BBVA Research

Climate Change: Bounding Uncertainty. An Application to Drought Analysis in Spain

BBVA Research | Economics of Climate Change

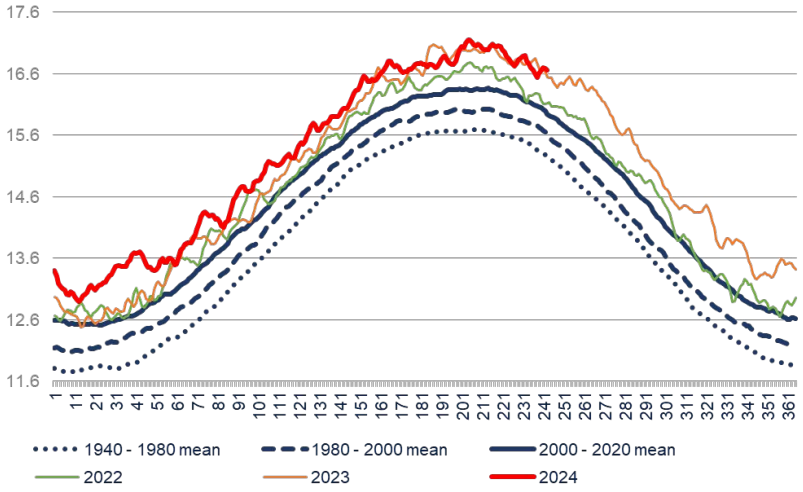
Resiliencia del agua para la resiliencia económica en el contexto de Cambio Climático: gestionando los riesgos económicos y financieros
Madrid 4 de octubre de 2024

Creating Opportunities

Evidence of global warming is unequivocal, with human activity as primary cause

Global temperatures are rising and will likely exceed 1.5°C above pre-industrial levels in next five years, according to the World Meteorological Organization

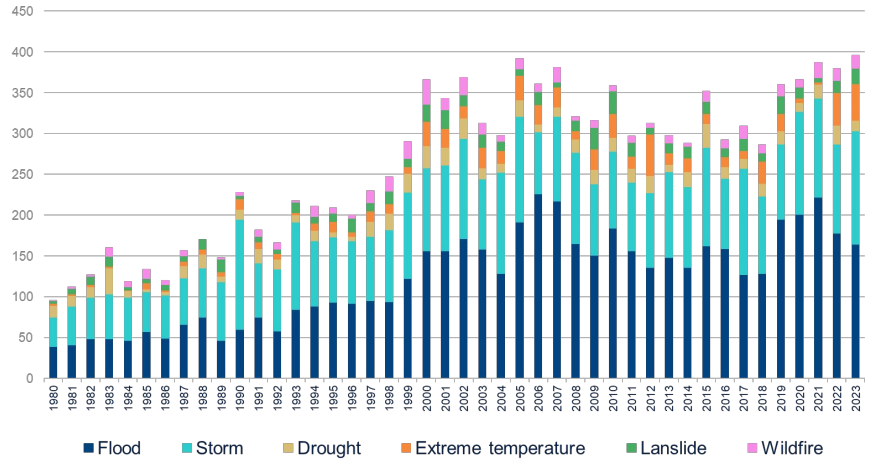
WORLD TEMPERATURE EVOLUTION (ºC)
1980-2024



Note: Daily mean surface air temperature (2-meter height)
Source: BBVA Research from ERA5 hourly data on single levels

The frequency and intensity of extreme events are increasing. Global warming affects the water cycle and weather patterns, which exacerbates extreme events

WORLD CLIMATE-RELATED ACUTE EVENTS
1980-2023



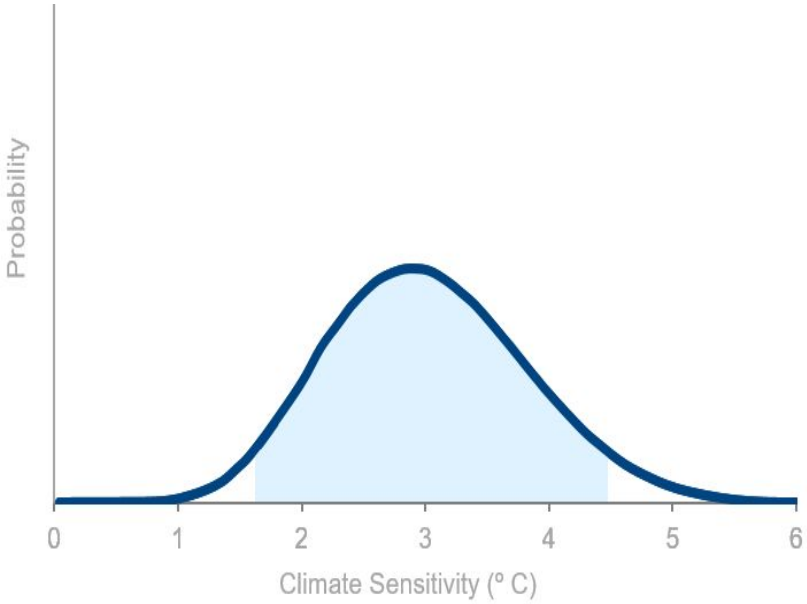
Source: BBVA Research from EM-DAT

Uncertainty is the signature feature of climate change in measurement, modelling, …

Measurement uncertainty

CLIMATE SENSITIVITY TO CO_2

(Meta analysis; area: 90% of probability interval)

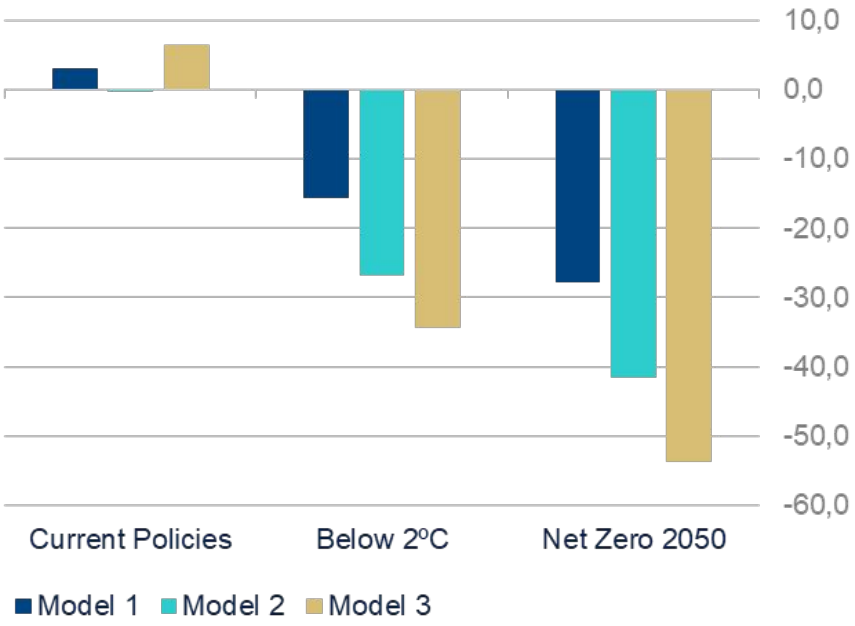


Source: Andrés y Doménech (2020) based on Knutti, Rugenstein and Hegerl (2017).

Modelling uncertainty

GHG EMISSIONS

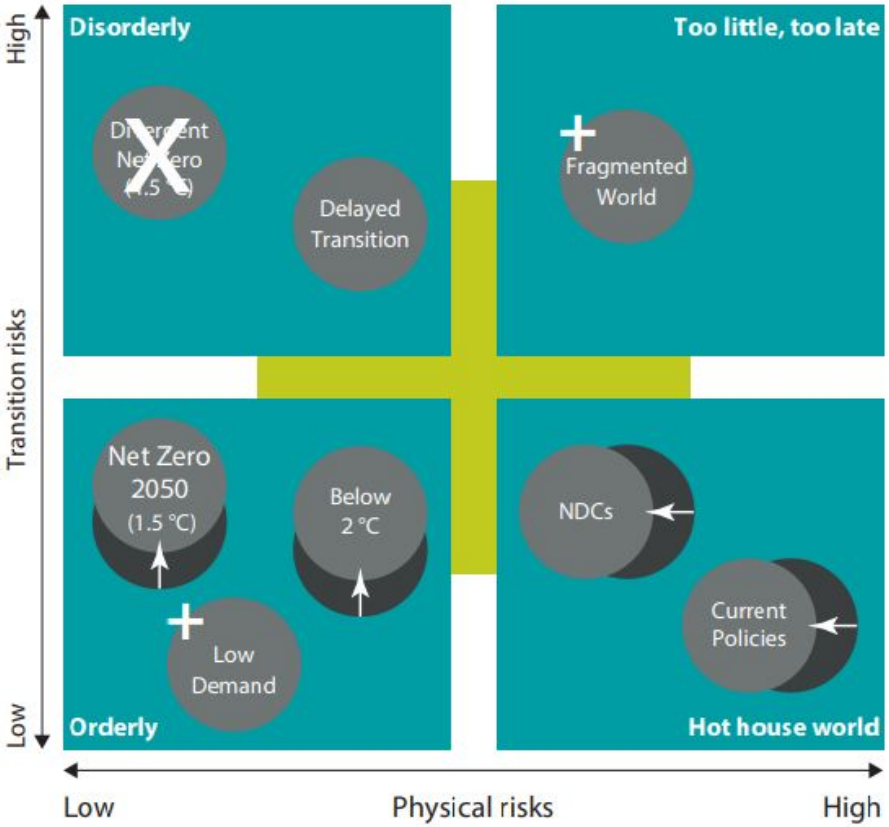
% 2020-2030



Source: BBVA Research, NGFS Scenarios

… and scenarios definition, a work in progress, at the rhythm of climate policy advances and expected behavioral changes

NGFS SCENARIOS FRAMEWORK: FROM PHASE III to PHASE IV



Source: NGFS Scenarios for central banks and supervisors

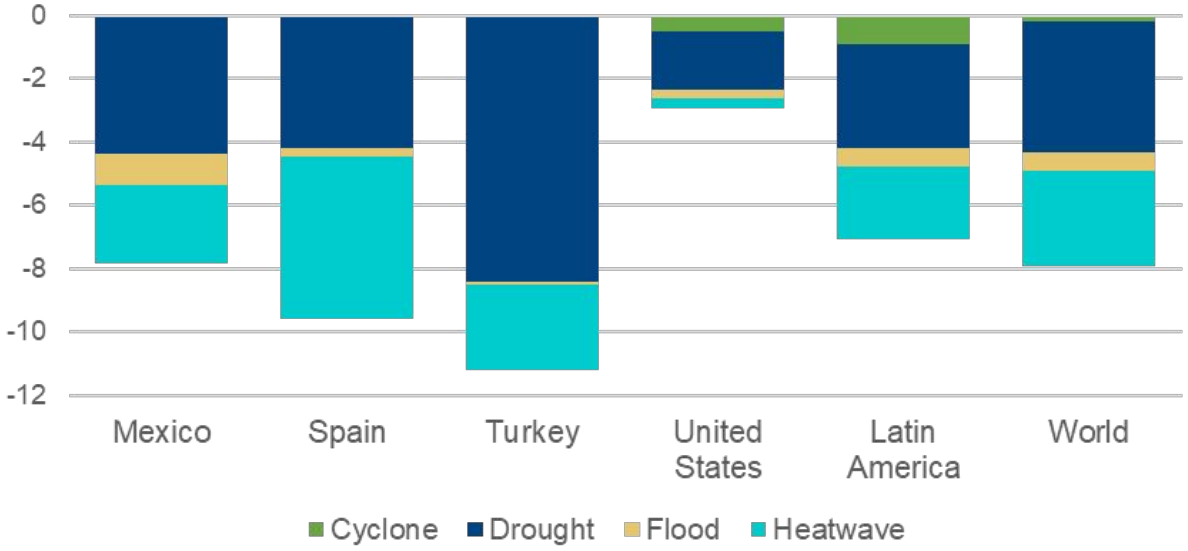
NGFS: Phase IV unveils a **more disorderly** set of alternative climate futures (*)

- The new Fragmented World Scenario paints a pessimistic tableau shaped by delated and divergent global climate policies, projecting over 5% global GDP loss by 2050.

(*) More details: "NGFS: Phase IV unveils more disorderly alternative climate futures". BBVA Research. Nov 24, 2023

… and scenarios definition, a work in progress, at the rhythm of climate policy advances and expected behavioral changes

IMPACT ON GDP IN 2050 BASED ON A CURRENT POLICIES SCENARIO
DIFFERENCE IN PP (2017 PPP)
IMPACT RELATIVE TO A REFERENCE SCENARIO W/O CLIMATE CHANGE.



Source: BBVA Research based on NGFS Phase IV.

- The above figure shows how GDP is impacted across scenarios compared with a hypothetical (and impossible) reference scenario in which no transition or physical risks occur.
- The displayed results correspond to damages using the 80th percentile of the modeling results, with the 100th percentile representing the most severe impact. NGFS has not yet released the impact with the median, which would be more logical, and provides impacts with high percentiles, amplifying the damage.

NGFS: Phase IV unveils a **more disorderly** set of alternative climate futures (*)

- The new Fragmented World Scenario paints a pessimistic tableau shaped by delated and divergent global climate policies, projecting over 5% global GDP loss by 2050.

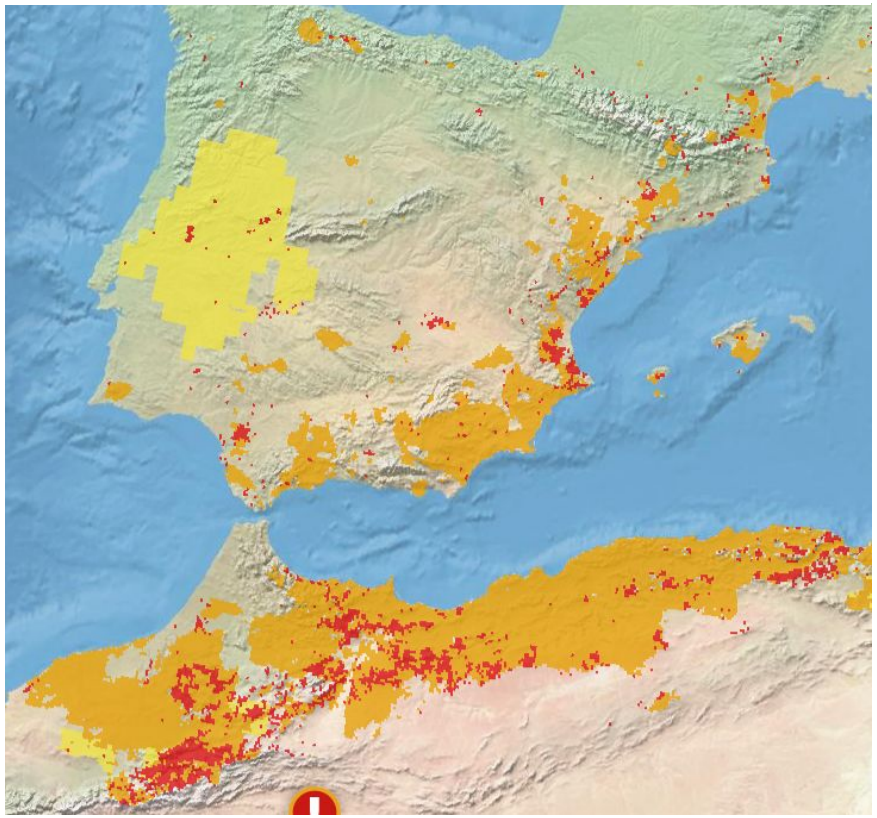
The NGFS Phase IV introduces an updated and improved assessment of acute physical risks, including heatwaves, droughts, river floods, and tropical cyclones. All in all, **in the long long term, the greater impact of climate events could come from droughts**.

- The projected economic impact of these hazards could lead to an **8% GDP loss** by 2050 under a Current Policies scenario.

(*) More details: "NGFS: Phase IV unveils more disorderly alternative climate futures". BBVA Research. Nov 24, 2023

What is Drought? It depends on the indicator used as reference

Combined Drought Indicator. September, 2024



Source: EU Science Hub EDO map

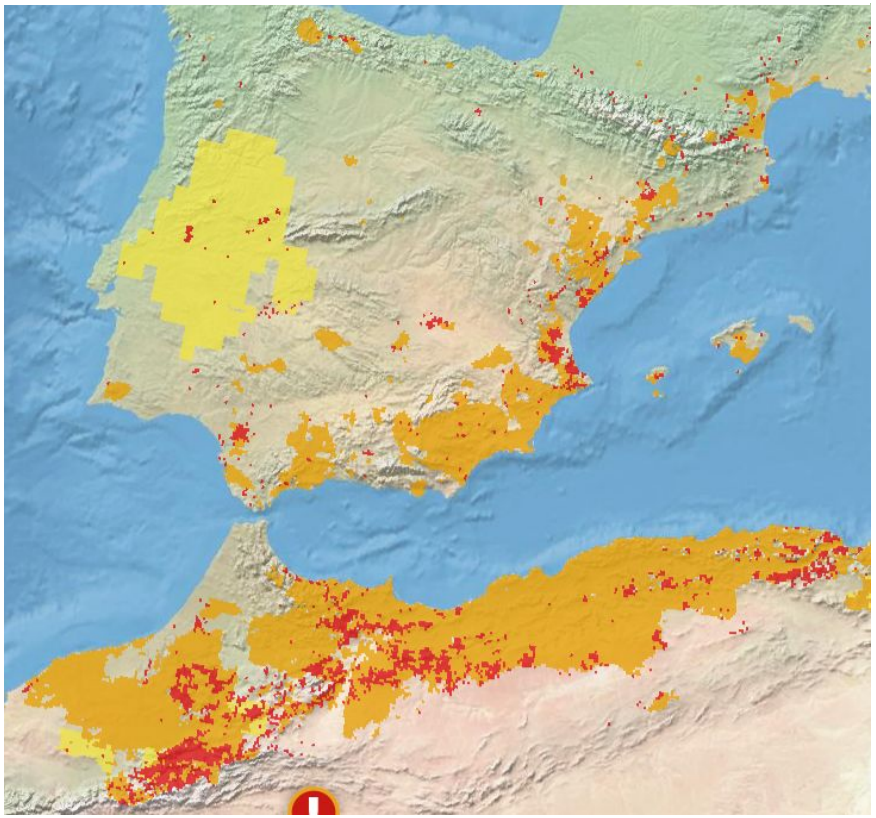
What is drought?(*) A multifaceted climate event that can be monitored by alternative indicators.

- Because droughts vary in type and involve inherent complexity, effective drought monitoring must rely on a variety of indicators that represent different aspects of the hydrological cycle (such as precipitation, soil moisture, reservoir and river levels, and groundwater) or measure impacts like water stress on vegetation.
- **Droughts** are the only catastrophic climatic event that **are protracted**, once they occur, droughts are persistent (vs. floods, wildfires, storms or even heat waves).

(*) "Drought is a climate extreme characterised by persistent unusual dry weather conditions affecting the hydrological balance. The conditions are usually associated with lack of precipitation, deficit in soil moisture and water reservoir storage, leading to widespread impacts." European and Global Drought Observatories.

Economic impact of droughts (*): geographical granularity, sectoral differentiation and not restricted to GDP

Combined Drought Indicator. September, 2024



Source: EU Science Hub EDO map

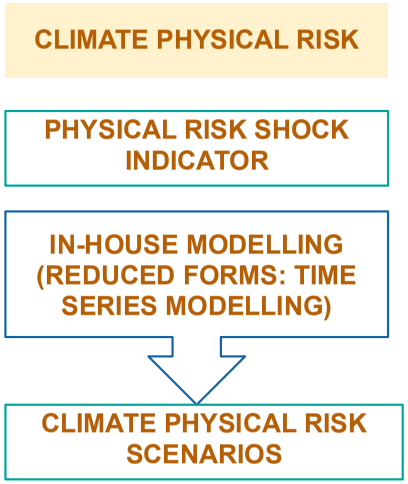
- **Direct impact**: the invaluable loss of human lives or physical damage to the property of households, businesses or public infrastructures.
- **Indirect impact:** changes in economic activity due to the interruption of production, loss of productivity, reduction in household income or due to alteration of economic perspectives.
- **Water and heat stresses** associated with **droughts** reduce **agricultural yields**, increase their **prices** and also **reduce the availability of hydropower** for electricity production.
- All in all, the indirect impact of a **drought** can be defined as a **negative supply shock over the GDP**: increasing prices and reducing the production and the income of the economy.

Source: EU Science Hub European Drought Observatory

(*) Further details: BBVA Research, The Stubborn World Drought, September 2, 2022

A practitioner's approach to climate risk analysis: A few alternative futures, "pure" climate variables anchor, and in-house modelling for bounding uncertainty

BBVA RESEARCH APPROACH TO CLIMATE RISKS



A practitioner's approach to climate risk analysis: A few alternative futures, "pure" climate variables anchor, and in-house modelling for bounding uncertainty

BBVA RESEARCH APPROACH TO CLIMATE RISKS

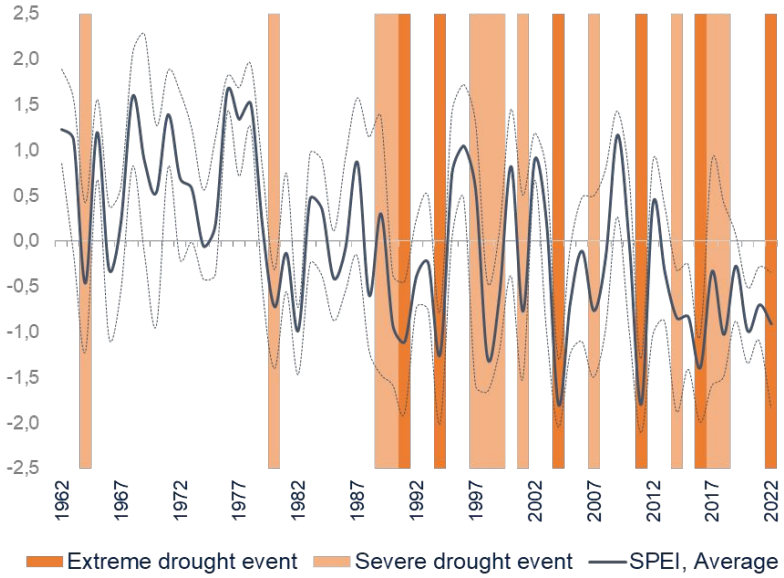
CLIMATE PHYSICAL RISK

PHYSICAL RISK SHOCK INDICATOR

IN-HOUSE MODELLING (REDUCED FORMS: TIME SERIES MODELLING)

CLIMATE PHYSICAL RISK SCENARIOS

SPAIN. SPEI, DROUGHT SYNTHETIC INDEX (Standardized Precipitation Evapotranspiration Index)



Source: BBVA Research, data from EM-DAT database and WB Climate Change Knowledge Portal. SPEI details can be found: A High Resolution Dataset of Drought Indices for Spain. Lower levels imply a more severe drought.

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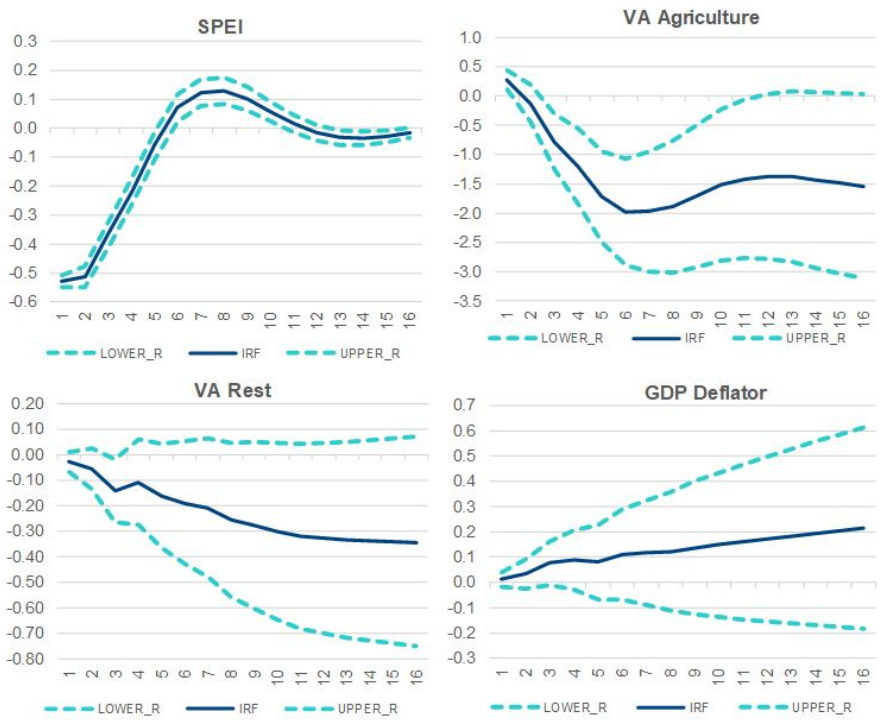
IN-HOUSE MODELLING (REDUCED FORMS: TIME SERIES MODELLING)

CLIMATE PHYSICAL RISK SCENARIOS

Droughts. Impulse Response Functions

One standard deviation -negative- shock on SPEI.
Quarterly data. Percentage deviation from the baseline.



- **A VARX model,** with Cholesky decomposition, has been used to **capture the impact of an exogenous SPEI shock** on Agriculture, GDP and inflation (GDP deflator).
- **A shock on SPEI has significant and lasting consequences on agricultural activity**. The rest of the economy is also negatively affected, while prices tend to increase.
- If **more detailed sectoral impacts** are required in the future, they could be obtained through **I-O analysis**.

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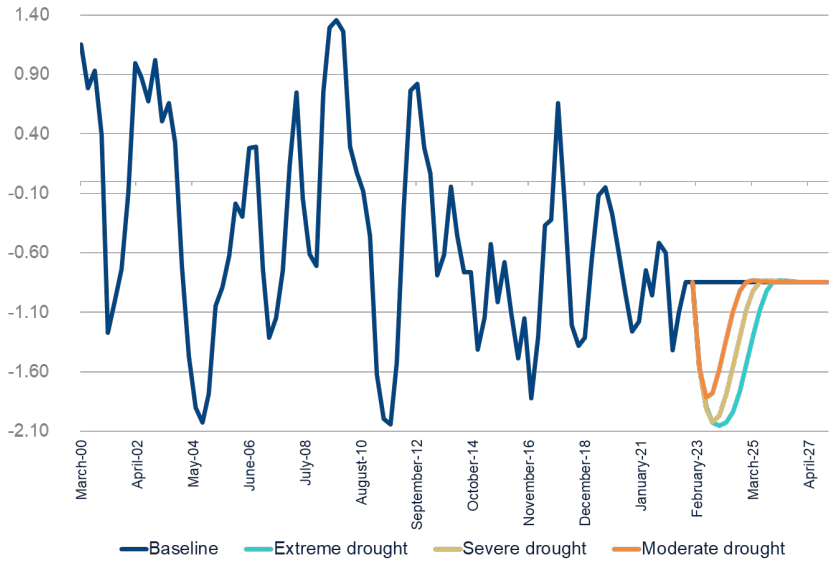
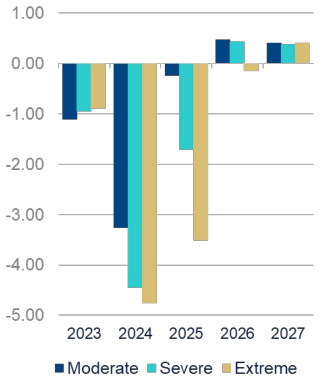
CLIMATE PHYSICAL RISK SCENARIOS

Alternative drought scenarios (SPEI). Baseline, Extreme drought, Severe drought and moderate drought.

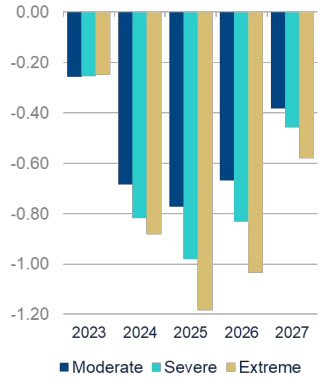


Source: BBVA Research

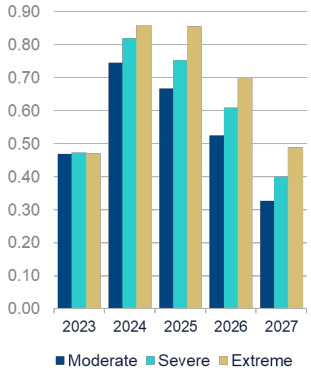
Agriculture growth gap vs. baseline scenario percentage points. y/y



GDP growth gap vs. baseline scenario percentage points. y/y



GDP deflator gap vs. baseline scenario percentage points. y/y



- The **moderate drought** scenario is similar to the worst drought registered in the last five years.
- The **severe drought** scenario replicates the worst drought registered in Spain.
- The **extreme drought** scenario replicates the severity of the worst drought but increases its duration.

Takeaways

Uncertainty, the signature feature of climate change analysis

- **Uncertainty** is the signature feature of climate change in measurement, modelling, and in deriving economic impacts on the economy.
- **The challenge**: Defining a workable playing field for the economic analysis of climate. The NGFS scenarios provide a “public good” for common understanding.

What is Drought? It depends on the indicator used as reference

- **Drought**: A multifaceted climate event that can be monitored by alternative indicators
- **SPEI:** The synthetic index shows a higher frequency and severity of droughts, likely closely related to global warming.

Drought’s Economic Impact

- **Economic impact of droughts:** Drought is a negative supply shock with compounded impacts, both direct and indirect, and not restricted to GDP.
- **A practitioner’s approach to climate risk analysis:** A few alternative futures, “pure” climate variables anchor, and in-house modelling for bounding uncertainty
- **A shock on SPEI has significant and lasting consequences on agricultural activity**. The rest of the economy is also negatively affected, while prices tend to increase.

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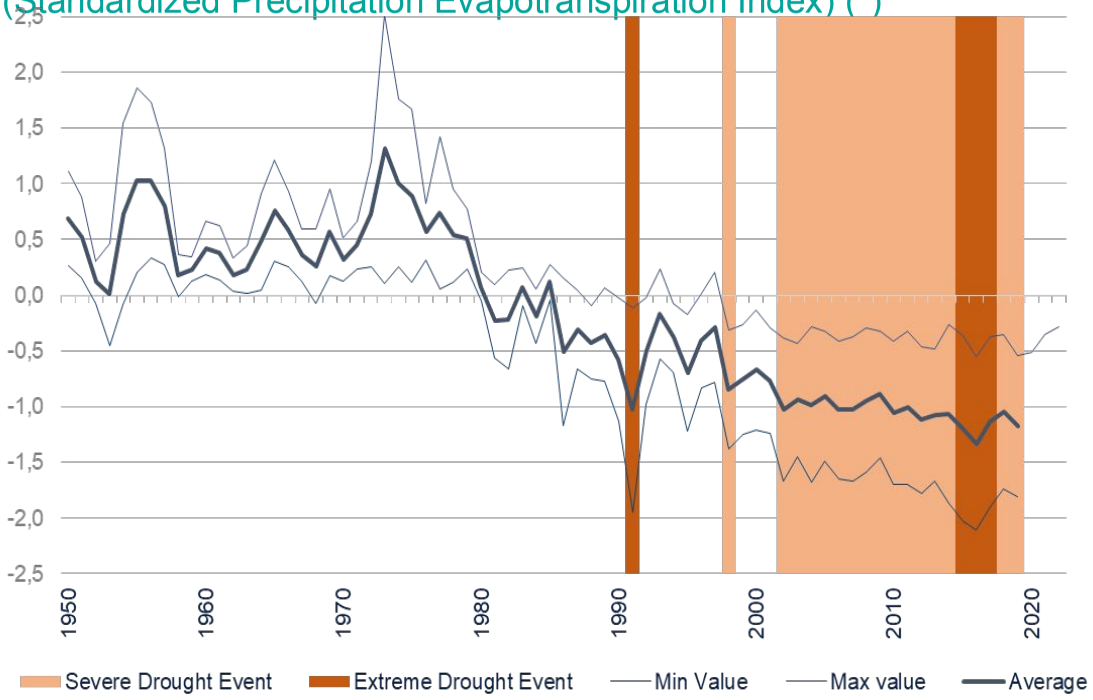
Creating Opportunities

A synthetic indicator of drought, SPEI: The gap between precipitation and evapotranspiration

WORLD DROUGHTS EVENTS WITH SPEI, DROUGHT SYNTHETIC INDEX. 1950-2022
(Standardized Precipitation Evapotranspiration Index) (*)



- **SPEI,** a multiscalar drought index based on the difference between precipitation and potential evapotranspiration, is showing a **decreasing trend** due to global warming conditions.
- That said, the **attribution of a climatic phenomenon** such as drought at a particular time and geography to human-induced climate change rather than natural climate variability is subject to **uncertainty.**
- SPEI is a **geographically located indicator**, so a wider geographic range means a **lesser representativeness** of a specific drought event.

Source: BBVA Research. SPEI details can be found: A High Resolution Dataset of Drought Indices for Spain. Lower levels imply a more severe drought.
(*) By reducing the geographic granularity, down to the level of a national economy or even bigger, the representativeness of the indicator is reduced by the very localized nature of the different intensity of the drought across territories. For this reason, bands with the maximum and minimum annual values are indicated.

SPEI. The Standardised Precipitation-Evapotranspiration Index

Drought effects are produced after a long period with shortage of precipitation. It is **difficult to quantify drought characteristics in terms of intensity, magnitude and spatial and temporal scale**. The definition of quantitative drought indices is one of the most widespread approaches. However, **subjectivity in the definition of drought** makes very difficult to determine a universal drought index.

- **SPEI** is a **multiscalar drought index based on climate data**. It can be used for determining the onset, duration and magnitude of drought episodes. These variables can be computed related to normal conditions in a variety of systems, such as crops, ecosystems, rivers etc.
- SPEI **is computed as the difference between precipitation and potential evapotranspiration**, net of their historical mean and standardised using the historical standard deviation.
- Under **global warming conditions**, SPEI can identify an increase in drought severity associated with higher water demand as a result of evapotranspiration.
- **AEMET** provides a monitoring drought tool which includes several indices with a high temporal and spatial resolution. Furthermore, **Digital CSIC** includes a SPEI calculator tha allows calculation of SPEI time series using precipitation and temperature data.
    - Details of how to do the calculations included in the presentation: SPEI Calculator: Methodology and Data document

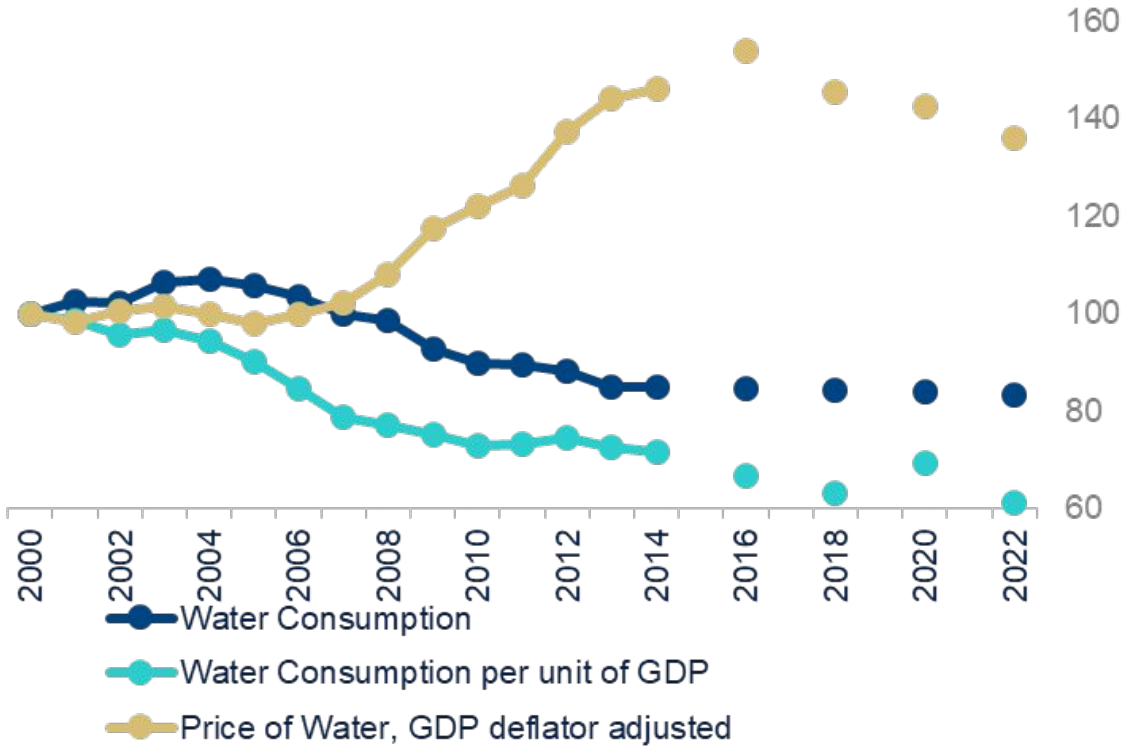
Table. Categorization of drought and wet grade according to the SPEI.

Categorization	SPEI values
Extremely wet	$SPEI \geq 2$
Severely wet	$1.5 \leq SPEI < 2$
Moderately wet	$1 \leq SPEI < 1.5$
Mildly wet	$0.5 < SPEI < 1$
Normal	$-0.5 \leq SPEI \leq 0.5$
Mild drought	$-1 < SPEI < -0.5$
Moderate drought	$-1.5 < SPEI \leq -1$
Severe drought	$-2 < SPEI \leq -1.5$
Extreme drought	$SPEI \leq -2$

Source: A multi-scale daily SPEI dataset for drought characterization at observation stations over mainland China from 1961 to 2018. This classification is widely used in scientific community.

Spain. Water Consumption, Intensity per GDP and Price

2000=100.



Source: BBVA Research from "Estadística sobre el suministro y saneamiento del agua"

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