



European  
Commission

# Drought in northern Italy

## March 2022

*GDO Analytical Report*

2022



Rapid  
Mapping



Risk & Recovery  
Mapping



Floods



Fires



Droughts



Population



Built-up  
areas

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# GDO Analytical Report

## Drought in northern Italy - March 2022

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 25/03/2022



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### Executive summary

- A severe drought has been affecting northern Italy and the Po River basin in particular. Dry conditions are related to a persistent lack of precipitation since December 2021.
- The severe precipitation deficit is already affecting water resources. Water competition from different sectors is likely to start sooner than usual, particularly at the beginning of the irrigation period, usually expected to start in April (e.g. for rice). Drought is already impacting the stored water volume for energy production in the Italian hydropower system. Most of the reservoirs are below the minimum historical values (1970-2019) since September 2021. The latest data shows an amount of stored energy of 774 GWh at the beginning of March 2022, 27.5% less than the 8-year minimum (1068 GWh in 2021).
- Poor snow accumulation is estimated by the Snow Water Equivalent indicator (40% of the 2009-2021 median conditions), with extremely low values in the southern Alps during winter. Warmer winter temperature also contributed to the reduced snow accumulation. These conditions cause concerns for melting snow contribution to river discharges in late spring, increasing the likelihood of hydrological drought in the coming months.
- Due to a slightly warmer than usual winter season, an early start of the growing season corresponds to better than normal conditions for vegetation growth in the region. However, the lack of precipitation may cause severe impacts as soon as re-growth takes up speed in spring.
- Drier than normal conditions are forecasted for most of Italy (and southern Europe in general) for the next three months. This makes it less probable that abundant precipitation will bring relief to the current situation, and it rises concerns about widespread and concurrent impacts.

### Precipitation

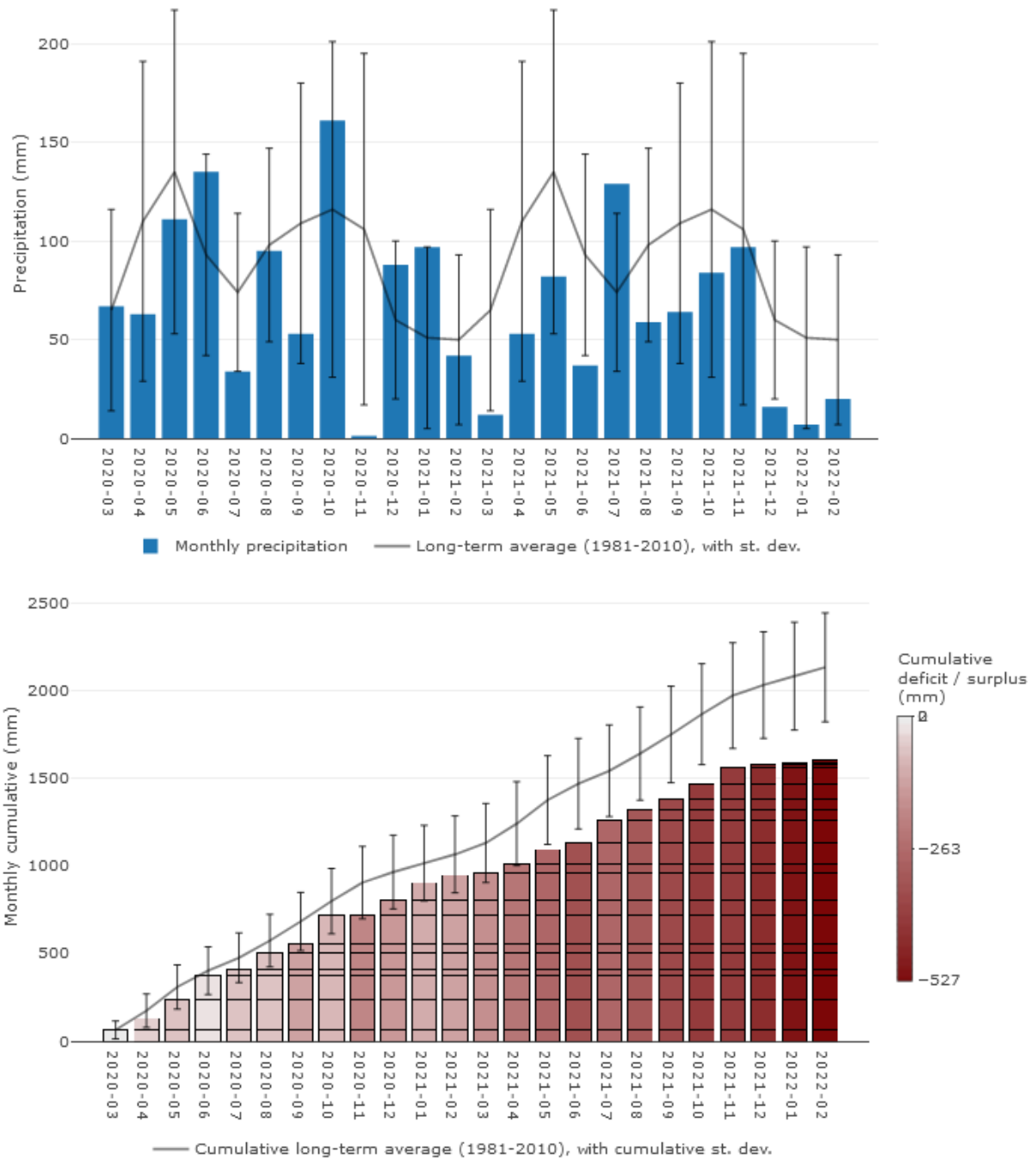
Total monthly precipitation is the main factor in understanding and characterising drought events. The climatic conditions of the analysed region are characterised by two main wet seasons in late spring and in autumn.

Almost no precipitation (about 40 mm from December 2021 to February 2022, against an expected value of 160 mm) has been observed in Piedmont since December 2021, resulting in a severe and rapidly increasing cumulative precipitation deficit (Fig. 1).

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**Figure 1:** Monthly total (upper panel) and cumulative (lower panel) precipitation – temporal evolution in Piedmont (45.8° N, 8.3° E) from March 2020 to February 2022.

The duration of the dry spell is quantified by the Standardized Continuous Dry Days Index (SCDDI, provided by Po River District Basin Authority; Fig. 2). Critical values are detected mainly

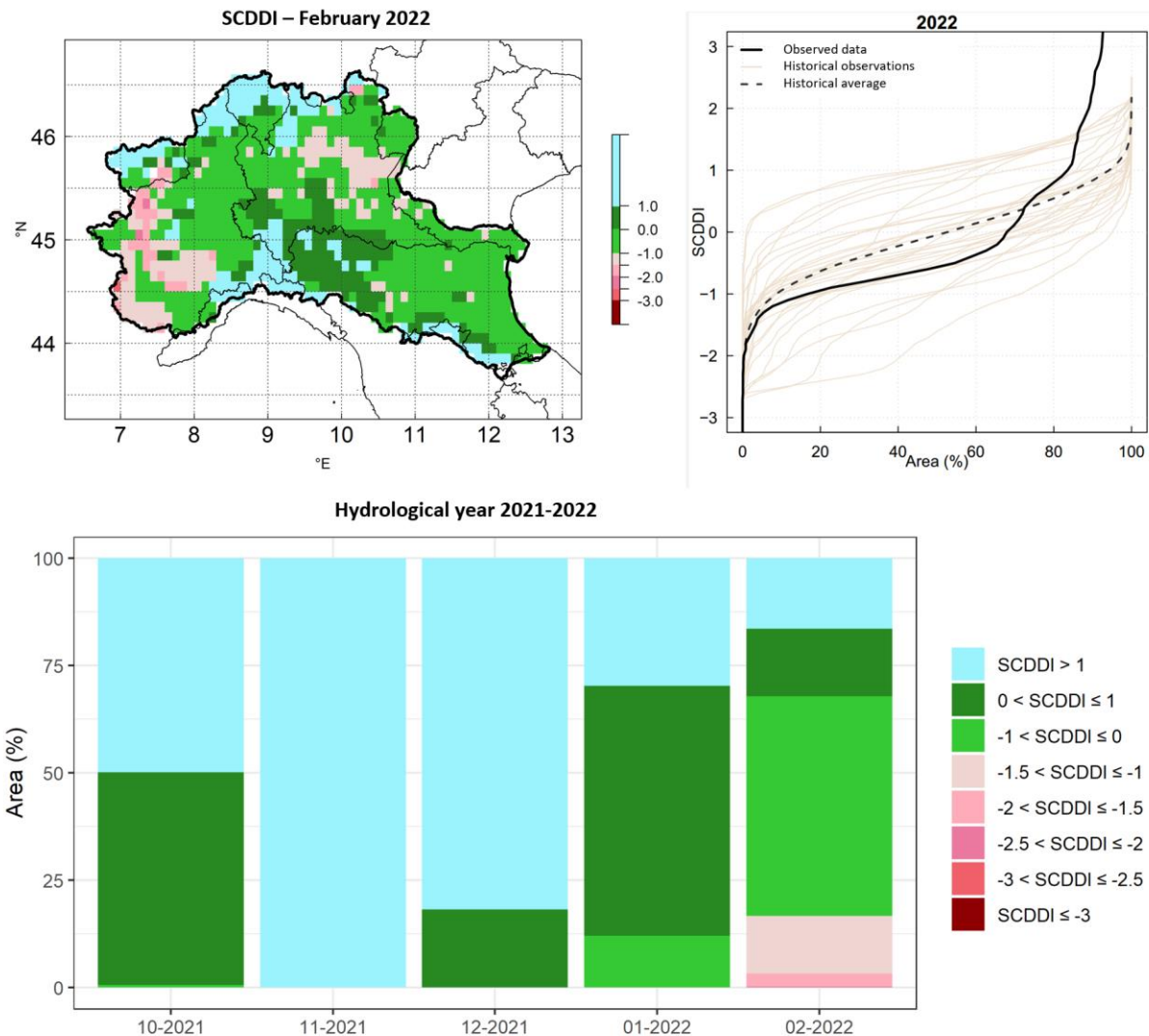
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in western Piedmont and in central-eastern Lombardy. The observed trend has worsened since December 2021, as precipitation has been either scarce or absent.

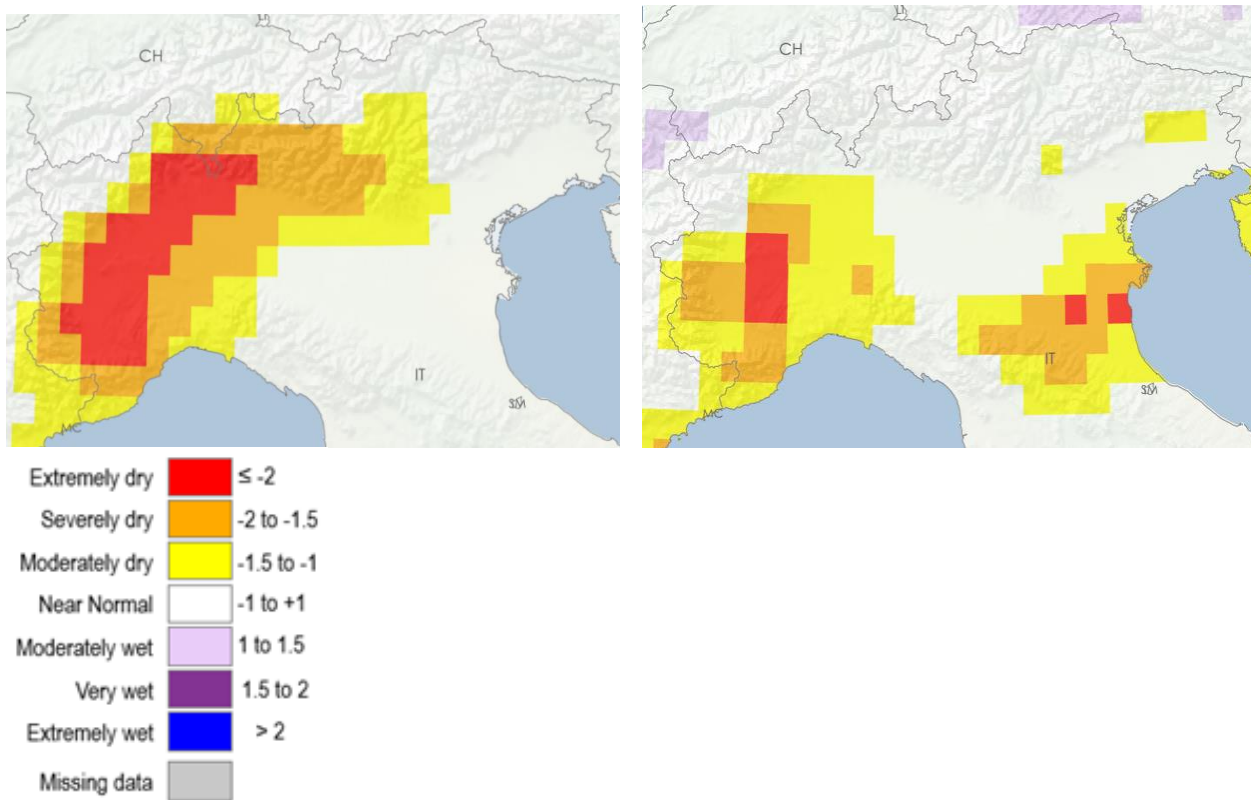


**Figure 2:** Standardized Continuous Dry Days Index (SCDDI) from October 2021 to February 2022. Light to dark red areas are the ones where the dry days duration has been critical. Source: Permanent Observatory on water use - Po River District Basin Authority.



### Standardized Precipitation Index (SPI)

The SPI<sup>1</sup> provides information on the intensity and duration of the precipitation deficit (or surplus). SPI-3 (3-month accumulation period) shows a wide and extremely dry area, covering almost completely Piedmont and north-western Lombardy. This results into immediate impacts on soil moisture, snowpack, and water level in the reservoirs. The severe precipitation deficit is affecting most of the bigger tributaries of the Po river. These conditions build upon a long-lasting precipitation deficit during 2021, especially in south-western Piedmont (Fig. 3), as shown by the SPI-12 (12-month accumulation period).



**Figure 3:** Standardized Precipitation Index SPI-3 (left panel) and SPI-12 (right panel) in February 2022.

The SPI-3 temporal evolution over the last two years (from March 2020 to February 2022) shows only sporadic dry conditions in 2021 (Fig. 4, upper panel); while, it reveals the rapidly-

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<sup>1</sup>SPI is used to monitor the occurrence and the intensity of drought. The lower (i.e., more negative) the SPI, the more intense is the drought. SPI can be computed for different accumulation periods: the 3-month period is often used to evaluate agricultural drought and the 12-month accumulation period can be used for hydrological drought, when rivers fall dry and groundwater tables lower.

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evolving severe dry conditions in February 2022. The longer accumulation period of 12 months (Fig. 4, lower panel) shows a progressive worsening over the same period. This provides the basis for a potentially severe crisis for both river flows and water availability for both the agricultural and the energy sectors.



**Figure 4:** Standardized Precipitation Index for 3- and 12-month accumulation periods (SPI-3, upper panel; SPI-12, lower panel) displaying the drought evolution in Piedmont from March 2020 to February 2022.

## Ensemble Soil Moisture Anomaly

The lack of precipitation induces reduction of soil water content. The aim of the Soil Moisture Anomaly index is to provide an assessment of the deviations of root zone water content from normal conditions, which is a direct measure of the drought associated with the difficulty for plants to extract water from the soil.

Drier than normal soil moisture conditions have been observed at the beginning of March 2022 over most of northern Italy. Soil moisture conditions reflect well the SPI-12 spatial distribution (Fig. 5).



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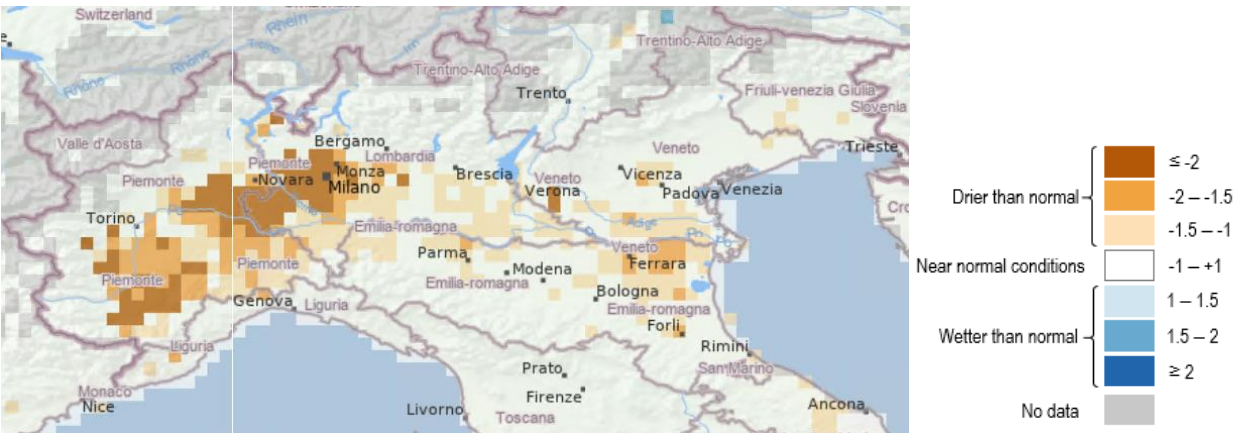
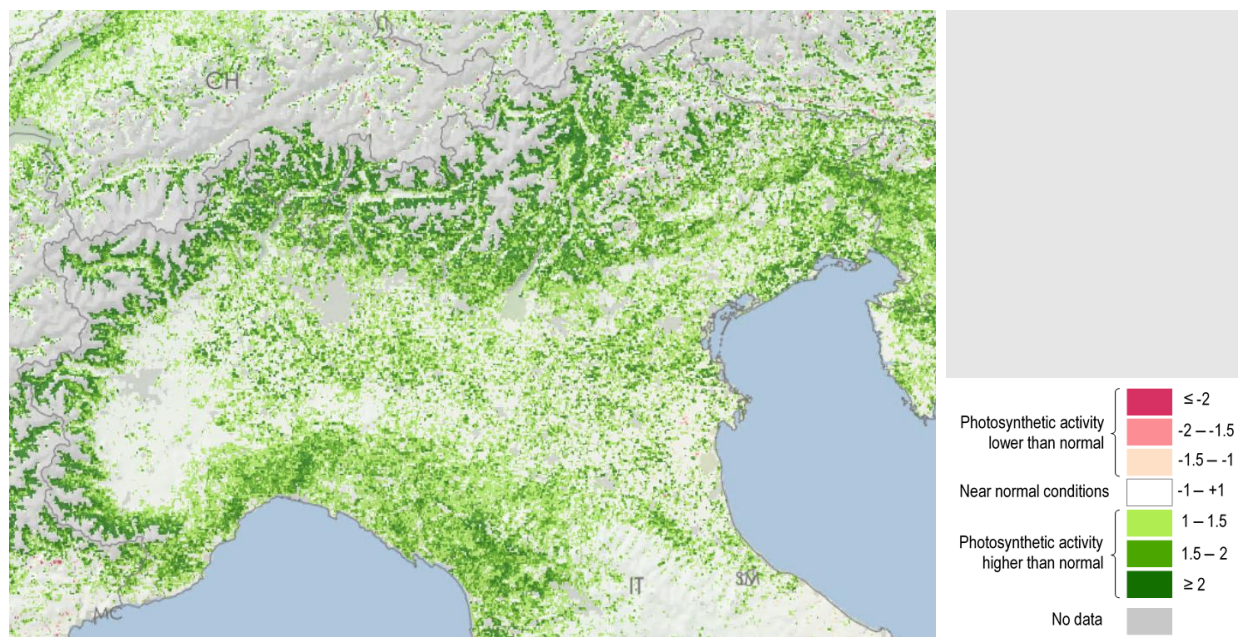


Figure 5: Ensemble Soil Moisture Anomaly - beginning of March 2022.

### FAPAR anomaly

The satellite-based EDO indicator fraction of Absorbed Photosynthetically Active Radiation (FAPAR) estimates the fraction of solar energy absorbed by leaves. FAPAR anomalies, specifically negative deviations from the long-term average, are an indicator of possible drought impacts on vegetation.

During the period preceding the core part of the growing season, plants have lower photosynthetic activity and lower water needs. Hence, temperature is the main constraint for photosynthetic activity rather than precipitation. The mild temperatures observed over most of northern Italy during winter caused higher-than-normal FAPAR values (Fig. 6), pointing to an early start of the growing season. Soil moisture will become extremely important for plant growing conditions - and hence FAPAR values - during spring and summer, which are key periods in terms of drought impacts in the agriculture sector.

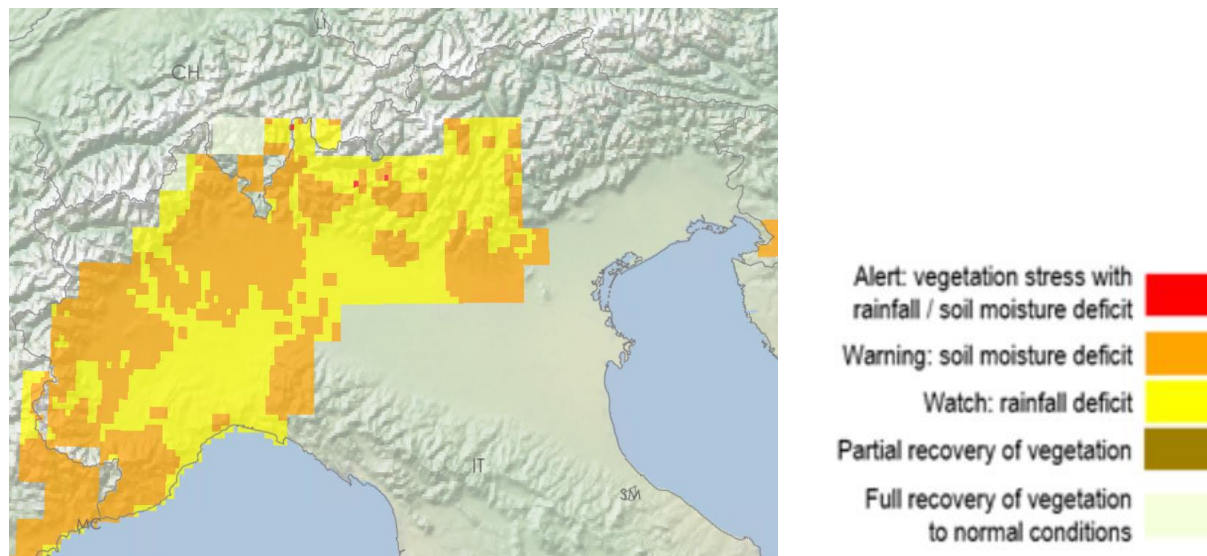


**Figure 6:** FAPAR Anomaly - beginning of March 2022.

### Combined Drought Indicator (CDI)

The Combined Drought Indicator (CDI) of the European Drought Observatory (EDO) is used to identify areas that may be affected in the near future by agricultural drought. The CDI is derived by combining the Standardized Precipitation Index (SPI), the Soil Moisture Index Anomaly (SMA), and the FAPAR anomaly. Areas are classified according to three primary drought classes: (1) “Watch”, indicating that precipitation is less than normal; (2) “Warning”, indicating that also soil moisture is in deficit; and (3) “Alert”, indicating that also vegetation shows signs of stress. Two additional classes - “Partial recovery” and “Recovery” - identify the stages of the vegetation recovery process.

At the beginning of March 2022, CDI shows either “Watch” or “Warning” levels in north-western Italy. The affected area covers the western and northern parts of the Po River basin, highlighting the relevance of the event in terms of extent and severity (Fig. 7). As already mentioned, the amount of precipitation during the next months (April-June) will be crucial in terms of impacts.



**Figure 7:** Combined Drought Indicator (CDI) – beginning of March 2022.

### Comparison with respect to the 1991-2020 average<sup>2</sup>

The winter season 2021/22 in the Po River basin has been anomalous, given the warmer than usual conditions and the scarcity of precipitation. A recent analysis by MeteoSwiss, ARPA (Regional Agency for the Protection of the Environment) Piemonte and ARPA Lombardia estimated a temperature anomaly of +2.1 °C, and an average precipitation deficit of 65% compared to the 1991-2020 average.

Considering the anomalies with respect to the 1991-2020 conditions (Fig. 8), we can provide a qualitative and quantitative classification of the 2021-2022 winter compared to recent years.

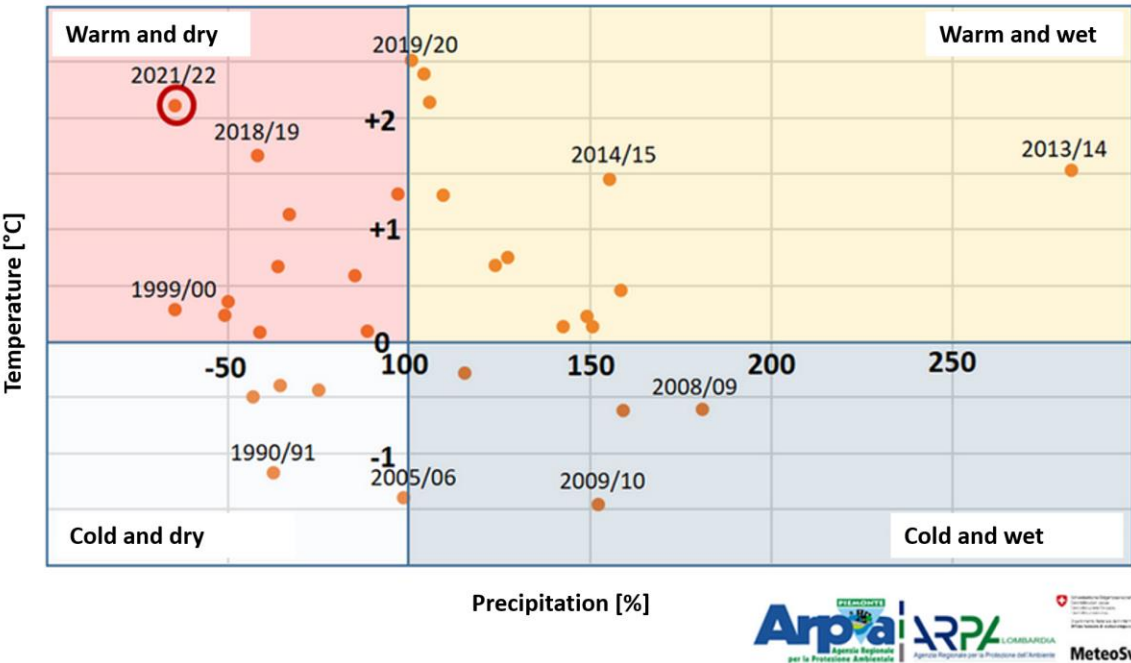
The 2021-2022 winter was the most dry and mild one in Lombardy, Piedmont and Southern Switzerland in the last 30 years at least, according to the available records for this report.

The winter 2018/19 was similar, but with slightly less-marked anomalies. The winter 2019/20 had recorded higher temperatures, but precipitation was close to the seasonal average.

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<sup>2</sup> <https://www.arpalombardia.it/Pages/Inverno-da-primato-in-Ticino,-Lombardia-e-Piemonte.aspx>

**Winter temperature and precipitation  
Piedmont and Lombardy (IT) and Ticino (CH)**  
*anomaly with respect to 1991-2020 baseline*



**Figure 8:** Anomalies with respect to the 1991-2020 average of mean winter temperature (vertical axis) and winter total precipitation (horizontal axis) from 1990/91, averaged over 31 survey stations. Source: MeteoSwiss, ARPA Piemonte and ARPA Lombardia<sup>3</sup>.

### Low-Flow Index

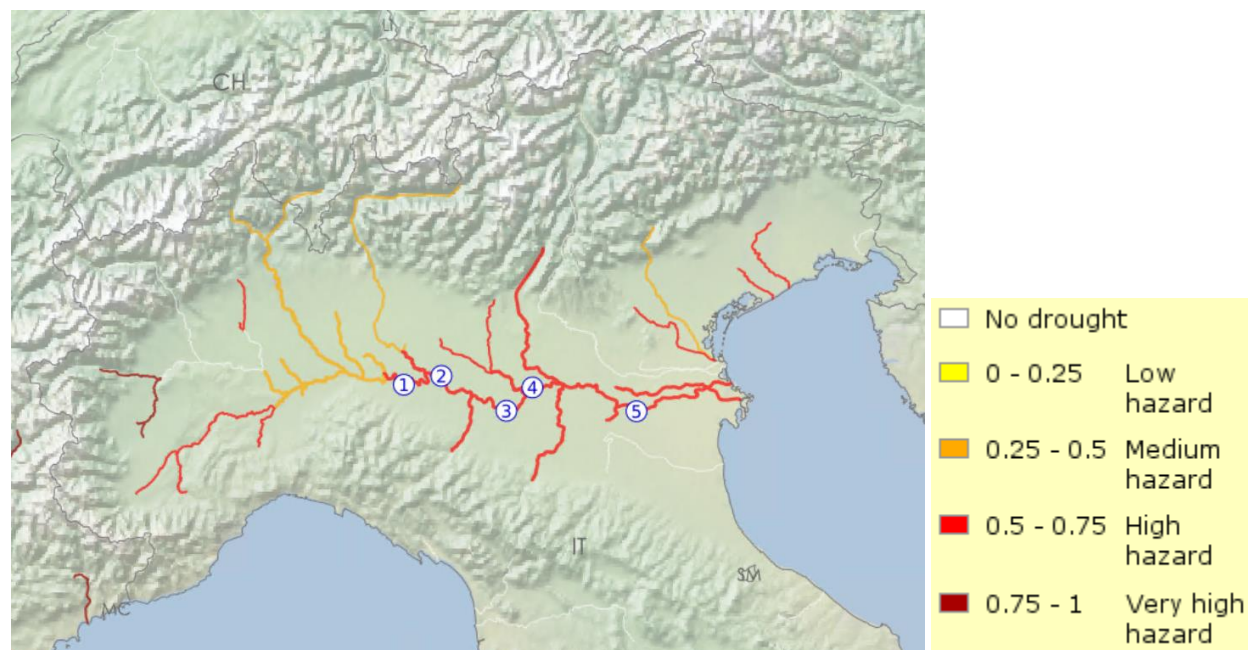
The Low-Flow Index (LFI) exploits the daily river water discharge simulated by the LISFLOOD hydrological model, in order to capture consecutive periods of unusually low streamflows. It compares the consequent water deficit during those periods with the historical climatological conditions.

At the beginning of March 2022, the LFI largely follows the behaviour of both soil moisture and long-term SPI conditions in the Po River basin (Fig. 9). There are strong deficits in the upper western part of the basin, and from the Adda confluence downstream to the outlet. This evidence

<sup>3</sup> <https://www.arpalombardia.it/Pages/Inverno-da-primato-in-Ticino,-Lombardia-e-Piemonte.aspx>



of hydrological drought is confirmed by the analyses performed on the observed data by the Po River District Basin Authority.



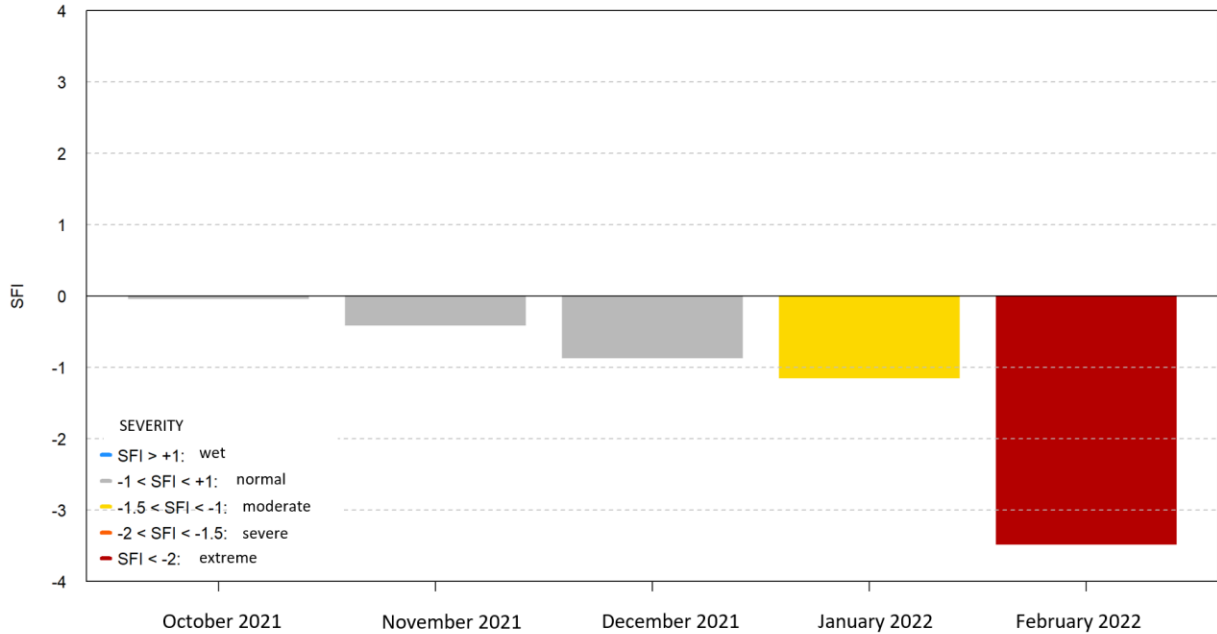
**Figure 9:** Low-Flow Index (LFI) at the beginning of March 2022. A Low-Flow Index of 0 corresponds to no drought and a value of 1 to the highest drought hazard. Circles represent the stations in Piacenza (1), Cremona (2), Boretto (3), Borgoforte (4) and Pontelagoscuro (5) sections.

The Standardized Flow Index (SFI), calculated from observations in the main sections of the Po river in February points to: extreme hydrological drought (SFI lower than  $-2$ ); severe hydrological drought (SFI lower than  $-1.5$ ) in both the Boretto and Pontelagoscuro sections; moderate hydrological drought (SFI lower than  $-1$ ) in the Cremona and Borgoforte sections (not shown here – see the March Bulletin of the Permanent Observatory on water use – Po River District Basin Authority).

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**Figure 10:** Standardized Flow Index (SFI) at Piacenza section from October to February 2022. Source: Permanent Observatory on water use - Po River District Basin Authority.

As of 23<sup>rd</sup> of March, precipitation has been missing for more than 100 days, with an average deficit of 65%, and rainfall is not forecasted for the following days. This is triggering a sharp drop of rivers' discharges, already below the minimum values for Trebbia, Secchia, and Reno rivers since 1972, and a reduction of 75% of discharge for Dora Baltea, Adda, and Ticino rivers. The most critical Po River section is around Piacenza, featuring a 66% deficit and a discharge of 260 m<sup>3</sup>/s, outlining extreme hydrological drought conditions.<sup>4</sup>

Furthermore, sea water intrusion in the Po River Delta, which is a major cultivation zone, is severe (March 2022) and comparable to the most critical values registered in summer 2003 (Fig. 11). If precipitation forecasts for the next three months will realise, river flows are likely to reach record low values during summer.

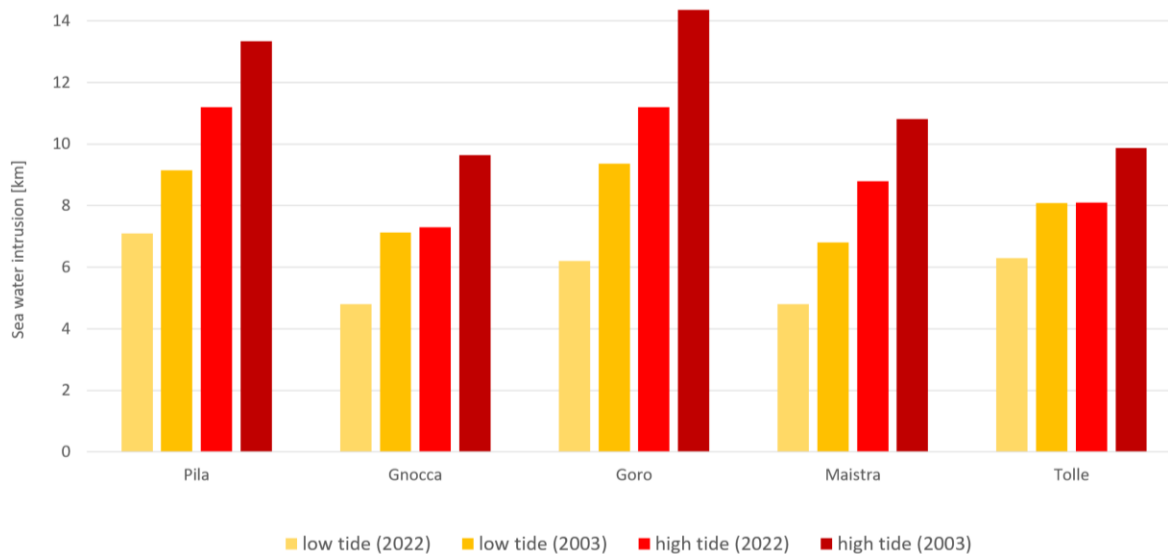
<sup>4</sup> <https://www.adbpo.it/la-siccita-si-fa-grave-nel-distretto-padano/>



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**Figure 11:** Sea water intrusion distance in km on 16<sup>th</sup> March 2022 compared to the summer values observed in 2003 (upper) and location of river branches (lower). Source: Permanent Observatory on water use - Po River District Basin Authority.

## Snow Water Equivalent<sup>5</sup>

This section is based on data and information provided by the operational snow monitoring system for Italy (S3M-Italy) developed and maintained by CIMA (Centro Internazionale in

<sup>5</sup> CIMA Research Foundation

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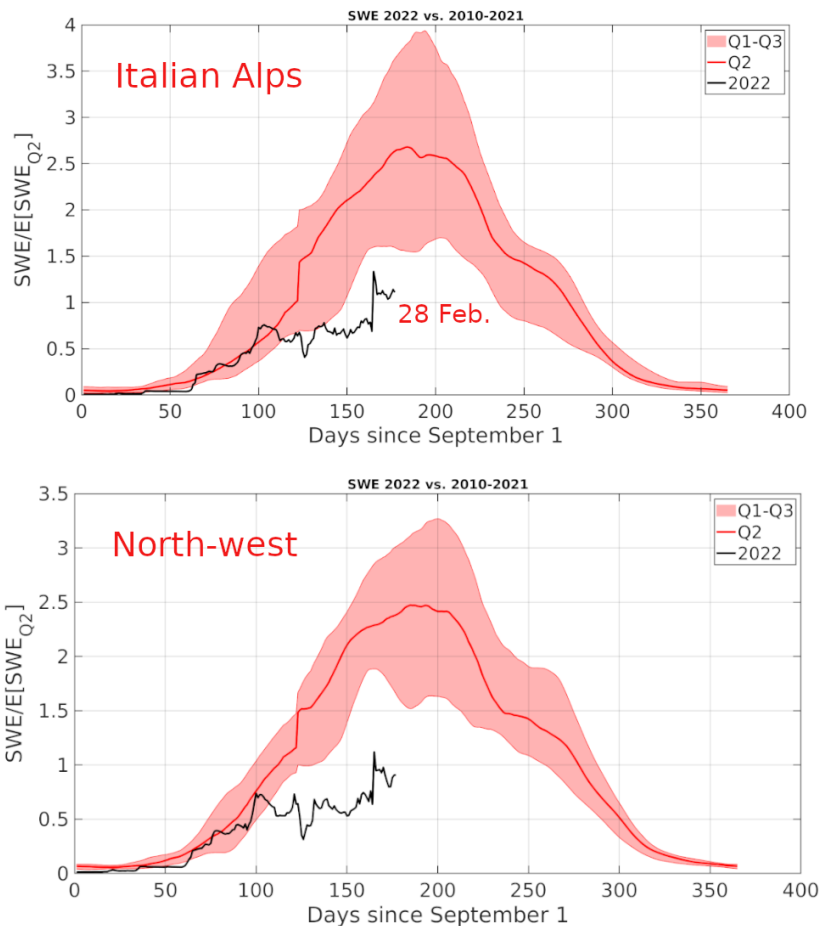
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Monitoraggio Ambientale, International Center for Environmental Monitoring) Research Foundation on behalf of the Italian Civil Protection Department (DPC). This system provides hourly snapshots of snow depth and mass content (Snow Water Equivalent, SWE) at 200 m resolution.

In the Italian Alps, the snow season started with average accumulation in November 2021, but a much drier period followed. Consequently, snow water resources in the Italian Alps are below the first quartile of the 2009-2021 climatology (end of February 2022; Fig. 12), and correspond approximately to 40% of the 2009-2021 median conditions. This deficit is more pronounced in the north-western Italian Alps, where currently the snow water resources are at about 37% of the 2009-2021 median conditions (Fig. 12, lower panel).

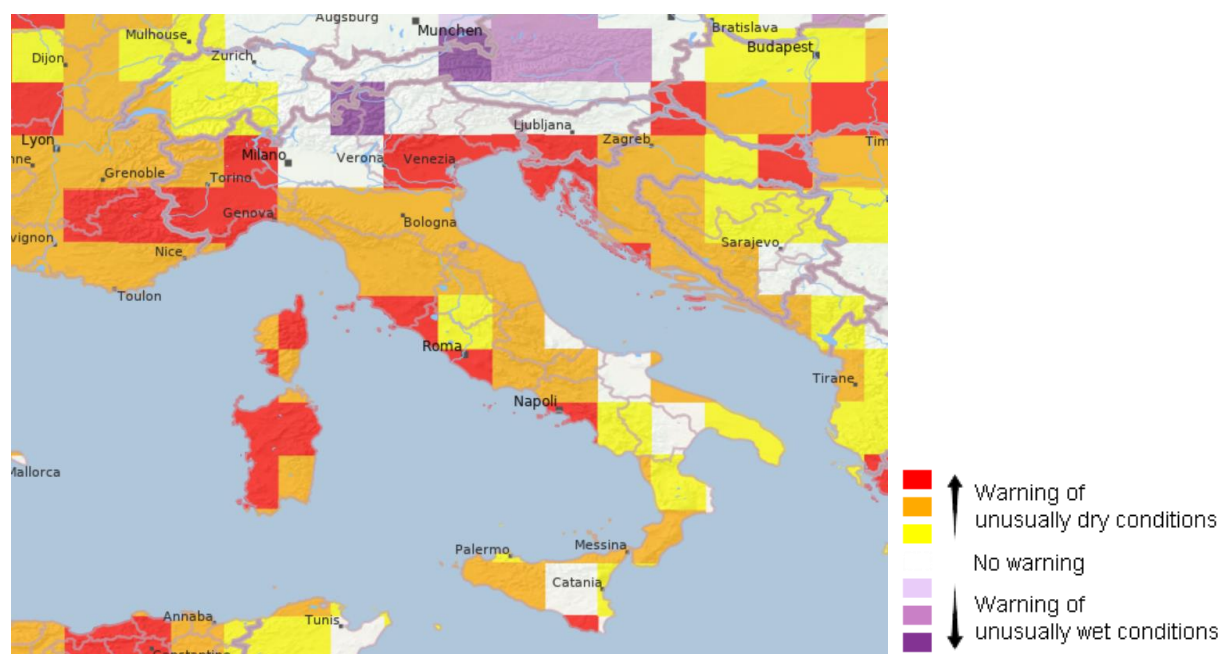


**Figure 12:** Normalized Snow Water Equivalent for the 2021-22 snow season (black line) compared to the 2009-2021 climatology for all the Italian Alps (upper panel) and for the north-western Alps (lower panel). The red line represents the median (Q2), while the light red area encloses the zone between the first (Q1) and last (Q3) quartiles.

### Seasonal forecast

The Indicator for 'forecasting unusually wet and dry conditions' provides early warnings for Europe. The indicator is computed from forecasted SPI-1, SPI-3 and SPI-6 derived from the ECMWF seasonal forecast system SEAS5.

Severely drier than normal weather conditions are predicted over Piedmont and the southern part of Veneto in the period March-May 2022. Drier than normal conditions are forecasted for most of Italy too, with other severe spots: in Sardinia, along the western Italian coast, in the Provence region and Corsica in France. The chance for recovery from the current deficit is very low, in absence of above-average precipitation. These negative forecasts raise concerns for the evolution of the drought into an extreme and persistent event. Monitoring the evolution in the next months is essential for risk and impact assessment and early warning (Fig. 13).



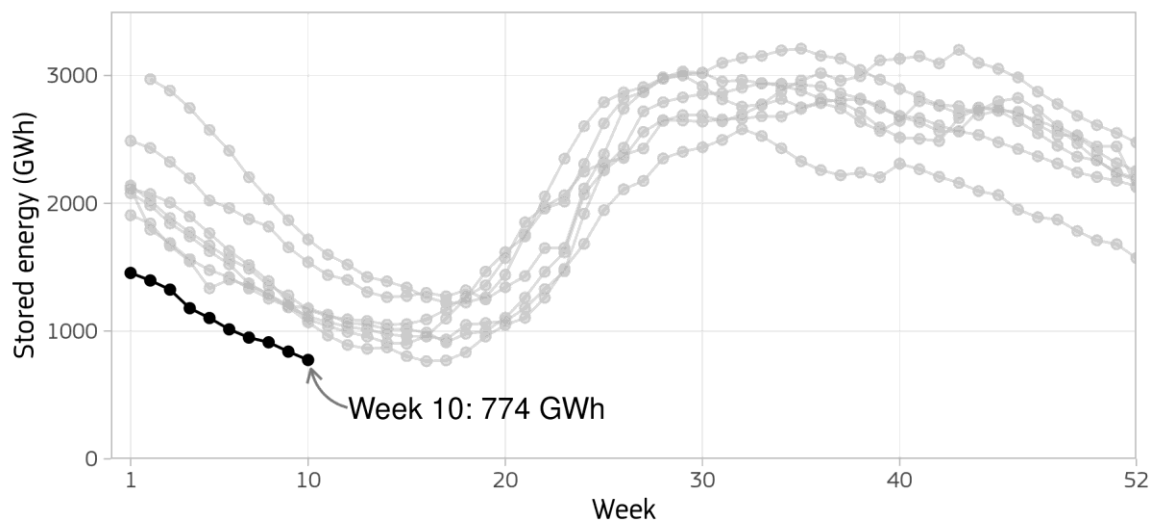
**Figure 13:** Indicator for forecasting unusually wet and dry conditions for 3 months, February to April 2022.

## Reported impacts

### Energy

The ongoing drought is affecting the energy storage in the Italian hydropower system. The water levels in many Italian reservoirs are below the minimum historical values (considering the period 1970-2019) since September 2021 (monthly bulletins data from Terna S.p.A<sup>6</sup>). At the beginning of March 2022, the stored energy value in the Italian reservoirs was 1839 GWh, i.e. the 28.2% of the total storage capacity vs a historical (1970-2019) observed minimum of 30.4% for the same period. The Italian transmission system operator provides statistics at national level only, but the weekly level of the storages is available also at subnational level (bidding zones). Figure 14 shows the level of the hydropower reservoirs in the North bidding zone<sup>7</sup> for the years 2015-2022. The latest data shows an amount of stored energy of 774 GWh at week 10, 27.5% less than the 8-year minimum (1068 GWh in 2021).

The current level of the Italian hydropower reservoirs may exacerbate the current situation of the Italian power market which is already experiencing record-breaking wholesale prices.<sup>8</sup>



Data for Italy-North (BZN). Source: ENTSO-E Transparency Platform (accessed 18/03/2022)

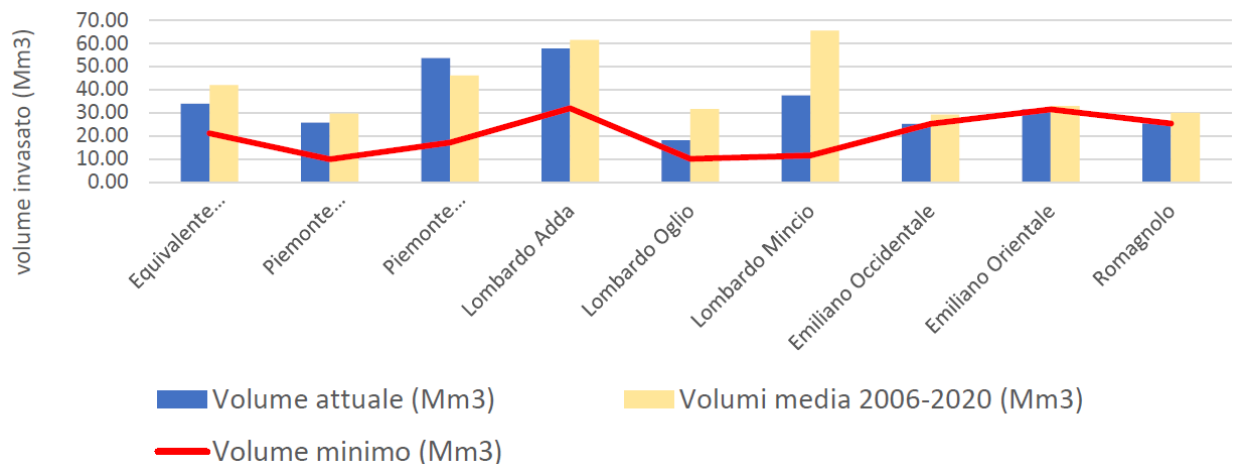
**Figure 14:** Hydropower storage levels in North Italy for the period 2015-2022. Each grey line represents a specific year. The black line is associated with 2022. Source: ENTSO-E Transparency Platform.

<sup>6</sup> <https://www.terna.it/en/electric-system/publications/monthly-report>

<sup>7</sup> The North bidding zone includes the following Italian regions: Valle d'Aosta, Piemonte, Lombardia, Veneto, Liguria, Friuli Venezia-Giulia, Trentino Alto Adige, Emilia-Romagna

<sup>8</sup> European Commission Joint Research Centre Directorate C: Energy, Transport & Climate Unit C.7: Knowledge for the Energy Union

The stored water volume in the artificial mountain reservoirs is below the average of the years 2006-2020 in almost all the sub-basins. Many values are critical and close to the historical minimum (Fig. 15). Overall, the water availability in the mountain reservoirs is below the average and corresponds to 36% of the total available volume.



**Figure 15:** Cumulative stored water volume on 16<sup>th</sup> March 2022 (blue bars), average stored water volume for the same period (2006-2020, yellow bars), and historical minimum volume (red line) for mountain reservoirs for each sub-basin of the Po basin from west to east, source to outlet. Source: Permanent Observatory on water use - Po River District Basin Authority.

### Agriculture

According to the latest edition of the JRC-MARS Bulletin on Crop Monitoring in Europe published on 21 March 2022<sup>9</sup>, winter crops in northern Italy are still in normal conditions, but the water stress is reducing the yield potential. Rain is urgently needed to avoid further reducing the yield potential, to favour fertiliser application, and to allow for good spring crops sowing conditions.

The colder than usual weather since 20 February is helping to reduce evapotranspiration, but, as soon as temperatures will increase, the impact of water stress will likely become noticeable.

As shown in the previous sections, water availability for irrigation will be lower than usual, as the Po river and its main tributaries are already at very low levels and limited recharge is expected from snowmelt. Irrigation will start sooner than usual, most likely at the beginning of April, and could be requested not only for rice, but for winter crops as well. This means that

<sup>9</sup> [https://joint-research-centre.ec.europa.eu/jrc-news/fair-start-spring-most-european-crops-2022-03-21\\_en](https://joint-research-centre.ec.europa.eu/jrc-news/fair-start-spring-most-european-crops-2022-03-21_en)

competition for water will start sooner than usual with possible negative effects on the rice-sown area. Under the given conditions, rice marginal areas (i.e. less productive areas) are not planted. The peak in water demand will occur in May as usual because of the overlapping water demand from rice and maize producers.<sup>10</sup>

According to the Permanent Observatory on water use over Po River district, this critical situation may exacerbate at the beginning of the irrigation period because the water demand will be significantly higher than the water availability. Winter 2021-2022 appears to be the driest in the last ten years and potentially worse than 2006-2007. Due to the critical situation at the Po River Delta for the sea water intrusion, it may become difficult or not possible to derivate water for irrigation, both from canals and from surface aquifers. Brackish water could cause damages to fruit and vegetables crops, with impacts also on natural habitat.<sup>11</sup>

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<sup>10</sup> European Commission Joint Research Centre Food Security Unit – D5

<sup>11</sup> <https://www.adbpo.it/siccita-estrema-nel-distretto-del-po-nessuna-pioggia-in-vista-fino-alla-meta-di-aprile-e-ulteriore-calo-delle-portate/>



# GDO Analytical Report

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### ***Glossary of terms and acronyms:***

ARPA	Agenzia Regionale per la Protezione dell'Ambiente
CDI	Combined Drought Indicator
CEMS	Copernicus Emergency Management Service
CIMA	Centro Internazionale in Monitoraggio Ambientale
DPC	Dipartimento di Protezione Civile
EDO	European Drought Observatory
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
ERA5	ECMWF Reanalysis v5
ERCC	European Emergency Response Coordination Centre
FAO	Food and Agriculture Organization of the United Nations
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
GDO	Global Drought Observatory
GPCC	Global Precipitation Climatology Centre
JRC	Joint Research Centre
LFI	Low-Flow Index
MARS	Monitoring Agricultural Resources
RDri-Agri	Risk of Drought Impact for Agriculture
SCDDI	Standardized Continuous Dry Days Index
SFI	Standardized Flow Index
SMA	Soil Moisture Index (SMI) Anomaly
SMI	Soil Moisture Index
SPI	Standardized Precipitation Index
SWE	Snow Water Equivalent

### ***EDO indicators versioning:***

The GDO/EDO indicators appear in this report with the following versions:

GDO Ensemble Soil Moisture Anomaly, v.2.3.0

FAPAR (fraction of Absorbed Photosynthetically Active Radiation) Anomaly 1.3.2

Indicator for forecasting unusually wet and dry conditions 1.0.0

Precipitation (GPCC) 1.2.0

Risk of Drought Impact for Agriculture (RDri-Agri) 2.3.2

Standardized Precipitation Index (SPI, GPCC, 1-dd resolution) 1.2.0 for charts; SPI ERA5 (1/4-dd resolution) for maps. SPI ERA5 is a provisional dataset which replaces SPI Blended and Interpolated (v.1.2.0), unavailable in the considered period due to an issue in source data.

Combined Drought Indicator (CDI) 1.5.0  
Low-Flow Index 2.1.0

Check <https://edo.jrc.ec.europa.eu/download> for more details on indicator versions.

### **Distribution:**

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# GDO Analytical Report

## Drought in northern Italy - March 2022

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 25/03/2022



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