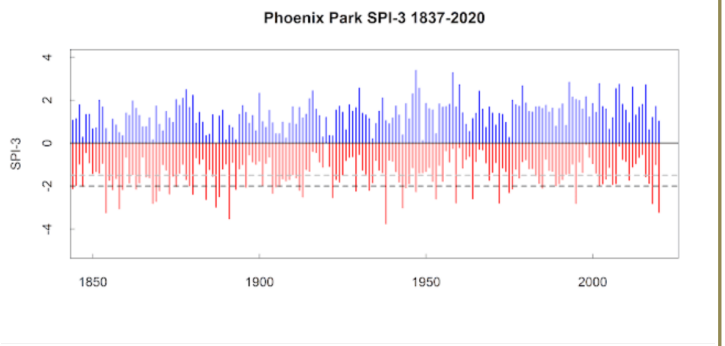
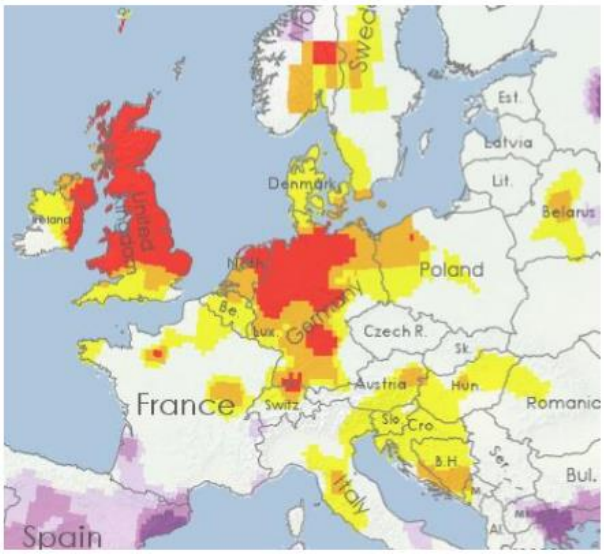


Figure 2: Precipitation records from the Phoenix Park 1837 to 2020 plotted by researcher from Maynooth University. Blue shows wetter than average whereas red represents dryer than average. The darker dashed line shows extreme drought.

The short-term SPI (at time-scale of one and three months) provides the best insight on the current dry spell. The precipitation anomaly from March to May (SPI-3) is extremely low over eastern Ireland, most of the UK according to The European Drought Observatory who monitor climatic conditions across Europe, Figure 3.



SPI-3, May 2020 (March to May cumulative)

Figure 3: European Drought Observatory Bulletin on Drought conditions in Europe Spring 2020

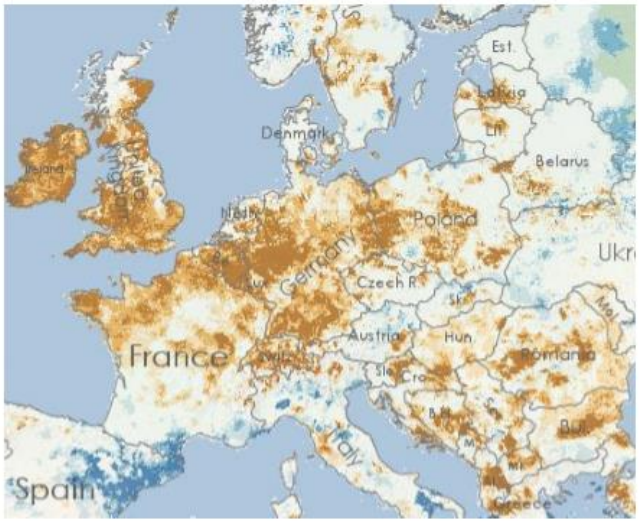


Figure 4: Soil moisture anomaly, Irelands brown shading indicates drier than normal SMD ≤-2, 10th May to 10th June 2020, European Drought Observatory

Impacts of Meteorological droughts

Meteorological droughts can impact on water supply with reduced headroom in the system and can result in the implementation of restrictions usually for short periods of time and possibly in specific locations.

Recent research, using SPI along with indices on drought duration and severity, to analyse long term variability and trends in meteorological droughts in Western Europe, found the largest trend for increasing drought conditions in summertime, is likely to occur in the British and Irish Isles.

High temperatures increase the evapotranspiration rate of water from the land, and cause much higher water demand for consumption, thus contribute substantially to drought severity, even in the absence of relevant rainfall deficits. In May 2020, higher than normal temperatures persisted over Ireland, Wales, England. Eastern Ireland had the sunniest and driest May since 1929.

Enhanced evapotranspiration and rainfall deficits can result in soil moisture deficits and Figure 4 shows a map of soil moisture anomaly (different soil moisture content from normal) across Ireland.

Agricultural Drought

Agricultural drought, which is typically a result of meteorological drought, is when there is reduced crop production due to insufficient soil moisture.

Soil moisture conditions are determined by temperature, precipitation, evapotranspiration and the physical characteristics of the soil (such as whether it is clay usually poorly-drained, silt, sand generally well-drained or loam). Consequently, there is large spatial and temporal variation between soil types, regions and seasons and their vulnerability to loss of soil moisture. The prediction of soil water status is important for agricultural and environmental management.

Soil moisture is important as it affects the upward and downward movement of water and nutrients. It is an essential source of water to plants and organisms, providing nutrients to plants and it influences soil temperature and incidence of erosion. Saturated soils (Figure 5) can retain no more water so overland flow will occur. At field capacity gravitational drainage has occurred and moisture is available to plants. In dry soils, water can remain tightly bound to soil particles but plants

cannot access this water and therefore experiences water stress and reaches wilting point (Figure 5).

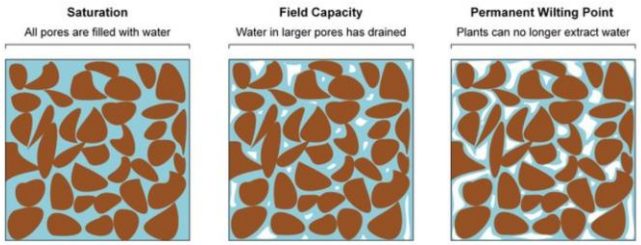


Figure 5: Saturated soil cannot hold additional moisture and moisture is available for plant use: at field capacity the soil is saturated, capillary water is available for plant uptake, whereas hygroscopic water is present if soil is not completely dry, but it is unavailable for plant roots and wilting will occur[1].

Soil moisture deficits

Soil moisture conditions are measured and communicated as soil moisture deficit (SMD): the amount of water required to replenish soil water content to field capacity (the amount of water the soil can hold without water being in excess) (Figure 4).

- **Soil Moisture Deficit (SMD)** is the amount of rain needed to bring the soil moisture content back to field capacity.
- **Field capacity (SMD=0)** is the amount of water the soil can hold against gravity i.e. the maximum water a pot plant can be watered and not leak water. Negative SMD indicates a water surplus, which will be drained over time through either infiltration or overland flow or both.
- **Saturation** is reached when SMD= -10mm, i.e. a water surplus of 10mm. Positive SMD is below field capacity and rain can infiltrate to the capacity of the SMD amount.

Soil moisture deficit is calculated from the cumulative balance of precipitation, evapotranspiration and drainage (percolation or overland flow). Evapotranspiration is calculated from daily values of precipitation (mm/day), maximum temperature (°C), minimum temperature (°C), global radiation and wind speed, altitude and albedo. Figure 6, below shows ranges of soil moisture deficit for different soil types in Ireland on June 22nd 2020.

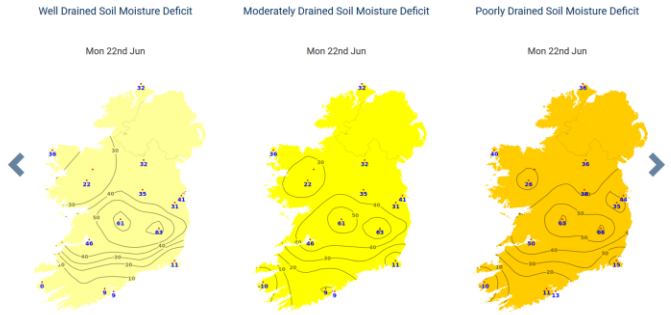


Figure 6: Soil moisture deficits for different soil types across Ireland from Met Eireann 22nd June 2020, deficits show the amount of water needed to meet field capacity, growth restriction occurs at >30mm SMD

Agricultural droughts in Ireland

Researchers at Maynooth University catalogued 250 years of drought, recording 7 major drought-rich periods between 1850-2015. Over the period drought resulted in death and agricultural hardship across Ireland.

The European Drought Observatory (EDO) publish maps of data on conditions in Ireland the Soil moisture anomaly looks at difference from normal conditions (Figure 7 below).

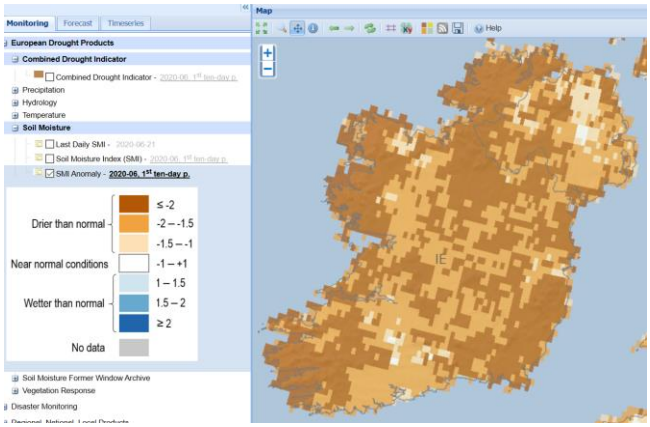


Figure 7: EDO Maps of Soil moisture anomaly (assessment of topsoil, areas drier than normal)

[1]https://www.researchgate.net/publication/317501722_Understanding_Soil_Water_Content_and_Thresholds_For_Irrigation_Management/figures?lo=1

Agricultural drought impacts

Vegetation can be stunted during periods of drought leading to slower grass growth and lower yields. There will be lower milk yields from dairy cattle and animals may need supplementary feeds. With sustained drought conditions there may be a shortage in winter feeds. Impacts are likely to be more severe in the drier regions of the country and where there are free draining soils and it will take longer to return to partial or full recovery.

Pest and disease outbreaks can occur during periods of drought, but occurrences have typically been low in Ireland. The EC JRC MARS Bulletin crop yield forecasts for Ireland, are reduced for spring barley, due to the dry conditions that affected crop growth in many areas across the country during the Spring 2020 period.

Hydrological drought

A hydrological drought occurs when there is below-normal water availability in rivers, streams, reservoirs, lakes, or groundwater as such it refers to surface and sub-surface water availability.

Figure 8 shows the hydrological cycle and the fluxes and storage of water within it.

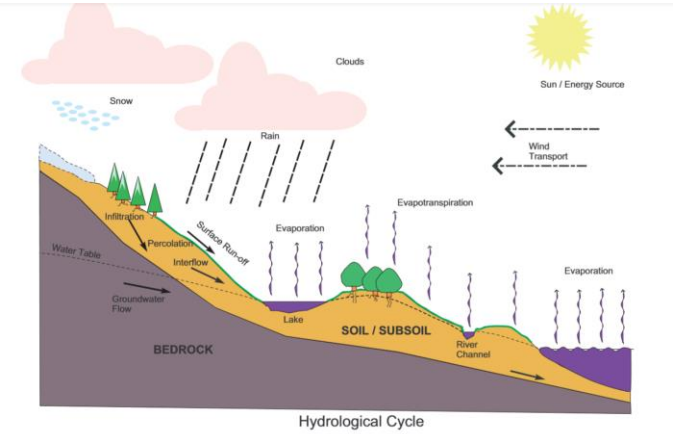


Figure 8: Hydrological cycle shows the stores and fluxes of water in the atmosphere and through the landscape[2]

Hydrological cycle

Water is evaporated into the atmosphere from the oceans, rivers, lakes, land surface and vegetation. It may be carried by winds before falling as precipitation either on the ocean (receives 74% of all precipitation) or on land (receives 26% of total precipitation). Some of the precipitation may be intercepted by vegetation and returned back into the atmosphere through evapotranspiration without reaching the ground surface. Precipitation reaching the ground surface may infiltrate into the soil, or run off over the surface or evaporate back into the atmosphere. If the soil is saturated with moisture and further precipitation occurs, water may percolate downwards to recharge an aquifer or may move laterally to emerge, at a lower location, as a spring or surface flow.

Water that does reach the water table recharges the groundwater aquifer and moves through it to emerge at a river or lake bed or at the ocean.

Flow levels

In a river catchment the water balance is the state of equilibrium between water inputs and water outputs. It accounts for all water into and out of the catchment, including precipitation, evaporation, transpiration, runoff as well as the movement of water within the catchment such as infiltration and the recharge of groundwater and reservoir storage in lakes, wetlands, rivers and aquifers.

If precipitation exceeds evapotranspiration loss, a positive water balance occurs, such that if a soil moisture surplus occurs this increases run-off resulting in greater storage in rivers, lakes and groundwater.

If evapotranspiration exceeds precipitation, a negative water balance occurs, plants have to utilise water from the soil store leaving it depleted

[2] Bruen, Michael 2009 Hydrology and the Water Framework Directive in Ireland. Biology and Environment: Proceedings of the Royal Irish Academy 109B, 207–20. DOI: 10.3318/BIOE.2009.109.3.207.

and so that run-off to rivers, lakes and groundwater is reduced resulting in lower flow levels.

In this way, changes in the amount of moisture in the soil reflects storage in lakes, rivers and groundwater. In summer, when plant growth is at its highest, evapotranspiration exceeds precipitation, soil moisture and flow levels are at their lowest. In autumn, when precipitation begins to exceed evapotranspiration again the excess moisture will be used to recharge the soil first until it reaches field capacity, but once saturated drainage will occur leading to the replenishment of rivers, lakes and groundwater.

The European Data Observatory have a Low Flow Index (LFI) as an indicator of hydrological drought and reflects the total water deficit in the river discharge when the discharge drops below a threshold. Figure 9 shows the Irish rivers with hazardous low flows in June 2020.

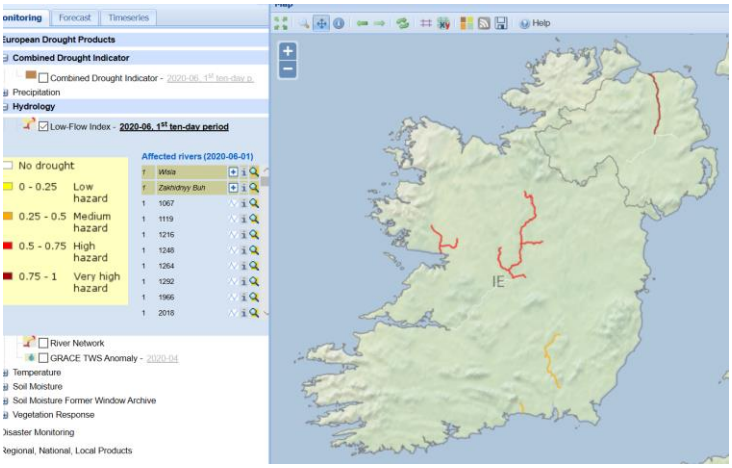


Figure 9: Rivers with high hazard low flow levels in the first 10 days of June 2020 from the European Drought Observatory

Groundwater recharge

Hydrogeology Ireland identifies two types of groundwater recharge: direct (vertical infiltration from precipitation) through the soils; or indirect from infiltration following runoff which usually occurs in karst areas. The amount and type of recharge will depend on soil and subsoil types, flow mechanisms and saturation, geology, topography, precipitation amount and duration, vegetation, available groundwater storage, influent rivers and the presence of karst. Groundwater recharge will be significantly slower when soil moisture levels are low.

Impact of low flow levels

Low flow levels reduce the resilience of water supply systems, both surface and groundwater and have negative impacts on water quality owing to less dilution of pollutants and aquatic ecosystems are negatively impacted owing to restricted habitats.

Recent decades are not representative of long-term drought records in Ireland. In the past, continuous drought periods occurred (1854-1860) and 1800-1809 when 3 droughts with brief interludes occurred. A recurrence of such conditions would have major impacts on Ireland's water resources, water quality and food supply.