G20 CLIMATE RISK ATLAS

Impacts, policy, economics

cmcc

FRANCE

With the scientific contribution of Enel Foundation

How to read the Atlas: graphs, colours and scenarios.

The maps used in this Atlas are taken from **The World Bank Official Boundaries** - ***https://datacatalog.worldbank.org/search/dataset/0038272*** (accessed on May 28, 2021). For the section Energy, the maps are based on Panoply Data Viewer ***https://www.giss.nasa.gov/tools/panoply/credits.html***

Each sector of this Atlas contains data and information on various climate scenarios.

When reported in graphs, the **colour black** indicates data and information referring to the current state, the past or the baseline.

When the authors refer to **RCP (Representative Concentration Pathways)**, the 3 colours used across the factsheet refer to 3 scenarios, which are 3 different development options with different levels of greenhouse gas emissions, **respectively low emissions (green), medium emissions (orange), and high emissions (red)**. The same colour code is used when RCPs are associated with Shared Socioeconomic Pathways (SSP).

In some cases, the authors refer to global warming scenarios. In these cases, the 3 colours used refer to a temperature rise of **1.5°C (green), 2°C (dark green), and 4°C (red)**.

When the authors refer exclusively to **Shared Socioeconomic Pathways - SSPs** (Population affected by river floods in the section: "Water"), data related to **SSP3** - that encompasses, among other things, slow economic growth, material-intensive consumption, and persisting or worsening inequalities – **are reported in a lighter shade**; **SSP5** – which refers to social and economic development that is coupled with an energy-intensive lifestyle and the abundant exploitation of fossil fuel resources – is shown using a **middle shade of the colour**, whereas data related to **the present** conditions **are represented in a dark shade**.

Further details on scenarios, methodologies, and the full list of references are available at: **www.g20climaterisks.org**

Concept and graphic design by element6.eu

FRANCE
CLIMATE

OVERVIEW

France features a temperate climate in the European area and a tropical climate overseas. Looking at the European area, the western part has an oceanic climate with average rainfall spread over many days and modest annual temperature variations. The central-eastern areas have a continental climate which harbours cold winters and hot summers. The south-east has a Mediterranean climate which leads to hot and dry summers.

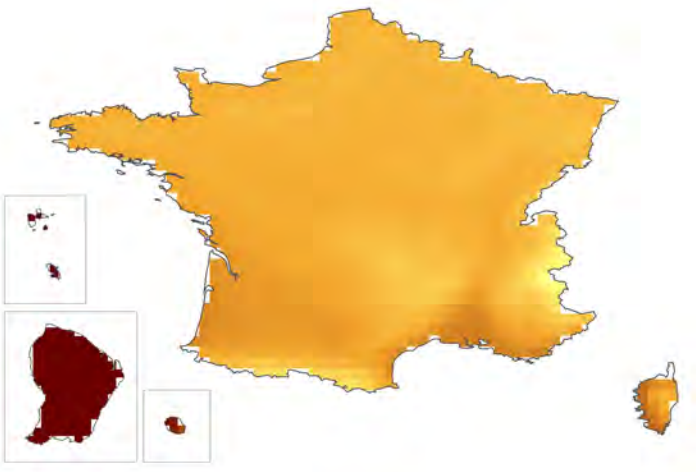
TEMPERATURE

France's European area has a temperature regime in line with most temperate climates. The warmest temperatures are found in the south-east. On the other hand, the overseas departments have higher temperatures which are influenced by their geographical location.

MEAN TEMPERATURE

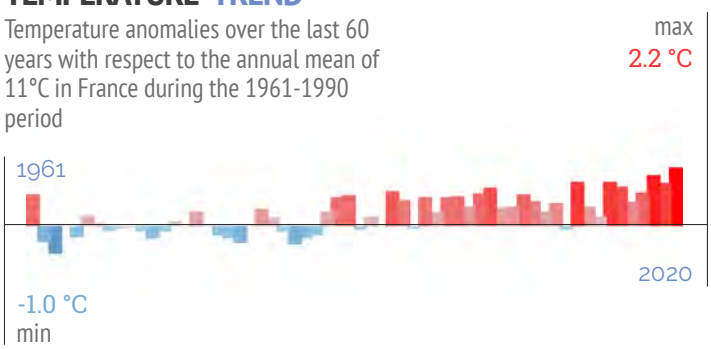
+0 — 27

Celsius degrees / Over 1991-2020



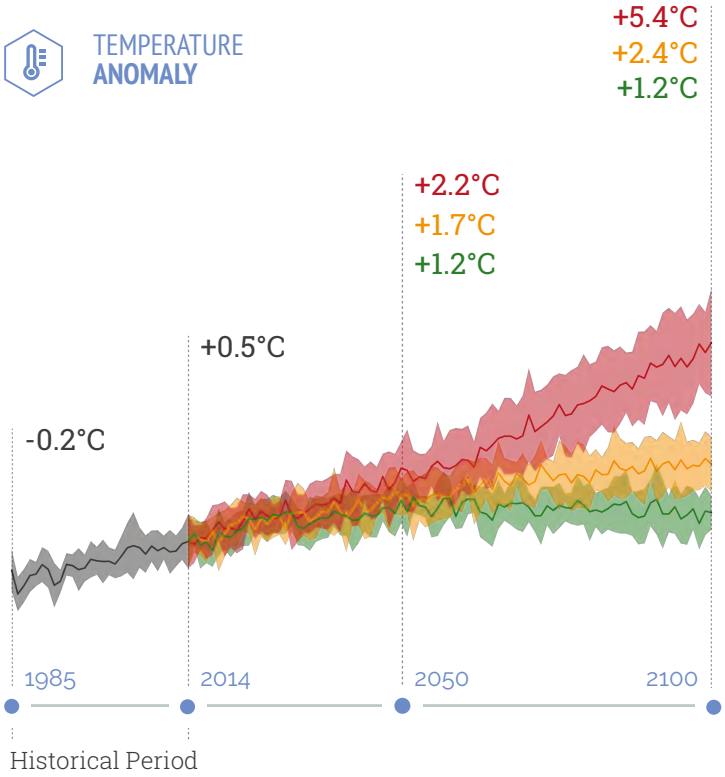
TEMPERATURE TREND

Temperature anomalies over the last 60 years with respect to the annual mean of 11°C in France during the 1961-1990 period



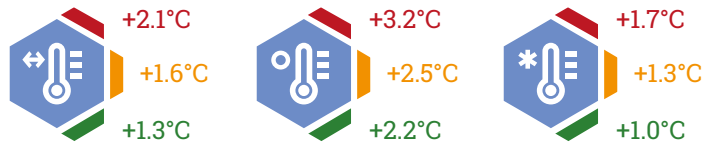
TEMPERATURE PROJECTIONS

Under a low emissions scenario projected temperature variations will remain contained at around +1.2°C, both by 2050 and 2100.
Under a high emissions scenario, with no reduction in GHG emissions, much greater temperature anomalies are expected by both 2050 and 2100.



EXPECTED VARIATION FOR TEMPERATURE AT 2050

The indicators show variations in selected temperature characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.



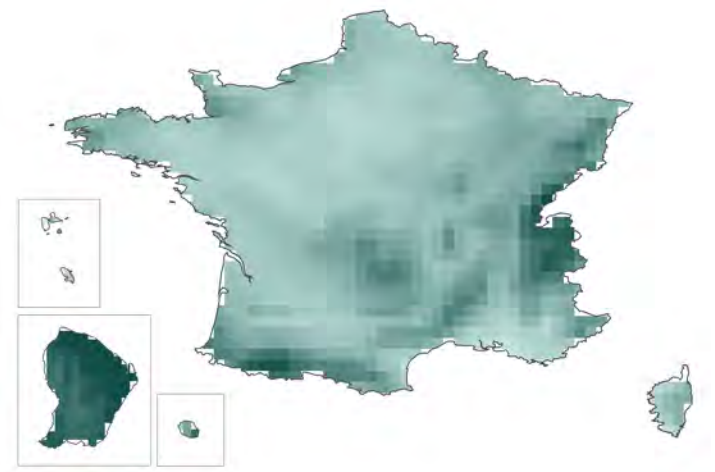
PRECIPITATION

The rainfall regime in France is very complex and influenced by opposite patterns at a local level and inter-annual variations. The overseas departments are generally more or less rainy depending on their geographical location and specific climate conditions.
In the European area, average rainfall in the western and central areas is distributed over many days. In mountainous areas, such as the Alps and Pyrénées, precipitation patterns are highly variable with heavy rainfall and snow three to six months a year.

MEAN PRECIPITATION

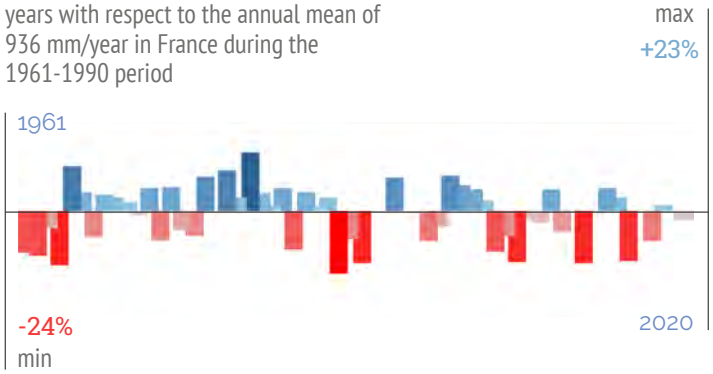
492 — 2,642

mm/year / Over 1991-2020



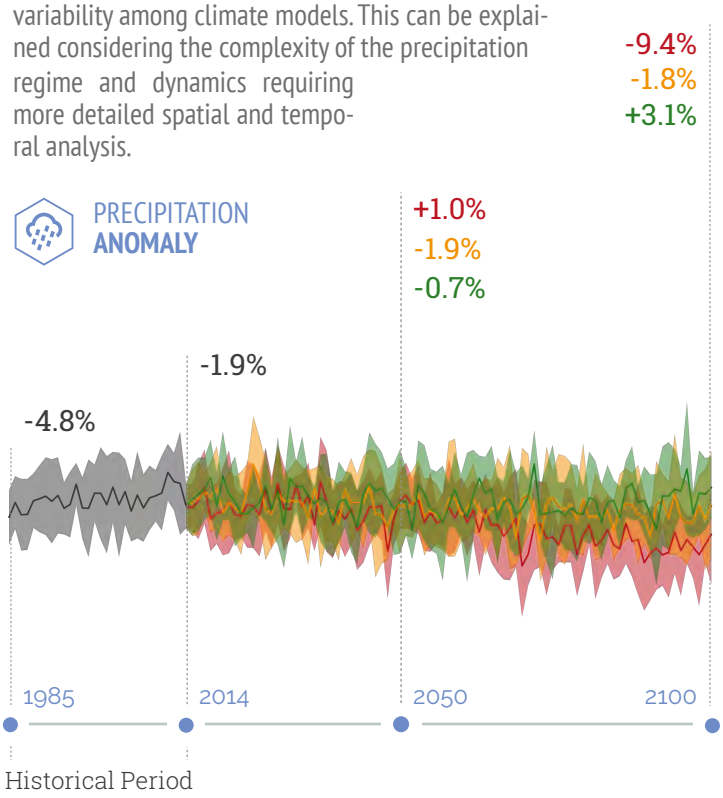
PRECIPITATION TREND

Precipiation anomalies over the last 60 years with respect to the annual mean of 936 mm/year in France during the 1961-1990 period



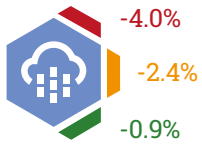
PRECIPITATION PROJECTIONS

Precipitation trends show a very complex signal, under all emissions scenarios, with a very large variability among climate models. This can be explained considering the complexity of the precipitation regime and dynamics requiring more detailed spatial and temporal analysis.

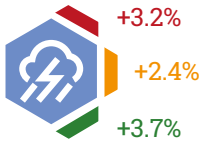


EXPECTED VARIATION FOR PRECIPITATION AT 2050

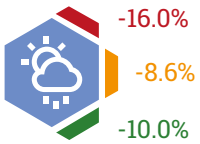
The indicators show variations in selected precipitation characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.



Annual total precipitation



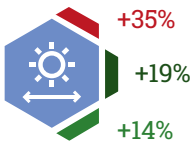
Precipitation of wettest month



Precipitation of warmest quarter

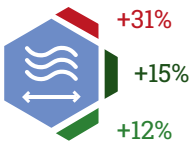
VARIATION OF SPECIFIC CLIMATE INDICATORS

Climate indicators variation showing impacts of climate change on sectors such as agriculture, health and water. Analysis considers 3 threshold average temperature increase: **+1.5°C**, **+2°C**, **+4°C**.



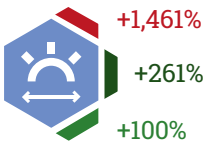
Agricultural drought proportion of time

% of time



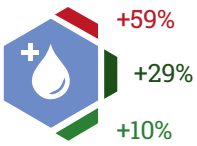
Hydrological drought proportion of time

% of time



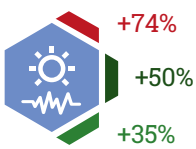
Heatwave duration

% of time



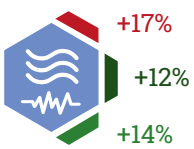
Runoff increase

% of area



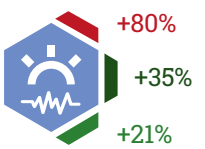
Agricultural drought frequency

% of change



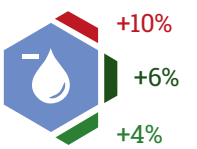
Hydrological drought frequency

% of change



Heatwave frequency

% of change



Runoff decrease

% of area

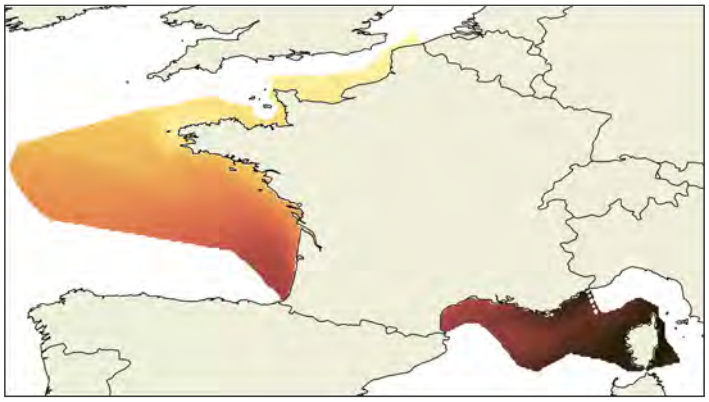
FRANCE OCEAN

OCEAN IN FRANCE

France's marine exclusive economic zone (EEZ) is mainly characterized by temperate coastal waters, which host a large variety of ecosystems and maritime activities. The wide enseble of coastal systems can be divided into three main areas, namely the Atlantic region, the North and Mediterranean seas.

CURRENT CLIMATE CONDITIONS

Mean sea surface temperature reflects the different climate regimes, from the cold Atlantic waters to the warmer ones on southern coasts.

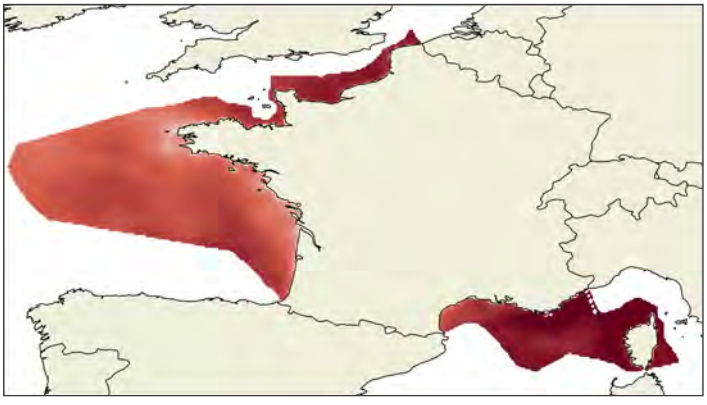


12 — 19 **MEAN**

SEA SURFACE TEMPERATURE

Celsius degrees / Over 1991-2020

0 — 0.4 **TREND**

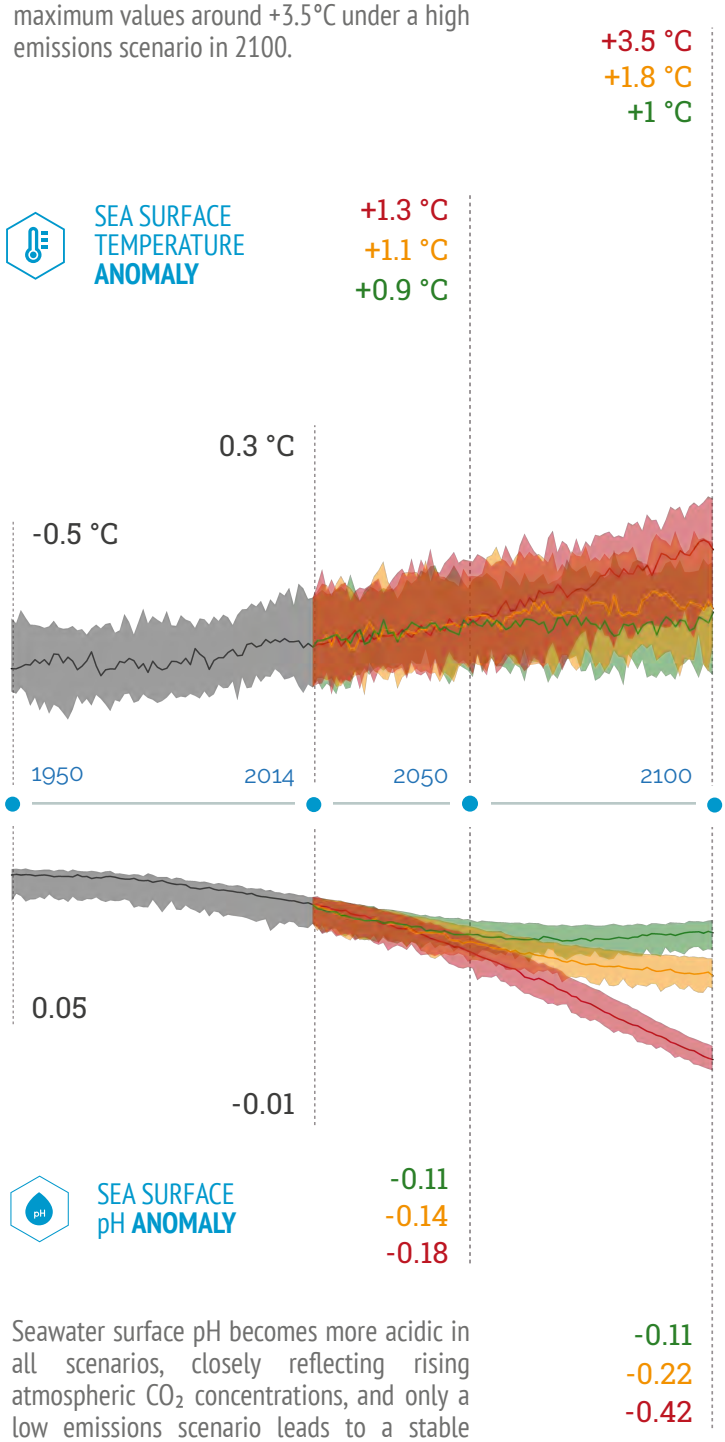


Surface temperature trends indicate a general warming of 0.4°C per decade in all marine areas.

FUTURE PROJECTIONS

Projected annual changes within the marine EEZ for the two most significant marine indicators of climate change: sea surface water temperatures and pH.

Seawater temperature changes are in line with the definitions of each scenario, with maximum values around +3.5°C under a high emissions scenario in 2100.



Seawater surface pH becomes more acidic in all scenarios, closely reflecting rising atmospheric CO_2 concentrations, and only a low emissions scenario leads to a stable condition by 2100.

ECOSYSTEM INDICATORS AT 2050

Regional changes in key marine ecosystem indicators under projected future scenarios by mid-century (2036-2065) with respect to present climate conditions (1985-2014).

	Atlantic	Mediterranean	North Sea
Temperature regulates the metabolism of marine organisms determining which habitats remain suitable. Excessive warming will likely push ecosystems beyond tolerance thresholds.	14.93°C +0.96 °C +0.72 °C +0.44 °C	17.78°C +1.53 °C +1.31 °C +1.42 °C	13.54°C +1.47 °C +1.34 °C +0.92 °C
pH represents the acid/base status of marine waters, where a decreasing pH reflects the acidification of the ocean due to increased absorption of atmospheric CO_2.	8.11 -0.18 -0.14 -0.11	8.12 -0.16 -0.14 -0.11	8.09 -0.18 -0.14 -0.11
Oxygen is fundamental to sustain marine life and its reduction can have a large impact on coastal ecosystem services including fisheries and aquaculture.	257.08 mmol/m³ -1.18 % -0.9 % -0.27 %	240.06 mmol/m³ -2.58 % -1.92 % -1.29 %	268.76 mmol/m³ -3.18 % -2.72 % -2.28 %
Chlorophyll is an indicator of the biomass available at the base of the marine food web supporting all ecosystem productivity.	0.49 mg/m³ -19.8 % -19.59 % -30.61 %	0.23 mg/m³ -6.84 % -23.93 % -57.69 %	0.41 mg/m³ -24.21 % -23.23 % -27.14 %

FISH CATCH POTENTIAL

Fish catch potential is an estimate of the maximum fish catch achievable given the marine resources available over a sustained period. It is linked to the concept of maximum sustainable yield, meaning the maximum amount of fish that can be extracted from a system without causing a collapse in fish populations.

It is a characteristic of the natural system, which is substantially different from realized catch, and a direct result of the fishery policy in place. The data reported concerns the French part of the Atlantic Ocean and the English Channel only.

Fish catch percentage change

2050

-33.4%

-45.1%

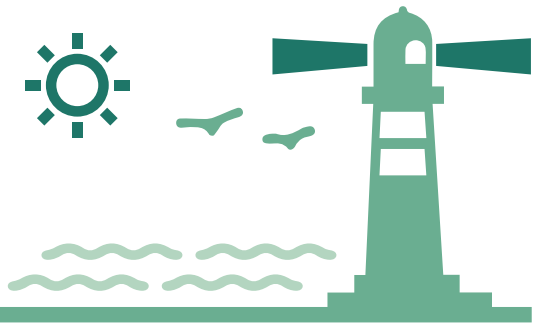
ANALYSIS DETAILS

All datasets were analysed using only data from within the marine EEZ and therefore excluding overseas territories, detached islands and any disputed or joint territories with other nations. In the assessment of current climate conditions, seawater surface tempererature data was obtained using satellite observations distributed in the framework of ESA Climate Change Initiative.

Future projections of marine indicators are represented by the combined analysis of results from 15 different Earth System models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6). These models include new and better representations of physical and biogeochemical processes, compared to previous IPCC assessment reports.

Fish catch potential data was obtained using the FAO's technical report and refers to the best and worst case climate scenarios from the Fifth IPCC Assessment Report. These mean estimates are subject to substantial uncertainties as discussed in the original work.

FRANCE COASTS



OVERVIEW

The 7,330 kilometres of French coastline are split into three regions, the largest being on the Atlantic ocean, followed by stretches along the southern North Sea and the Mediterranean Sea, with a further 850 kilometres around the island of Corsica. Just over 40% of the coastline is rocky, with the rest of the coastline a mixture of open beaches, sand flats, and mudflats. 39% of France's 67 million residents live in coastal regions, with notable coastal cities including Marseille, Montpellier, and La Rochelle.

Shoreline Length

7,330 km

Sandy Coast Retreat at 2050

-49.6 m

CLIMATE CHANGE HAZARDS

Coastal hazards such as erosion, storm tide inundation and permanent flooding, can have strong adverse impacts on coastal regions, with loss of sandy shores, damage to settlements, infrastructure and ecosystems. Climate change can exacerbate these impacts due to rising sea levels and increasing impacts of waves and storms. Acute impacts of climate change will be felt on the French coast, with sea level rise and its consequences affecting numerous locations. The combined pressure of these environmental changes can lead to a variety of negative impacts on the population, infrastructure, and natural environment of France's coastal regions.

SEA LEVEL RISE

Relative sea level rise has been observed over the past century around the coast of France, with a yearly average increase of approximately 1.86 millimetres per year since the 1990s. The latest IPCC projections indicate that, by 2050, global sea levels may rise between 0.18 metres, under a low emissions scenario, and 0.23 metres, under a high emissions scenario.

Observed and projected sea level rise at 2050

1.86 mm/year

0.23 m

0.18 m

EXTREME SEA LEVEL

On average, one in 100 extreme sea level events are expected to rise from 3.25 metres at present day to 3.52 metres by 2050 under a medium emissions scenario.

Current and projected extreme sea level at 2050

3.25 m

3.58 m

3.52 m

OBSERVED STORMS

Exposure of the French coastline to unpredictable oceans makes it inherently vulnerable to the impacts of extreme waves and storm surges. Furthermore, these events have been increasingly frequent over recent decades. For example, the devastating 2010 Xynthia windstorm caused billions of euros worth of damage and left 47 people dead when it hit the Atlantic coast. While not all events are so extreme, the continued impacts are being felt through shoreline erosion.

FUTURE STORMS

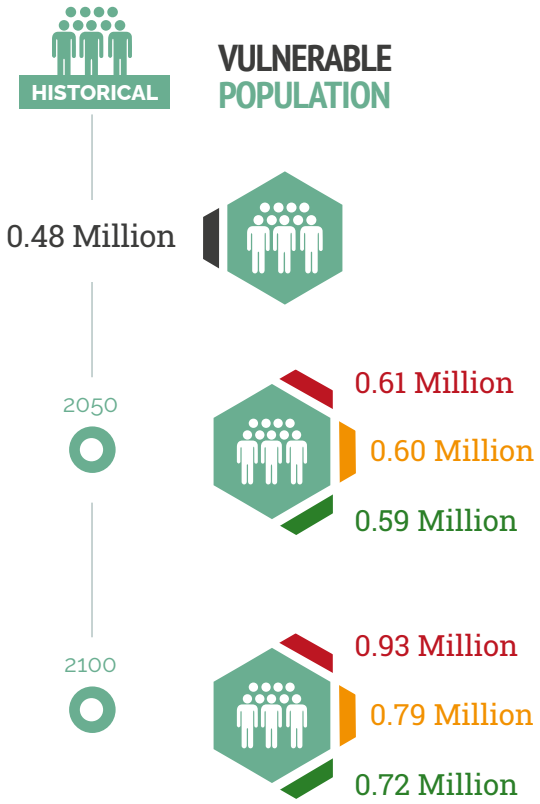
Future storm pattern projections do not give immediate cause for concern, with no significant increase in intensity forecasted for the coming decades. However, the expected rise in sea level will raise the vulnerability of coastal regions, with higher energy waves becoming more frequent. Combined with a growing coastal population and increased precipitation, flood related damages are expected to increase by over 50% by 2100 under a medium emissions scenario.

VULNERABILITY AND RISK

All regions of the French coastline are vulnerable to the risks posed by climate change. With significant populations living in coastal areas, property and infrastructure are threatened by rising sea levels that could cause erosion or even permanent submersion.

This could be the case for up to 140,000 properties in the region of Languedoc-Roussillon alone, leading to massive economic repercussions. Increasing urbanisation along the coastline will also put more people at risk, as seen with the deaths of those living in newer properties following the 2010 Xynthia windstorm.

Valuable environmental zones and habitats could be lost, particularly salt marshes and sand dunes that are more susceptible to the negative impacts of climate change. Much of France's economic productivity is based in the coastal regions. In fact, the blue economy adds 30 billion euros to the country's GDP, largely through tourism and shipping ports, both of which are vulnerable to storm surges and rising sea levels. Under a medium emissions scenario, the population exposed to the annual coastal flood level is expected to increase from 6.32 million to 6.68 million by 2050.



INFLUENCE OF SEA LEVEL RISE ON EXTREME SEA LEVEL

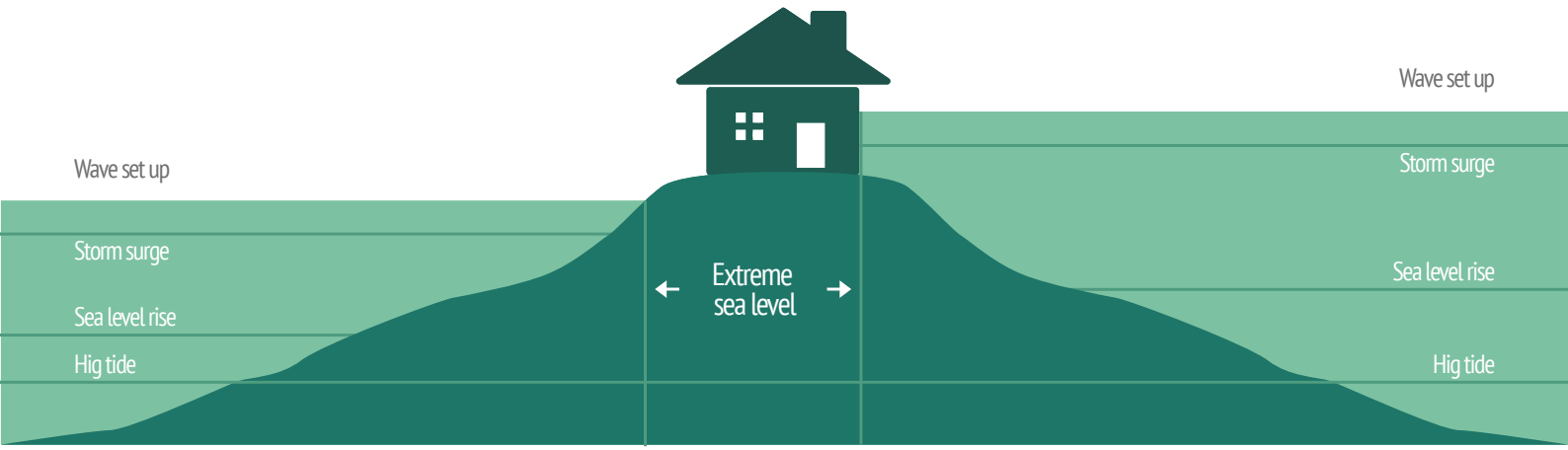
Present and future sea level rise are a consequence of carbon induced global warming causing melting ice and ocean expansion due to heat accumulation.

The extreme sea levels reported here are based on the 100-year storm surge + wave set up + sea level rise + high tide indicators. The first two parameters (storm surge + wave set up) are based on the 100-year value for the event; sea level rise is its projected value at 2050; and high tide is the absolute value of the highest tide calculated for a given locality, which won't be influenced by climate change.

+ Wave set up refers to the accumulation of water near the shore due to the presence of breaking waves.

+ Storm surge is an occasional increase in sea level driven by shoreward wind-driven water circulation and atmospheric pressure.

+ High tide is usually the highest tide reached in a given location based on tide records.



Present sea levels have risen globally by approximately 20 centimetres over the past century.

Future sea level rise is a projection based on different global warming scenarios, at approximately 100 centimetres by the end of 2100, with consequent inundation during extreme sea level events.

FRANCE
WATER

OVERVIEW

France has an available water stock that is well above the population's needs, providing a buffer against the risk of water stress.

Average annual precipitation ranges from 500 to 2,000 millimetres depending on the geographical location, with lowland areas far from the coast receiving the least amount of rain, whereas mountain areas and the coasts get the most.

The country's water needs stand at 32 billion cubic metres per year. With approximately 270,000 kilometres of permanent waterways and groundwater reserves estimated at 2,000 billion cubic metres, France has a considerable amount of water resources.

Renewable internal freshwater resources
200 billion m^3

Renewable internal freshwater resources per capita
2,988 m^3

The watersheds of the four main French rivers, Garonne, Loire, Rhone and Seine, drain 63% of the territory's water. The rest is provided by numerous coastal basins, the Adour, Somme, Charente, Var, or tributaries of rivers from neighboring countries such as the Rhine and Escaut. On top of the good levels of precipitation and total runoff, France also has very good natural storage capacities, thanks to mountain ranges and large underground aquifers.

CLIMATE CHANGE HAZARDS

Climate change can affect water resources through increasing temperatures, higher rates of evapotranspiration and altered rainfall patterns. This leads to changes in the water cycle, including decrease of snow and ice coverage, alterations of surface runoff and groundwater storage, as well as drought and flood occurrence. The impacts of climate change on France show an increased vulnerability to floods and droughts. Water systems have displayed overall changes throughout the entire country, especially French Alpine glaciers which have shrunk, as well as the glaciers in the Pyrenees. A reduction in the quantity of water resources, coupled with a potential increase in anthropogenic pressure due to demographic growth, could also have significant impacts on water quality.

KEY POINT RUNOFF

In southern France and in major southern river basins, hydrological models have shown that a warming climate induces a decrease in the mean annual runoff, a shift to earlier snow melting in mountainous areas and more severe low-flow conditions.

At a country scale, an average increase in surface runoff by approximately 24% and 1% is expected respectively under low and medium emissions scenarios for the 2045-2055 period compared to 2015-2025.

If temperatures rise by 1.5°C, 2°C or 4°C, 4%, 6.1% or 10% of the country will likely experience an increase in runoff, while 10%, 28.6% or 59% of the surface of the country will likely experience a respective decrease in runoff.

2050

Changes in annual runoff
% of change

+0.8%
+24.0%

2050

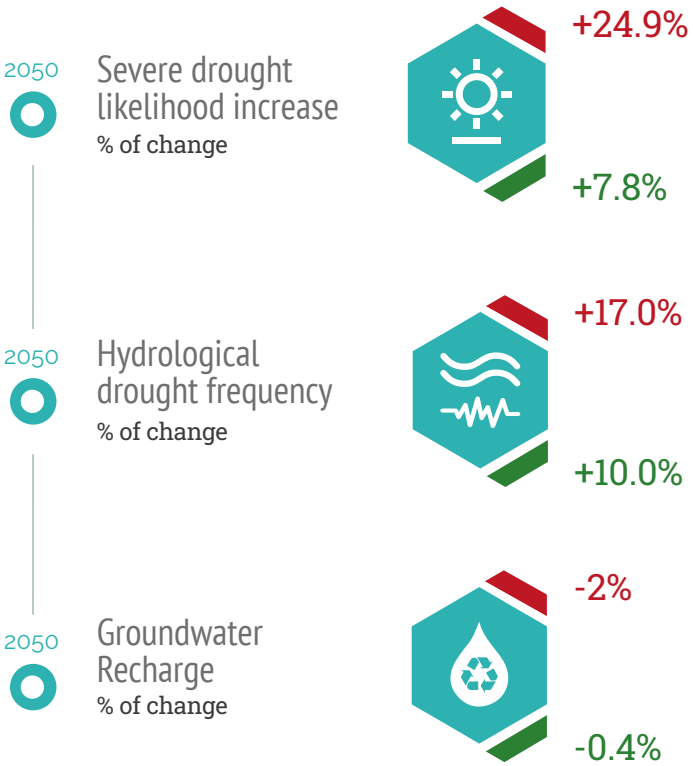
Runoff increase
% of area

+10.0%
+4.0%

KEY POINT DROUGHTS

Serious damage to buildings and infrastructure can occur if soil shrinkage is pronounced under drought conditions. For instance, in France, soil subsidence has caused as much damage as floods in recent years. The effects of drought can be aggravated due to aquifer overexploitation.

The southern part of the country (and the whole Mediterranean area) emerged as particularly at risk: temperature increase during the last decades has been accompanied by a local decrease in summer precipitations and an increase in autumn precipitations. Temporal trends in precipitation, temperature and solar radiation have resulted in drier and warmer conditions over the region. Projections indicate that there will be more frequent and severe droughts, surpassing the worst droughts 1981-2010 period.



KEY POINT GROUNDWATER

The climate change impact on surface waters and groundwater resources in several European regions is very problematic. In this context, France has been experiencing large changes in precipitation that affected the groundwater framework in the country. Several works at national scale have projected the impact of climate change on groundwater recharge in France. Confirmed by the diversity of approaches, the emerging trend shows a decrease in recharge primarily caused by increased evapotranspiration.

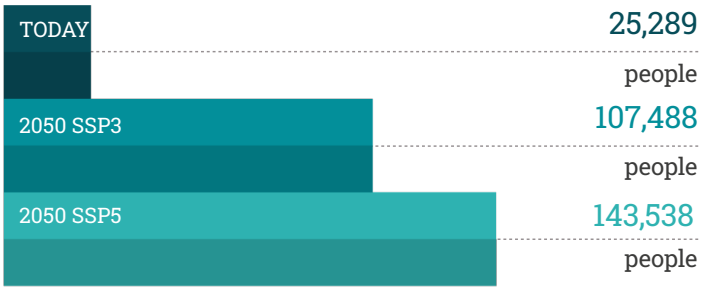
A local example of how climate change may affect the groundwater framework in France is the Rhone-Mediteranee et Corse (RMC) basin: studies show that the RMC basin is moving towards an almost general reduction in groundwater recharge. The trend is around an average decrease in recharge of -10 to -30%. It is most marked in the Aude and the Pyrenees-Orientales where it could reach nearly -50%. At the country level, a -0.4%, -1.3% and +2.7% change of the annual groundwater recharge for the period 2045-2055 compared to the timeframe 2015-2025 is expected under low, medium and high emissions scenarios.

KEY POINT FLOODS

Many studies support the hypothesis of an increase of heavy rainfall events due to global warming, favouring the occurrence of high magnitude torrential flood events in high-altitude catchments. Generalized upward trends in flood magnitude in the northwest of France, downward trends in the southwest and mixed patterns in the center have been found.

Several recent flood events occurred in France, such as in October 2020 and during the summer 2021. This is in line with a detected trend in the intensity of extreme rainfall in many regions of France in the last 50 years of records. Changing rain patterns may affect the frequency and intensity of floods. Changes in the population exposed to river floods are expected, with an increase from about 25,000 in the present day to about 107,000 under SSP3 and 144,000 under SSP5 by 2050. As such, potential impacts related to river floods might increase.

POPULATION AFFECTED BY RIVER FLOODS

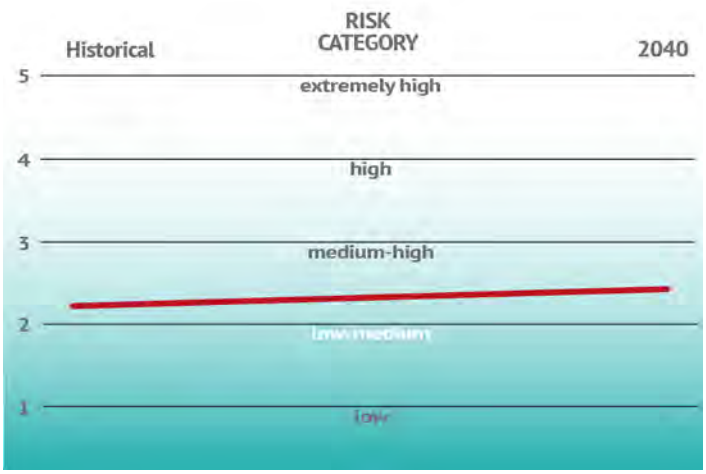


RISK INDICATORS

The water stress index summarises current and future water related vulnerabilities and risks at the global level. Scores are based on the ratio of total water withdrawals, including agriculture, industrial and human consumption, to available renewable surface and groundwater supplies.

WATER STRESS

France's water stress level is considered medium-high for the recent past (1960-2014 average), and it may increase in the near future (2030-2050) based on climate change projections.



FRANCE
AGRICULTURE

OVERVIEW

France is the first European country for agricultural production, amounting to 16% of the EU's agricultural land and around 17% of its value. The primary sector counts for around 1.6% of the internal GDP and 2.5% of employment.

The main productions of cereals, oilseeds and industrial crops (mainly sugarbeet) are located in the central-northern plain and in the south-western region, whereas wine production occurs in the southern part of the country, in the Rhone valley and in the Aquitaine region, around the city of Bordeaux.

Wine growing is the major crop with the most added value, generating 15% of France's agricultural revenues whilst occupying only 3% of agricultural land. Irrigation concerns around 6% of the agricultural area and it is mainly relevant to the Mediterranean regions.

39.9 Mt
Sugarbeet

12.6 Mt
Maize

35.4 Mt
Wheat

6.3 Mt
Grapes

5 Mt
Rapeseed

Added Value of Agriculture, Forestry and Fishing

34,341
USD Million

38,706
USD Million

Share of Agriculture Value added in Total GDP

2000 — 1.7 %

2018 — 1.5 %

Agricultural land

2000 — 19,495 Thousand HA

2018 — 19,132 Thousand HA

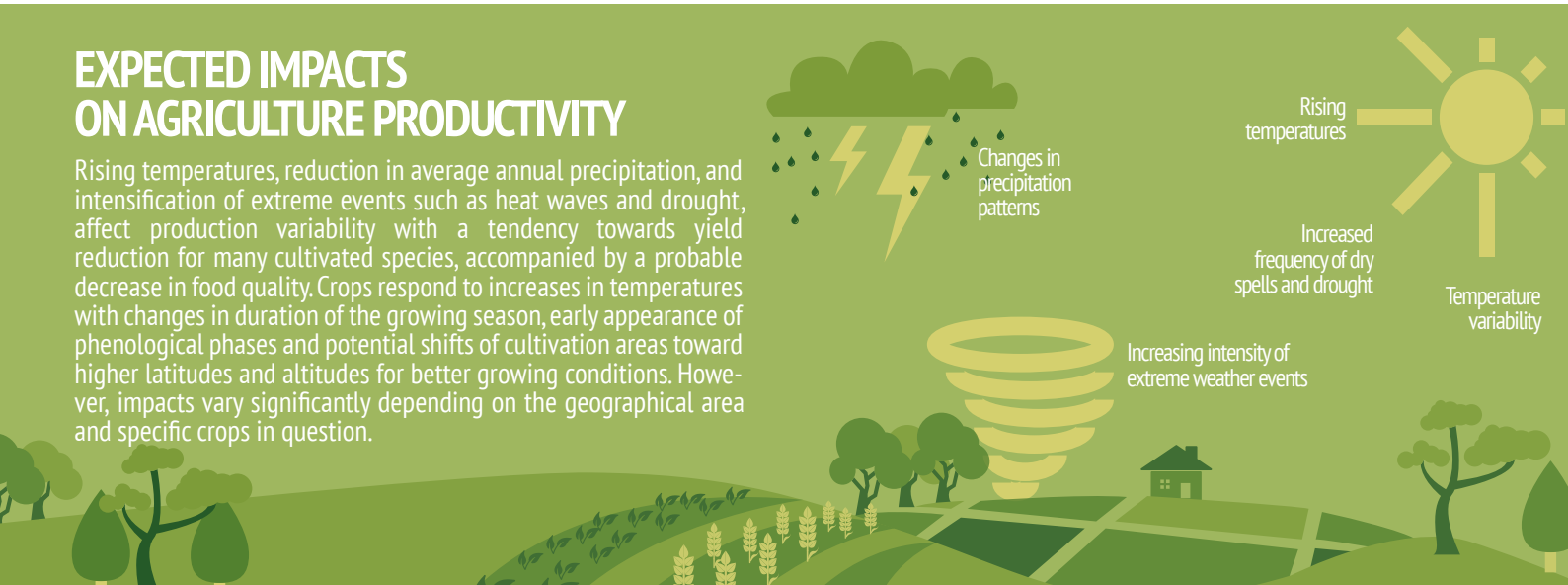
Area Equipped for Irrigation

2000 — 2,634 Thousand HA

2018 — 2,691 Thousand HA

EXPECTED IMPACTS ON AGRICULTURE PRODUCTIVITY

Rising temperatures, reduction in average annual precipitation, and intensification of extreme events such as heat waves and drought, affect production variability with a tendency towards yield reduction for many cultivated species, accompanied by a probable decrease in food quality. Crops respond to increases in temperatures with changes in duration of the growing season, early appearance of phenological phases and potential shifts of cultivation areas toward higher latitudes and altitudes for better growing conditions. However, impacts vary significantly depending on the geographical area and specific crops in question.

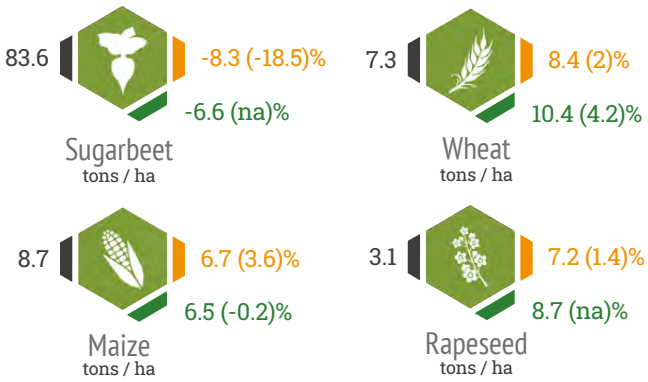


CROP PRODUCTIVITY

Crop productivity refers to the harvested yield of a crop per unit of land area. It is strongly influenced by climate and other environmental and management factors.

Climate change is expected to have an impact on the productivity of several major crops, although this may in part be offset by the fertilizing effect of higher CO_2.

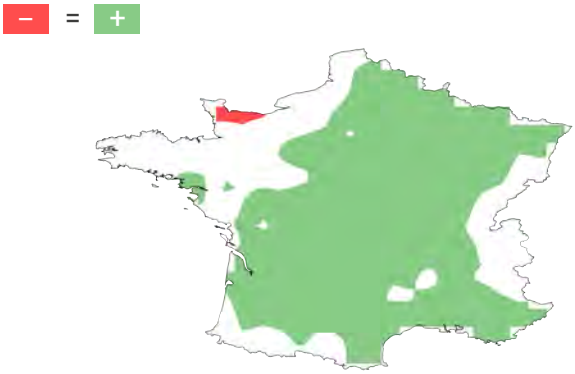
Impacts are estimated using a range of model projections based on low to high emission scenarios and reported as percentage changes between the 30-year average around the historical period and the 30-year average around 2050.



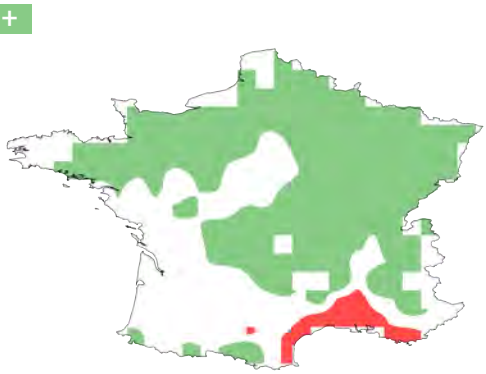
2050

Productivity change with (without) the CO_2 fertilization effect. Estimates assume sufficient water and nutrient supplies, and do not include impacts of pests, diseases, or extreme events.

CHANGE IN WHEAT



CHANGE IN MAIZE

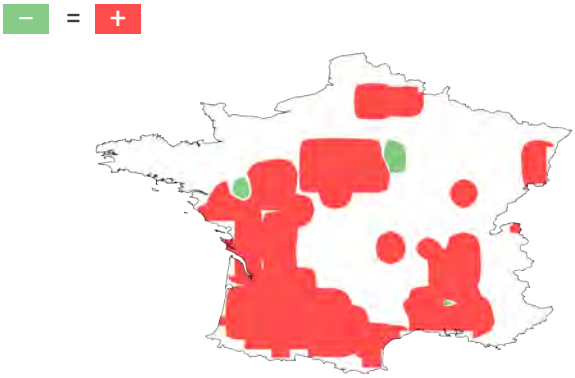


An increase in CO_2 may positively affect the production of C3 plants such as rice, wheat and beet, which are mostly located in the northern regions. Maize productivity shows a small gain in the north, whereas yields may fall in the south, due to the combined effects of extreme temperatures and drought. For grasslands in the central mountainous areas an increase in forage production up to 20% could occur, which would allow for a corresponding increase in animal stocking. In general, field crops and grasslands should be favored, except in the south where there is a risk of accentuated droughts accompanied by high temperatures. For permanent crops such as fruits and vineyards, the generalized advance of phenology may cause risk of frost at the flowering stage, and of reduced fruit quality due to an advance in the sensitive stages.

ADAPTATION IN AGRICULTURE AND WATER RESOURCES

Modern farming systems with abundant surface and groundwater resources have allowed France to become a net exporter of agricultural products. The agricultural sector is the main user of water resources (48% of total consumption in France) and will be particularly affected by summer droughts. Large areas of France have overexploited groundwater resources, which are also likely to decline significantly over the long term and in particular in the Loire basin and the south-west of France. Water scarcity can worsen conflicts between different sectors and reduce flows to natural ecosystems during summer periods.

CHANGE IN WATER DEMAND



2050

Agriculture
Water Demand
% of change

Further water saving programs in French agriculture should enhance measures for more efficient agriculture, agri-environmental measures, crop diversification and changes in crop practices.

FRANCE FORESTS

FORESTS IN FRANCE

When including French overseas territories all the main types of forests are present in France. From boreal forests in the southern alpine areas, to tropical ones with over 8 million hectares in Guyana alone. The main role, however, is played by deciduous temperate forests. In metropolitan France, wooded areas are almost entirely secondary and shaped by human intervention.

FORESTED AREA AND CARBON STORAGE

French forests account for more than 30% of land showing a constant and significant increasing trend in recent decades. According to the French Ministry of Agriculture and Food, French forests and related ecosystems currently store 88 million tons of CO_2 equivalent every year and high quality wood provides further 33 million tons for substitution effects such as use in buildings.

1990

23 Mln ha
Million hectares
Forested area

161 Tons/ha
Tons of Carbon per hectare
Carbon stock

2020

25 Mln ha
Million hectares
Forested area

165 Tons/ha
Tons of Carbon per hectare
Carbon stock

FOREST PRODUCTIVITY

Forest productivity or Net Primary Production is the net carbon captured by plants. It is the difference between the carbon gained by Gross Primary Production - net photosynthesis measured at the ecosystem scale - and carbon released by plants' respiration. It is expressed per unit land area.

2050

Productivity anomaly
Tons of Carbon per hectare per year

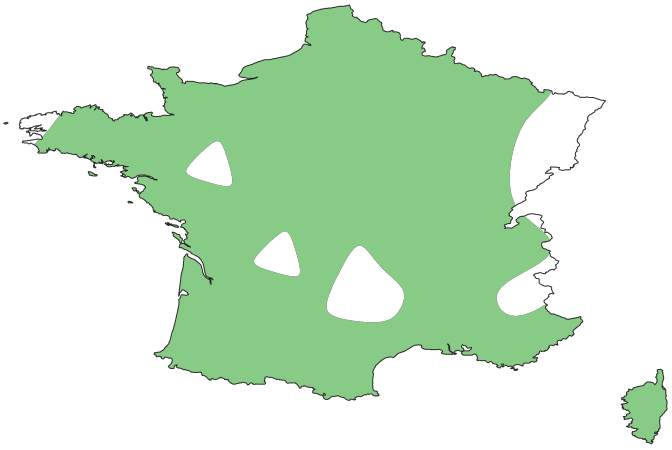
+0.79
+0.64

Generalized increase in net primary production by 2050. More accentuated under a medium emissions scenario, although with high uncertainty

+ Fertilizing effect of increasing atmospheric CO_2
+ Rising temperatures
+ Lengthening of growing season

No areas with an expected decrease in forest primary production

+ Increasing risk of drought stress



KEY SPECIES UNDER CLIMATE CHANGE

VULNERABILITY
BEECH
Beech forests show very high vulnerability

REDUCTION
SPRUCE
Strong reduction of suitability range for spruce in central France

EXPANSION
MED OAKS
Considerable expansion of mediterranean oaks (holm oak) in the south and temperate oaks in central and northern areas

REPLACEMENT
MARITIME PINE
Maritime pine may play an important replacement role throughout oceanic (western) France

FIRES IN FRANCE

Fire is a structural ecological process that provides several types of ecosystem services and impacts on socio-ecological systems, including human health, carbon budgets, and climate change. Changes in global fire activity are influenced by multiple factors such as land-cover change, policies, and climatic conditions. Fire also releases large quantities of greenhouse gases into the atmosphere, contributing to a vicious cycle.

During the last three decades, the total area affected by fire was approximately 577 thousand hectares with 138 thousand fires occurring.

BURNING
576 THOUSAND HECTARES

EMITTING
0.36 TERAGRAMES OF CARBON PER YEAR

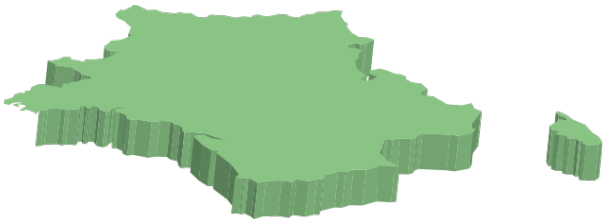
FOREST FIRE EMISSIONS CONTRIBUTED TO 29% OF TOTAL FIRE RELATED CARBON EMISSIONS

COSTING
209 MILLION USD IN 2003 COMPARED TO 97 MILLION USD IN A NORMAL YEAR

WHERE DO FIRES OCCUR?

There is a positive correlation between burned area and high vegetation cover (particularly shrublands), prolonged summer dryness, high unemployment rates, and tourism pressure.

Between 2000 and 2019 France contributed to 3.7% of the total burned area of the five most fire-affected European Countries.



Fires concentrate in south-eastern France and Corsica near the Mediterranean Sea where summer drought and winds facilitate the spread of wildfire.

FUTURE BURNED AREA

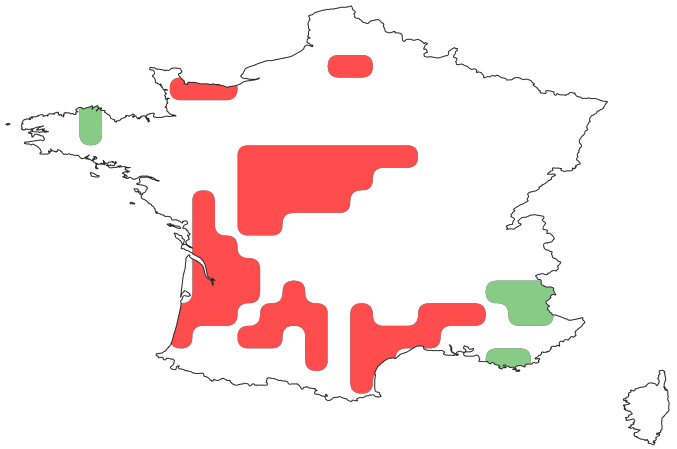
Under a low emissions scenario, burned area is expected to increase in central and southern France affecting temperate broadleaf and mixed forests. Under a medium emissions scenario, burned area is also expected to increase in the Mediterranean forests of southern France.

Burned Area
km² per year

2050

+130

+117



Decrease in burned areas for a low emissions scenario

Increase in burned areas for a low emissions scenario
+ Prolonged and more intense fire season
+ Increase in future weather risk due to warming and drought conditions

VARIATION OF SPECIFIC FIRE INDICATORS

% of change
Very high-to-extreme fire danger areas (Corsica and PACA regions)
2036-2045

+217%

+87%

% of change
Fire season lenght
2041-2070

+64%

% of change
PM2.5 emissions
2010-2050

+26%

+15%

FUTURE FIRE EMISSIONS

Scientists predict that fire emissions might increase over the Mediterra- nean, Cantabrian and northern Atlantic areas especially under a medium emissions scenario.

Fire Carbon emission
Teragrams of Carbon per year

2050

+1.6

+1.1

FRANCE
URBAN

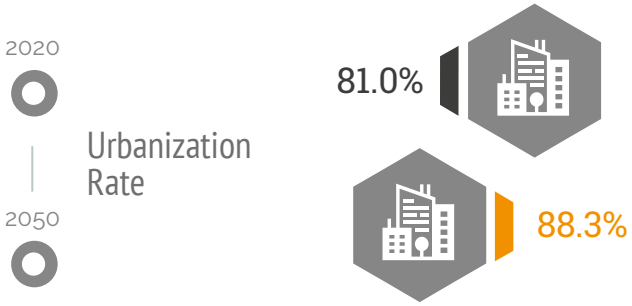
OVERVIEW

In France, 81% of the population lived in urban areas in 2020, this rate is expected to increase only slightly and reach 88% by 2050. The French urban landscape is characterized by a strong role of the central agglomeration of Paris, which is home to 20% of the French population, and an increasing number of growing agglomerations around the country.

The number of relatively small cities is expected to decline slightly, but these cities will remain the most important forms of urban agglomerations, giving home to more than half of the population. The country is still experiencing demographic growth in all types of agglomerations, and demand for dwellings is growing at an even faster pace.

Built up areas cover 4.91% of French territories (26,876.60 square kilometers).

Graphs refer to data provided by United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization

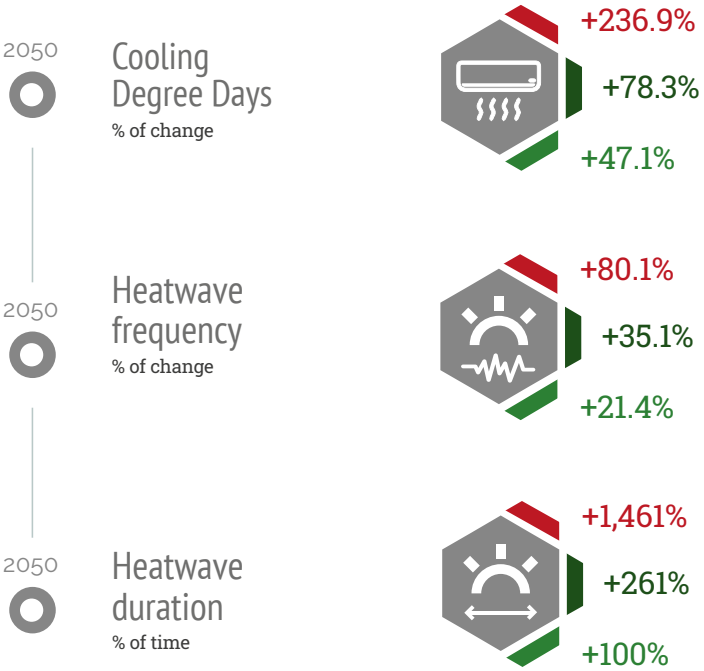


OVERVIEW OF KEY CLIMATE IMPACTS IN URBAN AREAS

French urban areas are expected to be affected by increasing temperatures and more frequent heatwaves as well as by changing precipitation patterns.

HEATWAVES AND HEAT STRESS

In August 2003, a heatwave affected most European countries. In France, the heatwave caused approximately 10 days of median temperatures of 37.5°C during the day and 20°C at night. In Paris, temperature differences between city centers and some rural areas reached 8°C during daytime and 7°C at night. France was the most affected country by the 2003 European heatwave, with an observed excess mortality of 14,800 additional deaths during a period of three weeks in August. 82% of the deaths attributable to the heatwave affected people aged 75 and over. Impacts were particularly heavy in the urban area of Paris and the surrounding departments, with an excess mortality of 150%. Under future warming scenarios, frequency of extreme events like heatwaves will increase, and in particular duration of heatwaves will increase, with major implications for urban areas, increasing, inter alia, the need for cooling facilities of living and working environments. Comparing french urban climate conditions for 2100 with those existing today, reveals that Paris would have a climate comparable to that of current-day Cordoba, whereas the climate of Marseille could become similar to what is actually experienced in Greek cities.



SOCIO-ECONOMIC FACTORS
DRIVING IMPACTS FROM HEATWAVES

During the 2003 heat wave mortality rates in Paris were driven by factors such as age, income, social isolation, illness and quality of insulation in homes. Over 90 victims lived alone and often in small apartments.

More than half the victims lived on the upper floors of buildings and/or in scarcely insulated roof-top dwellings where indoor-temperatures reached 40°C. During the 2003 heat wave, concentrations of pollutants in major French cities were up to 40% higher than the average for the previous years.

COASTAL FLOODING

The French territory is vulnerable to both coastal flooding and inundations from heavy rainfall inland. Although almost 5% of surfaces are covered by buildings and infrastructure, urbanization over the past decades has involved high risk coastal areas and flood prone areas along rivers. Artificialization of coastal areas is proceeding at high levels, with the concentration of building density three times higher than average French values.

FLOODING

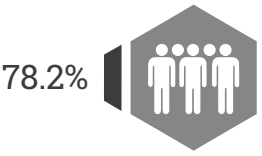
On top of coastal flooding, France is also vulnerable to inundations from heavy rainfall and river flooding inland. Furthermore, high risk areas such as flood prone zones along rivers have experienced new urbanization. In 2010, the winter storm Xynthia hit the French coast, causing 53 deaths and over 4 billion USD in overall damages.

In January 2018, flooding of the rivers Seine and Marne in France, which affected Paris, caused between 190 and 350 million euros in damages despite the flood risk protection measures in place. Under a high emissions scenario, sea level is expected to rise by 1 metre by the end of the century, bringing damage due to erosion, increasingly intense storm surges and extreme flooding to coastal settlements.

2017

Population exposed to air pollution

78.2%



2050

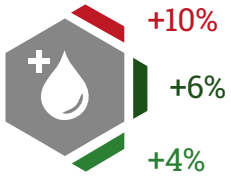
Projected sea level rise

2100

2050

Runoff increase

% of area



SURFACE SEALING AND FLOODS

Heavy precipitation in cities is problematic due to the high level of sealed surfaces. Soil sealing increases run off and reduces the amount of water absorbed by soil. Where there are large amounts of impervious ground cover, short duration extreme rainfall events can lead to increased flooding, even resulting in flash floods.

URBANIZATION OF FLOOD PLAINS

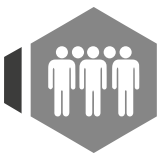
Despite overall precipitation decreasing, the impact of extreme and short-term precipitation events on built up urban environments is bound to increase.

2010

% of urban population

Population living in slums

0%

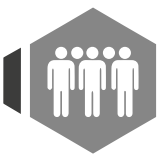


2018

% of total population

Urban population living in areas where elevation is below 5 meters

2.2%



FRANCE
HEALTH

OVERVIEW

The French population is vulnerable due to many climate hazards and extreme weather events, such as heatwaves, floods, and climate suitability for vectors. Changing weather patterns could also impact the emergence, distribution, and prevalence of vector-borne diseases in France, such as chikungunya, dengue, yellow fever, and leishmaniosis. Climate change is expected to increase mean annual temperature and the intensity and frequency of heatwaves, resulting in more people at risk of heat-related medical conditions. France also faces severe impacts from heatwaves.

HEAT RELATED MORTALITY

Under a high emissions scenario, heat-related deaths in the elderly (65+ years) is projected to increase to about 61 deaths per 100,000 by 2080, compared to the estimated baseline of about 4 deaths per 100,000 annually between 1961 and 1990. Under a medium emissions scenario, heat-related deaths in the elderly will be 11 per 100,000. In 2018, there was a 29% increase in heat-related deaths in France from a 2000 to 2004 baseline.

Nearly 15,000 people died during the 2003 heatwaves. Up until that year, heatwave events had been underestimated as a threat to French public health. Due to improved public health policies, the number of annual deaths declined to approximately 1,500 people per year during 2018 and 2019. 35.2% of heat-related mortality during 2000 to 2014 can be attributed to human-induced climate change.

IMPACTS ON LABOUR

Labour is directly affected by changes in environmental conditions. Warming affects both the number of hours worked (labour supply) and on the productivity of workers during their working hours (labour productivity). Both labour supply and productivity are projected to decrease under future climate change in most parts of the world, and particularly in tropical regions.

Parts of sub-Saharan Africa, south Asia, and southeast Asia are at highest risk under future warming scenarios. Future climate change will reduce global total labour in the low-exposure sectors by 18 percentage points and by24.8 percentage points in the high-exposure sectors under a 3.0°C warming scenario

Total labour in France is expected to decline by 2.3% under a low emissions scenario, and by 4.4% under a medium emissions scenario.

Heat-related mortality

% change with respect to 2000-2004

2018 +29%

Impact on total labour

% change with respect to 1986-2005 baseline

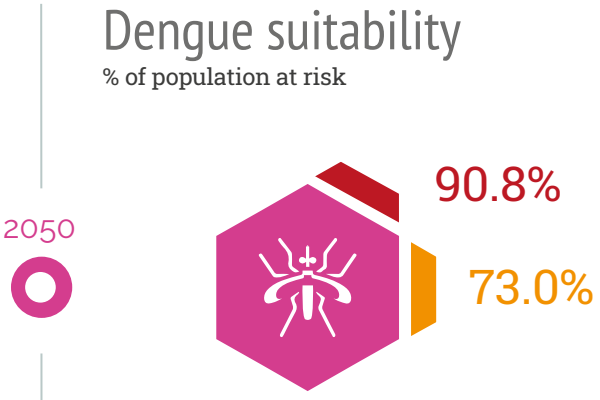
2050 -2.3 %

2080 -4.4%

CLIMATE CHANGE AND DENGUE

Dengue has spread throughout the tropical world over the past 60 years and now affects over half the world's population. Globally, vectorial capacity for both dengue vectors (A. aegypti and A. albopictus) has been rising steadily since the 1980s, with nine of the ten highest years occurring since 2000.

Climatic stressors are one important driver of the current distribution and incidence of dengue. Climate change is likely to expand the geographical distribution and suitability of several vector-borne human infectious diseases including dengue. The risk of dengue transmission is increased by warming climates, as the growth and development of mosquitoes are significantly influenced by temperature, precipitation, and humidity.



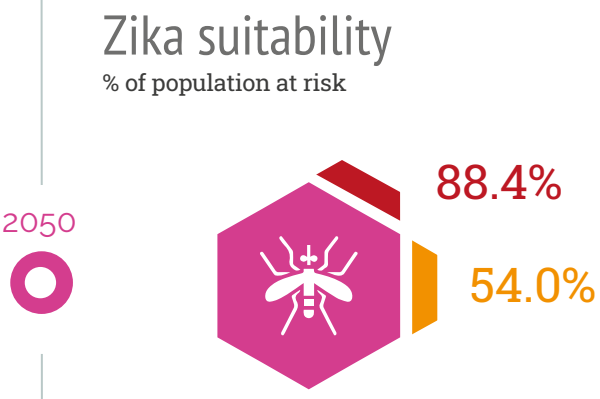
CLIMATE CHANGE AND ZIKA

Zika virus has spread to at least 49 countries and territories since 2013. Climate change impacts on transmission suitability risk have increased over the years and future warming over 1.3 billion additional people could face suitable transmission temperatures for Zika by 2050.

DENGUE AND ZIKA: POPULATION AT RISK

Epidemiological risks from dengue and Zika will increase due to climate change in France.

Under a medium emissions scenario, 73% of the population will be at risk of transmission-suitable mean temperatures for dengue by 2050, whereas 90.8% will be at risk under a high emissions scenario. In the case of Zika, 11.6% of the population will be at risk by 2050 under medium emissions, whereas 67.8% will be at risk under high emissions.



CLIMATE CHANGE AND MALARIA

In France, the number of imported malaria cases, mainly due to Plasmodium falciparum (85%), was estimated at about 82,000 for the 2000 to 2015 period. 11.3% of the French population will be at risk of malaria under low emissions scenario in 2050, whereas 14.7% will be at risk under a high emissions scenario.

POLLUTION AND PREMATURE MORTALITY

In 2014, some of the most populated cities, with available air pollution data, had annual mean PM2.5 levels above the WHO guideline value of 10 µg/m3. Under a medium emissions scenario, annual premature deaths due to long-term exposure to near-surface ozone and heat will increase from 6,130 in the 2010 baseline period, to 9,439 in 2050.

FRANCE ENERGY

ENERGY SYSTEM IN A NUTSHELL

The French energy system has a low carbon intensity, owing to the leading role of nuclear energy. France relies on imports for all of its oil and gas consumption.

France has begun an ambitious trajectory towards decarbonisation, with plans to significantly reduce the share of nuclear power and increase renewables in coming decades.

0.08
ktoe/US$
Energy intensity

48%
Import dependence ratio

CLIMATE CHANGE TODAY

NUCLEAR

Heatwaves are a proven issue for France's nuclear power generation, which needs sufficient water for cooling. In 2003, 2006, 2009 and 2018 heatwaves caused temporary shutdowns of nuclear plants in France due to cooling water shortages.

HEATWAVES

Heatwaves caused electricity demand to peak due to cooling needs, putting a strain on the system, already under stress due to cooling water shortages.

SLR

France's extensive coastline means energy infrastructure is affected by rising sea levels due to more frequent flooding.

ENERGY SUPPLY

The current energy mix of total primary energy supply in France shows a strong prevalence of nuclear, which accounts for 42% (2019). The remainder is made up of oil (28%), natural gas (15%) and renewables (11%).The share of renewables has almost doubled since 1990, while coal dropped from 9% to a 3% share only. France imports a relatively large amount of oil and natural gas.

ENERGY DEMAND

Energy in France is used by the transport sector (30%), the majority of which is used for road transport, followed by residential (24%), industrial (18%) and tertiary sectors (15%). Industry is responsible for most of the non-energy use of fuels (9%). The share of agriculture, forestry and fishing is just 2.9%. Energy use has declined since its peak in 2004, due to energy efficiency gains and weak economic growth.

FUTURE ENERGY DEMAND

Overall, in France the decrease in heating demand is going to be more than compensated by the increase in cooling needs resulting in a decrease in electricity demand of 104.4 PJ (or 29 million KWh) by 2050 under a medium emissions scenario. However, peak electricity demand for cooling is predicted to increase throughout Europe, with some of the largest increases in peak electricity demand predicted for France.

Net change in energy demand due to changes in HDD/CDD

Billion KWh

2050

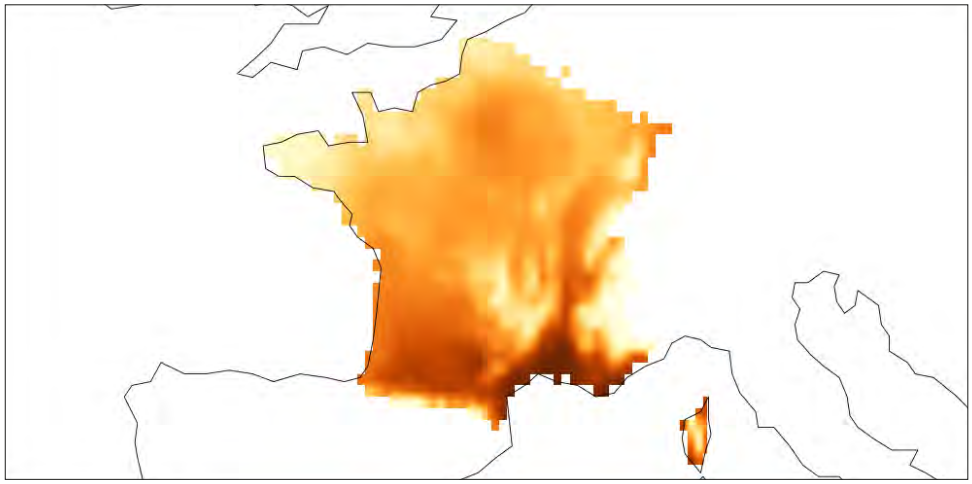
- 29

COOLING NEEDS

Strong increases in cooling needs are expected along the Mediterranean coast, the central-south regions and, to a lower extent, in the Paris area. Milder increases in Bretagne and Normandy and in the mountain areas (Massif Central and Alps).

COOLING DEGREE DAYS

0 — 363

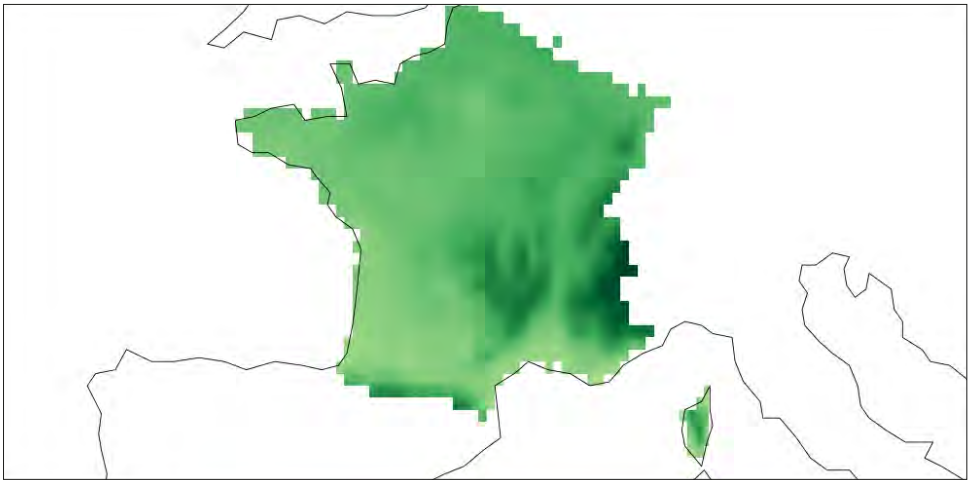


HEATING NEEDS

Marked decreases in heating needs are expected all over France, particularly in the mountain regions (Massif Central and Rhône - Alpes)

HEATING DEGREE DAYS

-826 — 0



FUTURE ENERGY SUPPLY

The future configuration of the French energy mix is likely to be determined by the evolution of climate mitigation policies and hence is outside the scope of this report. The EU net-zero carbon target by 2050 is likely to result in a marginal relevance of fossil fuels and their vulnerabilities to climate change, while carbon free sources and their vulnerabilities will prevail.

Change in Hydropower generation

% of change

2050

-4.41%

-4.36%

EXPECTED IMPACTS OF CLIMATE CHANGE

Spiking peak electricity demands during heatwaves and lower water availability during dry periods are the main threats posed to the French energy system. Hydropower may suffer from reduced water availability, particularly in the South.

More frequent extreme events might significantly increase stress on the energy system: besides heatwaves and the ensuing peaks in electricity demand, flash floods may also threaten energy infrastructure.

FRANCE
ECONOMY

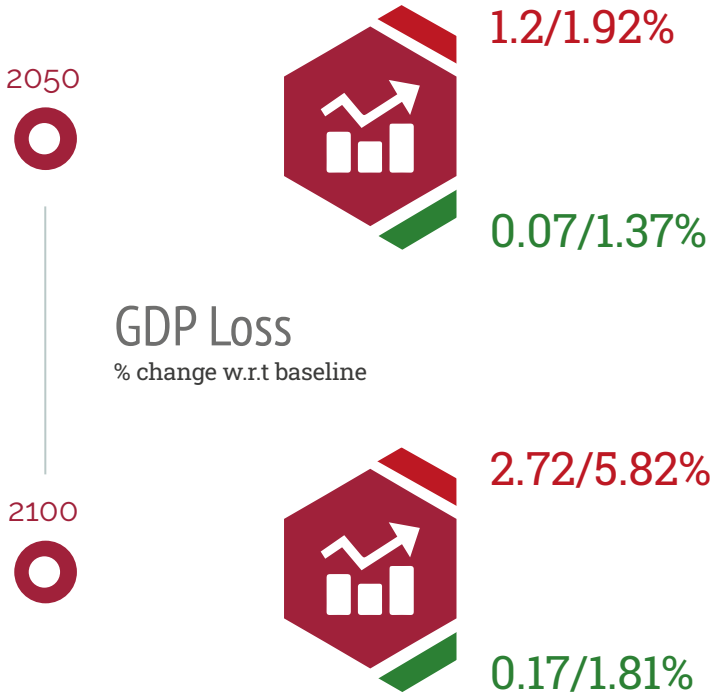
OVERVIEW

France is third wealthiest country in the Eurozone and eighth among G20 countries in 2020. France was hit severely by the COVID crisis, registering an 8.2% decline in real GDP growth rate in 2020.

IMPACTS ON GDP

Climate change is expected to have a great impact on the French economy. By 2050 GDP losses may reach about 30 billion EUR (about 1.4% of total GDP) under a low emissions scenario.

In 2100, under a higher emissions scenario climate change could reduce French GDP between 2.7% and5.8%, amounting to roughly 60 to 124 billion EUR.



SECTORAL ECONOMIC IMPACTS

IMPACTS ON INDUSTRY AND INFRASTRUCTURE

Major risks to infrastructure are coming from extreme events such as droughts and floods. In France physical infrastructure was heavily impacted by heatwaves with delays in transportation and power outages.

More than 40% of the 36,500 French communes have been affected by floods (both coastal and river), and flooding is responsible for 80% of the damage attributable to French natural disasters.

A first estimate of the Expected Annual Damage (EAD) to critical infrastructure in France ranges from 0.4 billion euros per year to 2.9 billion euros per year in 2050.

IMPACTS ON AGRICULTURE

Although the agricultural sector accounts only for 2.8% of total GDP, nearly 60% of France's mainland surface area is used for agriculture.

Crop yields are predicted to be negatively affected by climate change: under a high emissions scenario climate models predict a 21.0% decline in winter wheat yield, a 17.3% decline in winter barley yield, and a 33.6% decline in spring barley yield by the end of the century. Increased events such as heatwaves may represent a cost of up to more than 300 million EUR per year in 2100 for a crop such as wheat in the absence of adaptation measures.

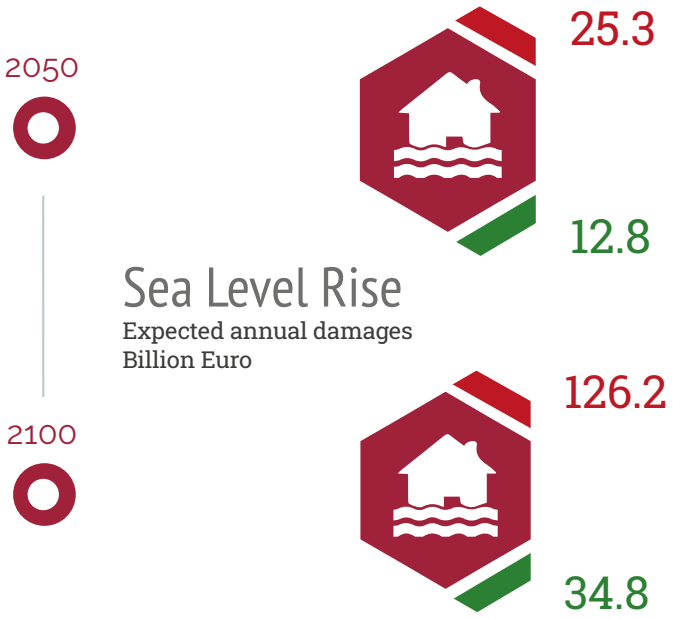
France is a major livestock farming country in the EU. Meadow yields are projected to increase in the northern area, whereas an increased vulnerability is projected in the peri-Mediterranean area with a loss of approximately -70% in the summer period.

The cost of compensating for these drops in yield could reach about 200 million EUR per year in the second half of the 21st century.

SEA LEVEL RISE DAMAGES

Under the current level of coastal protection, by mid century, sea-level rise and coastal flooding could cost the country 12.8 to 25.3 billion EUR in terms of expected damage to assets in low and high emissions scenarios, respectively.

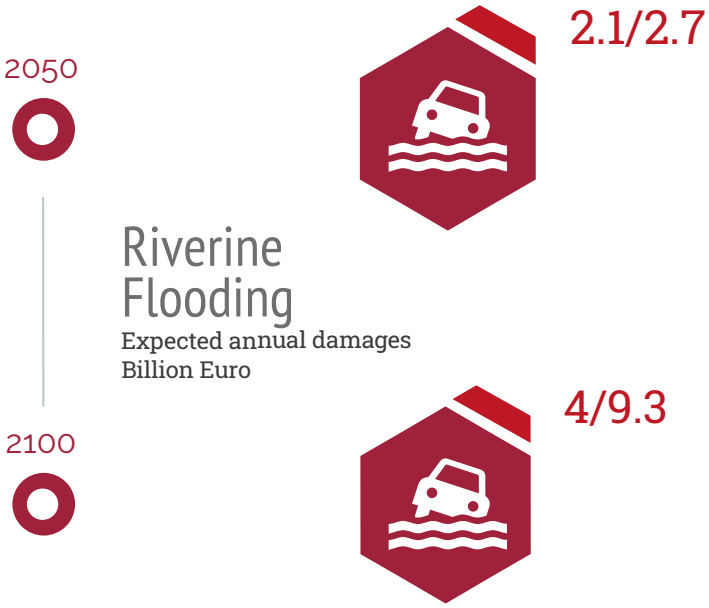
By the end of the century, expected losses can increase to 34.8 billion EUR in a low emissions scenario and to 126.2 billion EUR under a high emissions scenario.



RIVER FLOODING DAMAGES

Fluvial flooding is also expected to cause annual damages amounting to 2.1 billion EUR under a low emissions scenario and 2.7 billion EUR under a high emissions scenario.

By the end of the century the costs are projected to rise to 4 billion EUR under a low emissions scenario and could reach 9.3 billion EUR under a high emissions scenario.



IMPACTS ON ENERGY

As with all other economic sectors, energy supply and energy networks in France will be subject to more intense stress from extreme weather events.

Economic impacts of shifts in household and firm energy demand (see chapter on energy) are difficult to predict and will mostly lead to redistribution effects. In the case of France, the decrease in heating needs will prevail, bringing about a likely decrease in household and firm energy bills.

Expected annual damage to energy infrastructures is projected to show a 24-fold increase compared to present by mid century in a medium to high emissions scenario.

IMPACTS ON TOURISM

Climate change will potentially impact the tourism sector in France. Summer turnover will be negatively affected by a significant reduction in climate attractiveness.

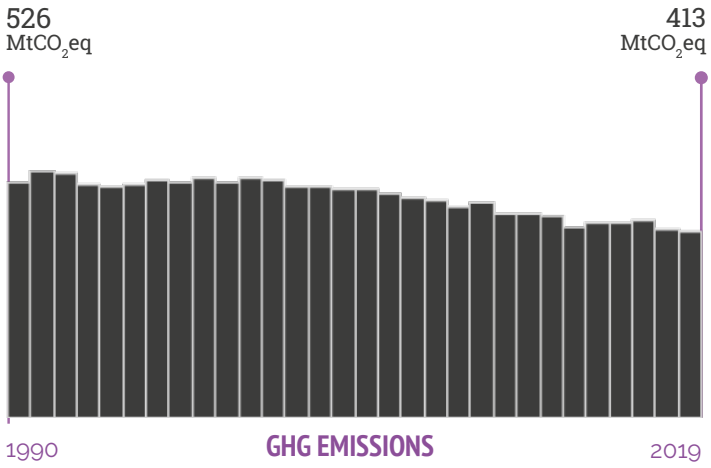
Without adaptation, economic losses associated with the tourism sector range from 15 to 19 billion EUR per year in 2100.

With respect to winter tourism, mountain activities represent 15.5% of total French tourism: a warming of 4°C, and the associated decrease in snow cover, would reduce the number of ski areas from 143 to 55 due to sufficient snow cover.

FRANCE
POLICY

OVERVIEW

France is responsible for 0.92% of global GHG emissions and has a slightly above global average rate of CO_2 emissions per capita. Emissions have been declining since 1991 and a net zero emissions by 2050 target has been set.



INTERNATIONAL COMMITMENTS

France has the same target as the EU. In its 2020 NDC update, it strengthened its emissions target to a 55% reduction below 1990 levels by 2030. France has also set itself a carbon neutral by 2050 target.

CLIMATE POLICY COMMITMENTS CHRONOLOGY

2002 — **KYOTO PROTOCOL - 1ST PERIOD**

No increase of GHG over the four year period 2008-2012, with respect to 1990 levels

2016 — **PARIS AGREEMENT - 1ST NDC**

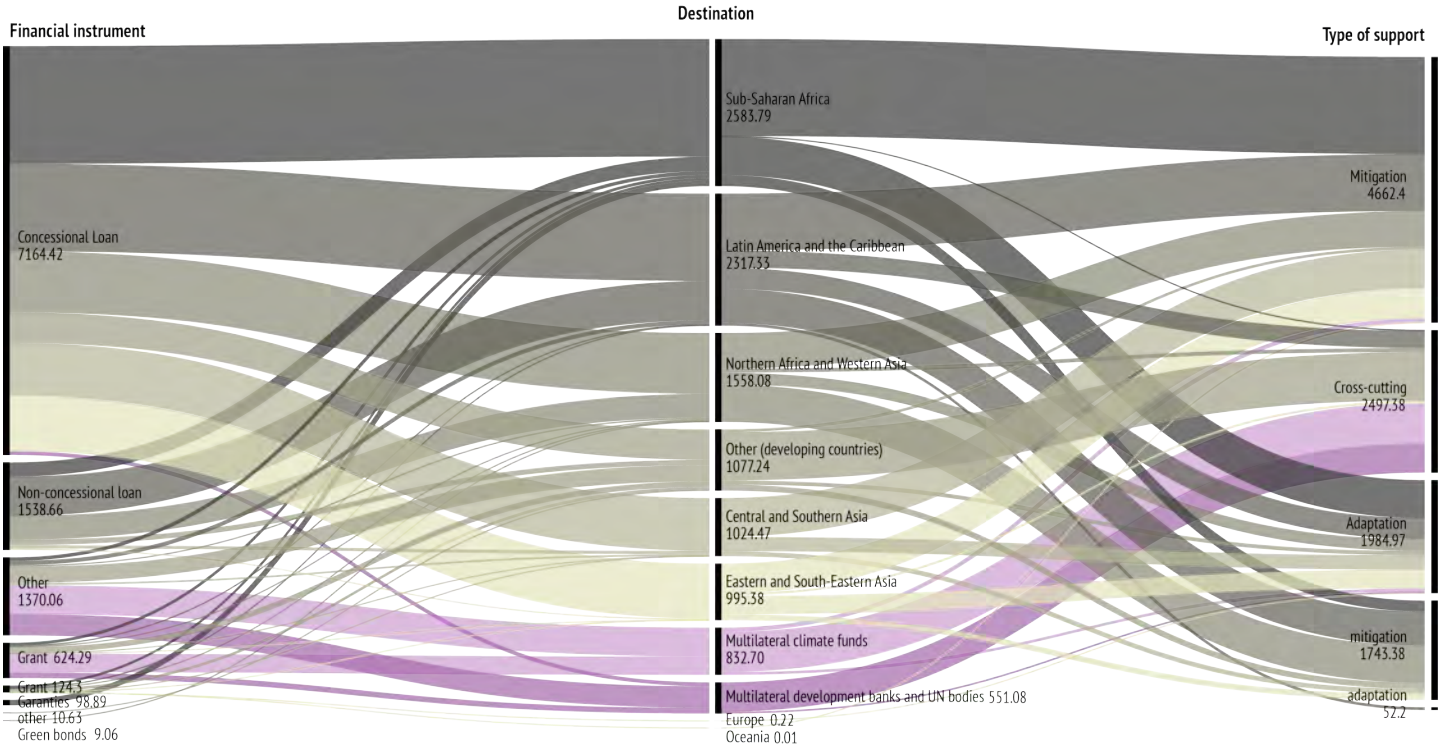
40% GHG reduction by 2030, with respect to 1990 levels

2020 — **PARIS AGREEMENT - NDC UPDATE**

55% GHG reduction by 2030, with respect to 1990 levels

INTERNATIONAL CLIMATE FINANCE ASSISTANCE

In the 4th Biennial Report, France reported 10.9 billion USD in development finance for climate in 2017-2018. The majority was mobilised in the form of loans and other financial products to finance mitigation projects particularly in sub-Saharan Africa and Latin America.



SUSTAINABLE RECOVERY POLICY

According to the Global Recovery Observatory, in 2020 the proportion of green spending out of total recovery spending was 38%.

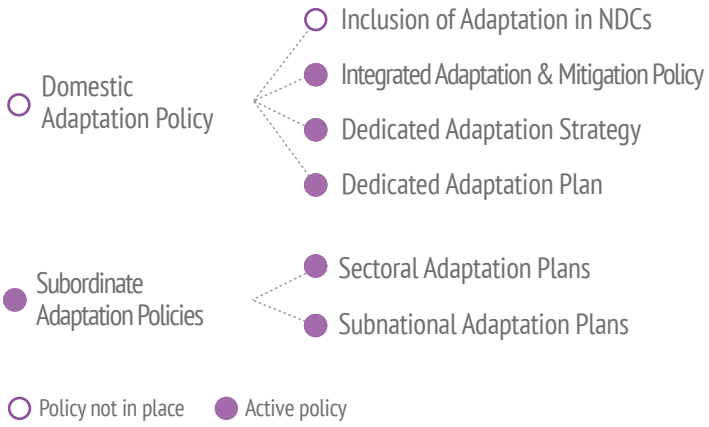
694.17 billion $
Total Spending

104.92 billion $
Recovery Spending

39.41 billion $
Green Spending

DOMESTIC ADAPTATION POLICY

The French National Strategy for Adaptation to Climate Change was adopted in 2006. The first National Adaptation Plan covered the period from 2011to 2015, the second National Adaptation Plan (2018-2022) covers the main sectors of the economy (agriculture, industry and tourism) and territories.



ADAPTATION POLICY HIGHLIGHTS

TRANSNATIONAL INITIATIVES

Provision of a prediction system allowing for management and optimization of snow in Alpine ski resorts (PROSNOW)

PROSNOW eases the decision-making process and provides more precise snow data to inform snow management strategies and tactics throughout the winter season

ECTAdapt

The aim of ECTAdapt is to develop a common policy on the adaptation to climate change in the Catalan Cross-border Area (Espacio Catalán Transfronterizo - ECT)

NATIONAL INITIATIVES

Climate Change Adaptation Resource Centre

A portal offering documentary resources and suggestions of local initiatives, to raise awareness on the reality of climate change and to facilitate the implementation of adaptation activities

Adapto

Adapto explores solutions to the impacts of climate change on the coast (e.g., sea level rise and more frequent extreme weather events) on 10 pilot sites owned by the Conservatoire du littoral

SUBNATIONAL INITIATIVES

Paris Climate Action Plan

The Climate Action Plan details and specifies the terms for adapting Paris to climate changes and the scarcity of resources in 35 actions that contribute to 30 objectives, while making the city more resilient, more attractive, and a nicer place to live

NATURE 4 CITY LIFE

The project aims to strengthen the integration of Green and Blue Infrastructures in urban planning projects to increase urban resilience to climate change in the Region Provence-Alpes-Côte d'Azur

ENERGY TRANSITION

France shows one of the first positions among G20 countries in the overall Energy Transition indicator.

In particular, France has an outstanding performance in Fossil Fuels, almost 30 points above the average, and Emissions, due to nuclear energy capacity. This also impacts on the Efficiency and Electrification domains that have became priorities in France's energy policy a long time ago.

On the other hand, nuclear generation capacity until now, had a negative influence on the poor penetration of renewables (almost 3 points below the average) even if the progressive ageing of the nuclear park will reverse the trend in the coming years.

Only actively pursuing an energy transition based on decarbonization and electrification – from policy and regulation, to health and education – will enable countries to benefit the most from future opportunities and fight climate change whilst ensuring an equitable distribution of wealth.

The Energy Transition indicators were developed by Enel Foundation in cooperation with SACE, and provide a retrospective analysis based on historical data.