G20 CLIMATE RISK ATLAS

Impacts, policy, economics

RUSSIA

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

RUSSIA CLIMATE

OVERVIEW

Russia features almost all world climates, with the exception of tropical, due to its huge landmass which crosses two continents. In general, its predominant climate is a highly continental one, with warm to hot and dry summers and cold winters which prevails in European and Asian Russia, with the exception of the tundra and the extreme southwest. Very strong easterly winds, called Buran, sometimes occur bringing freezing cold temperatures and snowstorms.

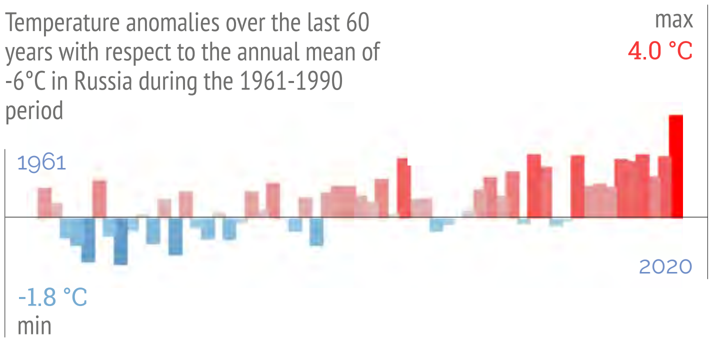
TEMPERATURE

The temperature regime in Russia varies from region to region. In general, two different areas can be detected: Northern and Central European Russia experience a cold climate, and Southern European Russia have higher temperatures, particularly around the Black Sea.

MEAN TEMPERATURE

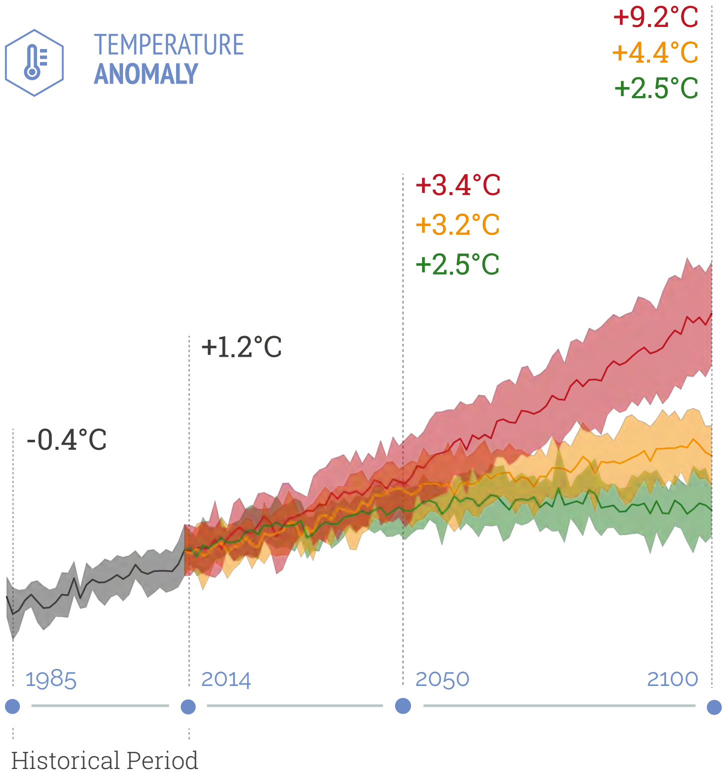
TEMPERATURE TREND

Temperature anomalies over the last 60 years with respect to the annual mean of -6°C in Russia during the 1961-1990 period



TEMPERATURE PROJECTIONS

Under a low emissions scenario projected temperature variations will reach +2.5°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.

Annual Mean Temperature	Max Temperature of warmest month	Min Temperature of coldest month
+3.9°C	+3.1°C	+5.2°C
+3.1°C	+2.4°C	+4.2°C
+2.6°C	+2.0°C	+3.2°C

PRECIPITATION

As with temperatures, the precipitation regime in Russia also varies from region to region due to the size of the country.

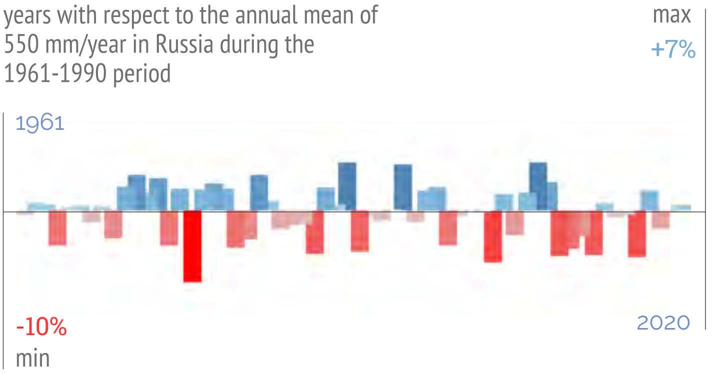
The main patterns for annual precipitation reveal that the western part of the country is the rainiest, whereas the central areas are the driest ones. Furthermore, precipitation values are higher in areas around the sea.

An average increase in precipitation in many areas of Russia, as well as rapid snow and glacier melting due to rising temperatures, may lead to an increase in risk of flooding.

MEAN PRECIPITATION

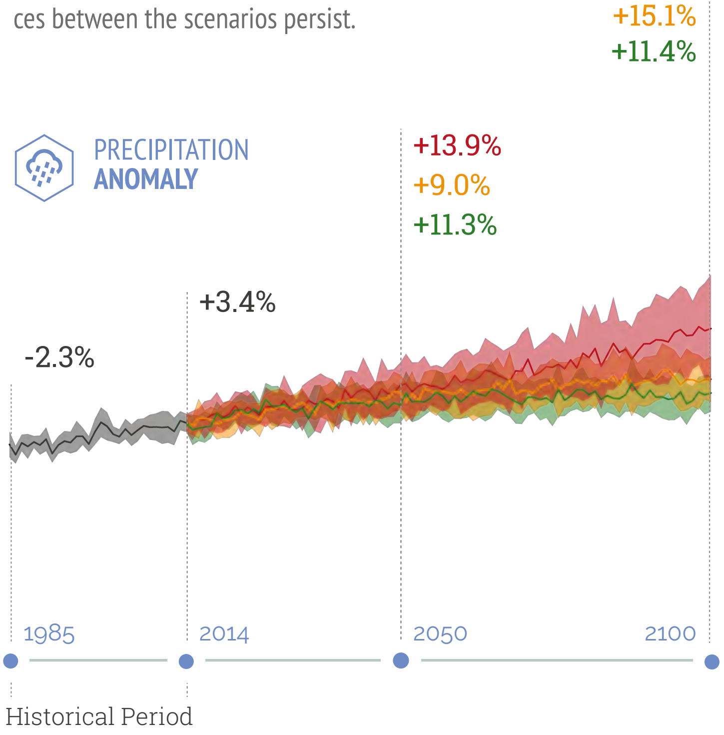
PRECIPITATION TREND

Precipiation anomalies over the last 60 years with respect to the annual mean of 550 mm/year in Russia during the 1961-1990 period



PRECIPITATION PROJECTIONS

Precipitation trends shows an increasing pattern for all the different scenarios. The variability is quite large over all the periods considered. It is more pronounced over the projections period but differences between the scenarios persist.



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.

+12.7%
+10.5%
+9.5%
Annual total precipitation

+10.8%
+9.2%
+8.7%
Precipitation of wettest month

+6.5%
+6.1%
+6.7%
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**.

+31%
+16%
+12%
Agricultural drought proportion of time
% of time

+20%
+9%
+8%
Hydrological drought proportion of time
% of time

+1,026%
+137%
+42%
Heatwave duration
% of time

+18%
+6%
+3%
Runoff increase
% of area

+69%
+38%
+28%
Agricultural drought frequency
% of change

+11%
+7%
+12%
Hydrological drought frequency
% of change

+81%
+28%
+17%
Heatwave frequency
% of change

+42%
+24%
+12%
Runoff decrease
% of area

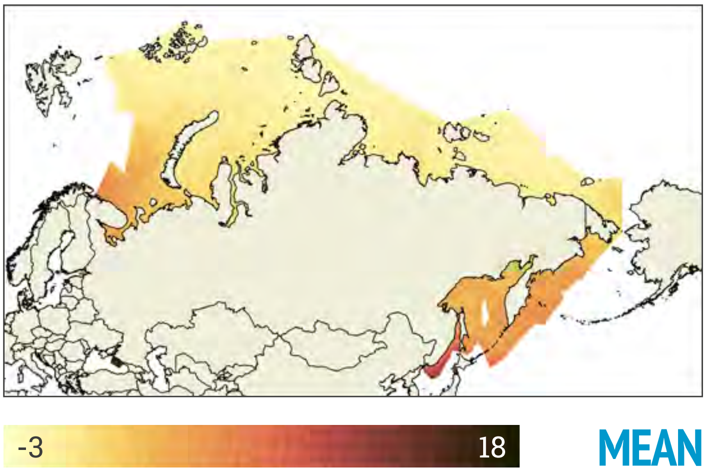
RUSSIA
OCEAN

OCEAN IN RUSSIA

Russia's marine exclusive economic zone (EEZ) is characterized by polar to temperate coastal waters which host a great concentration of wildlife and habitats. Russian coastal systems can be divided into four key areas: Arctic and Pacific marine regions and two small areas within the Baltic and Black Seas.

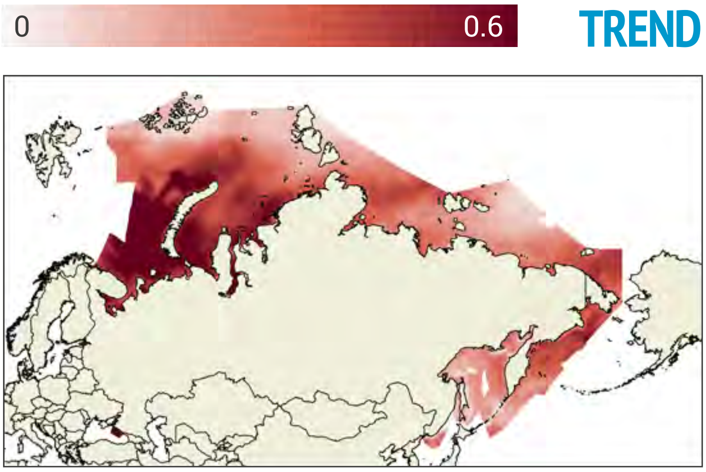
CURRENT CLIMATE CONDITIONS

Mean sea surface temperature reflects the different climate regimes, from the cold Arctic waters to the temperate regime of the southernmost Black Sea.



SEA SURFACE TEMPERATURE

Celsius degrees / Over 1991-2020

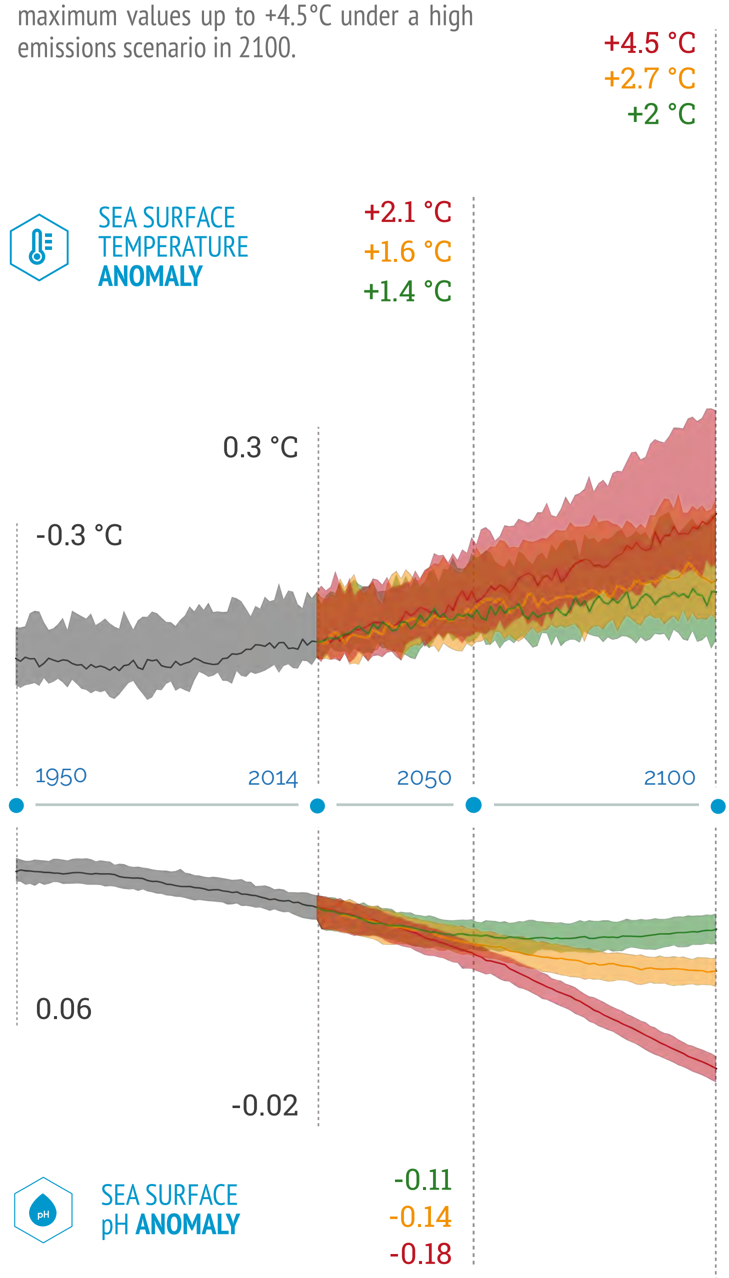


Surface temperature trends indicate a general warming of 0.2°C per decade in all marine areas, with increased gains up to 0.6°C per decade in the Arctic area.

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 up to +4.5°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).


Arctic


Baltic


Black Sea


Pacific

Temperature regulates the metabolism of marine organisms determining which habitats remain suitable. Excessive warming will likely push ecosystems beyond tolerance thresholds.

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.

Oxygen is fundamental to sustain marine life and its reduction can have a large impact on coastal ecosystem services including fisheries and aquaculture.

Chlorophyll is an indicator of the biomass available at the base of the marine food web supporting all ecosystem productivity.

	Arctic	Baltic	Black Sea	Pacific
Temperature	+1.33 °C -0.73°C +0.9 °C +0.64 °C	+2.38 °C 9.12°C +1.99 °C +1.7 °C	+2.06 °C 15.64°C +1.44 °C +1.24 °C	+2.36 °C 4.73°C +1.92 °C +1.92 °C
pH	-0.2 8.09 -0.16 -0.13	-0.21 7.83 -0.11 -0.12	-0.19 8.1 -0.14 -0.1	-0.16 8.08 -0.12 -0.09
Oxygen	-3.59 % 366 mmol/m^3 -2.64 % -1.66 %	-6.51 % 354.46 mmol/m^3 -5.33 % -4.95 %	-2.62 % 268.97 mmol/m^3 -2.95 % -3.82 %	-4.52 % 324.12 mmol/m3 -3.77 % -2.94 %
Chlorophyll	-19.76 % 0.33 mg/m^3 -12.16 % -25.84 %	-15.59 % 0.29 mg/m^3 -14.24 % -17.63 %	-3.88 % 0.23 mg/m^3 +8.19 % -3.02 %	-10.11 % 0.66 mg/m3 +4.68 % -7.54 %

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 exclude the Russian part of the Black Sea and the Caspian Sea.

Fish catch percentage change

2050

+34.4%

+31.6%

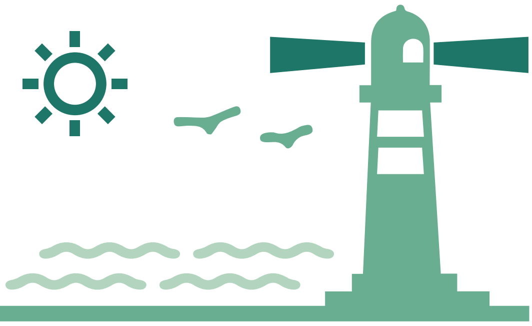
ANALYSIS DETAILS

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 tempereature 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.

RUSSIA COASTS



OVERVIEW

Russia's shorelines extend more than 110,000 kilometres and border the Baltic, Barents, Kara and East Siberian seas, the Pacific Ocean, the Black Sea and the Sea of Azov. Parts of the vast and diverse shoreline are permanently frosted during winter months. Most of the coastal population is concentrated in the more hospitable parts of the country, including St Petersburg and Kaliningrad on the Baltic Sea, Arkhangelsk on the White Sea and Vladivostok on the Pacific Ocean.

Shoreline Length

110,310 km

Sandy Coast Retreat at 2050

-18.9 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. Climate change impacts on Russian coasts are driven by sea level rise, changing storm patterns, and ice and permafrost melting in the northern regions.

Coastal erosion is likely to occur in response to sea level rise along the low lying coastal plains and beaches. Permafrost melting due to rising temperatures also leads to high rates of erosion, which is in turn exacerbated by sea level rise. Coastal flooding may also be accentuated by sea level rise, impacting populated areas, particularly in cities along the Baltic Sea such as Saint Petersburg.

SEA LEVEL RISE

Relative sea level rise in Russia has been observed over the past century with a yearly average increase of approximately 2.47 millimetres. All stations show similar trends for the past century and an acceleration in recent decades.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

2.47 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 2.78 metres at present day to 3.01 metres by 2050 under a medium emissions scenario.

Current and projected extreme sea level at 2050

2.78 m

3.05 m

3.01 m

OBSERVED STORMS

In general, all seas and oceans surrounding Russia are characterized by a wave climate driven by a range of weather systems with associated variability across seasons, years and decades. Whereas more climate variability is observed in the Pacific, driven in particular by the El Niño Southern Oscillation, in the northern and eastern seas surrounding Russia, and in the Black Sea, climate variability has been observed in recent decades and is mostly driven by large scale global oscillations. Storm surges can impact the Baltic Sea and the Gulf of Finland.

FUTURE STORMS

Changes in the wave climate impacting Russian coasts are expected to be in line with the changes projected for the wave climate regions the country is exposed to. For example, future increases in wave energy are expected in the Baltic Sea, and changes in wave energy distribution in the Arctic Sea will also increase due to the melting arctic ice pack. For the Black Sea the impact of climate change is quite uncertain, with both potential decreases or increases in the wave energy distribution. The Russian Pacific is expected to see a decrease in mean wave climate and an increase in extreme conditions. Overall rising sea levels will increase the frequency of extreme sea level events, such as the one in 100 year water level.

VULNERABILITY AND RISK

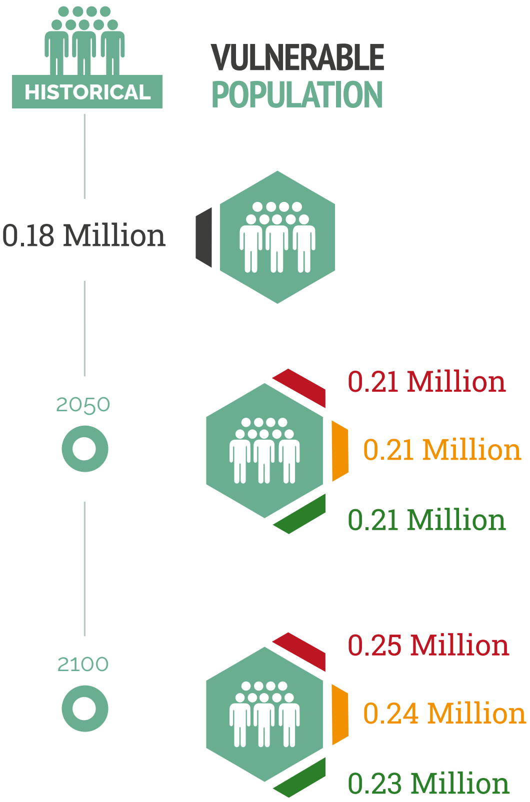
The vast Russian coast is characterised by coastal environments, settlements and urban areas with a range of vulnerabilities and risks associated with sea level rise and storms.

Russia's second largest city, St. Petersburg, is particularly vulnerable to sea level rise, which is already at risk of regular flooding when strong winds blow from the Gulf of Finland. This vulnerability will continue to increase as sea levels rise and storm surges grow more intense.

In the Black Sea, the city of Rostov and the Port of Novorossiysk are particularly exposed to the impacts of sea level rise. 56% of beaches in the Black Sea are projected to retreat by 50% of their maximum width considering a 0.5 metre sea level rise.

Under a medium emissions scenario, the total population exposed to the annual coastal flood level is expected to increase from 180,000 to 210,000 by 2050.

VULNERABLE POPULATION



INFLUENCE OF SEA LEVEL RISE ON EXTREME SEA LEVEL

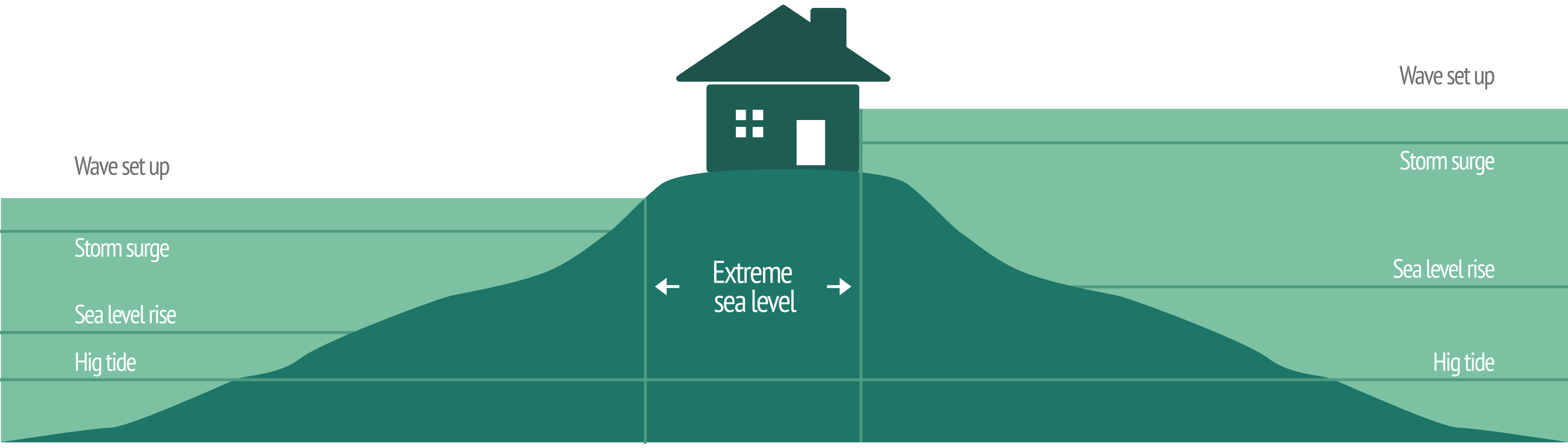
Present and future sea level rise are a consequence of carbon induced global warming causing melting ice and ocean expansion due to heat accumulation.

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.

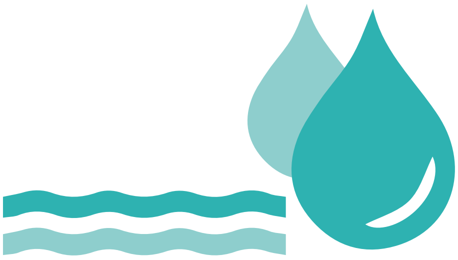
+ **High tide** is usually the highest tide reached in a given location based on tide records.



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.

RUSSIA
WATER



OVERVIEW

Russia is home to 20% of global freshwater resources. However, water is unevenly distributed within the Russian territory. The central and southern regions of European Russia, where 80% of the country's population and industry is concentrated, have only 10-15% of water resources.

In Russia, approximately 70% of drinking water comes from surface water and 30% from groundwater. Some of the largest freshwater bodies in the world include the Volga, Ob and Dnieper Rivers, as well as Lake Baikal, the world's largest freshwater lake.

Renewable internal freshwater resources
4,312
billion m^3

Renewable internal freshwater resources per capita
29,841
m^3

The overall intake of fresh water from water bodies in Russia is high, amounting to approximately 70 billion cubic metres per year. In 2016, the volume of fresh water used for economic activities amounted to 54.7 billion cubic metres. The main water consumers are manufacturing industries, heat supply and nuclear power companies, utility companies, and agriculture (particularly in the south).

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. Water availability in Russia is projected to increase by 8 to 10% over the next 30 years. However, the western side of the country is more vulnerable and likely to suffer from water stress. Managing the increased flows will also pose problems, especially when these coincide with extreme weather events. In addition, increasing water shortages are predicted for southern parts of European Russia and many densely populated areas, which already face water supply problems.

KEY POINT RUNOFF

River and surface runoff has been influenced by the general increase in water availability in large parts of Russia over the past decades, due to increasing temperatures and melting ice and snow cover. For example, the annual runoff of the Volga has increased by approximately 9% since the early 1980s and served as the main cause of an almost 2.5 metre rise in the Caspian Sea level.

At a country scale, an average increase in surface runoff by approximately -16% and -4% is expected respectively under low and high emissions scenarios for the 2045-2055 period compared to 2015-2025.

If temperatures rise by 1.5°C, 2°C or 4°C, 2%, 5.4% or 16% of the area of the country will likely experience an increase in runoff, while 4%, 12.3% or 39% of the surface of the country will likely experience a decrease in runoff, respectively.

2050

Changes in annual runoff
% of change

-4.4%

-15.7%

2050

Runoff increase
% of area

+42.0%

+12.0%

KEY POINT DROUGHTS

In Russia, extreme low flow events have been traditionally observed in the southern Asian part, in the basins of Western Siberia and in the Baikal region. However, during the last decade dry periods also started occurring further north: not only in the upstream regions but also in the middle course of the rivers. This may be attributed to an increase in the seasonal climate contrast, which is reflected in the redistribution of rainfall throughout the year. This effect leads to an increase in the duration of dry periods, which now occur not only in the summer but also in spring. Moreover, in the 21st century water scarcity is connected to the appearance of extreme low flow on the rivers of European Russia. These trends are particularly noticeable in the south of the region: in the basin of the Don, Volga and the Ural. For instance, a 8-year long drought event was observed in the Don River basin, which severely affected agriculture, industry and society.

2050

Severe drought likelihood increase

% of change

+5.1%

+5.2%

2050

Hydrological drought frequency

% of change

+11.0%

+7.0%

2050

Groundwater Recharge

% of change

+12.1%

+1.8%

KEY POINT GROUNDWATER

The amount and availability of surface water influences groundwater. Groundwater recharge by precipitation is the main source of groundwater resources, which are suffering from pressure from human uses, in particular in the areas where population density, agriculture and industry is concentrated.

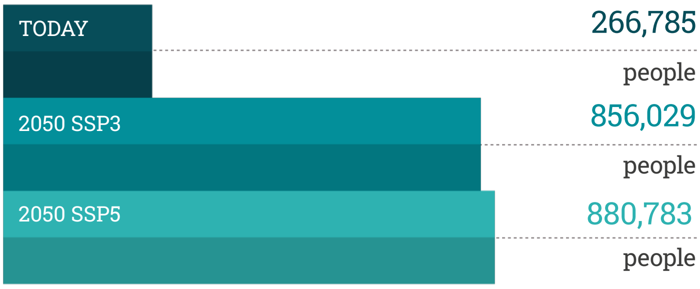
Other parts of Russia have abundant groundwater resources, in particular the remote areas of the northern and central part of the country. Large areas of Russia are expected to increase their groundwater availability, especially in less populated regions and in Siberia and eastern Russia. At the country level, a +1.8%, +5.1% and +12% change of the annual groundwater recharge for the period 2045-2055 compared to the timeframe 2015-2025 is expected respectively under under low, medium and high emissions scenarios.

KEY POINT FLOODS

Many areas of Russia are prone to flash floods and river floods. Extreme events have occurred in the past, with important damages and victims. In Krasnodar Krai, for instance, the equivalent of five months of rainfall fell overnight in summer 2012, leading to 171 casualties and more than 30,000 people affected. Recently, Siberia has also been affected by important floods, with the evacuation of several villages and tens of deaths in southeastern Siberia in 2019.

Furthermore, in 2021 the Sochi region experienced a flash flood and river flood in the same month, leading to extended damage, especially to infrastructure, and the evacuation of the population. Changing rain patterns may affect the frequency and intensity of floods and the population exposed to river floods is expected to increase from about 267,000 in the present day to about 850,000 under SSP3 and 880,000 under SSP5 by 2050, with a potential higher impact of flood events.

POPULATION AFFECTED BY RIVER FLOODS

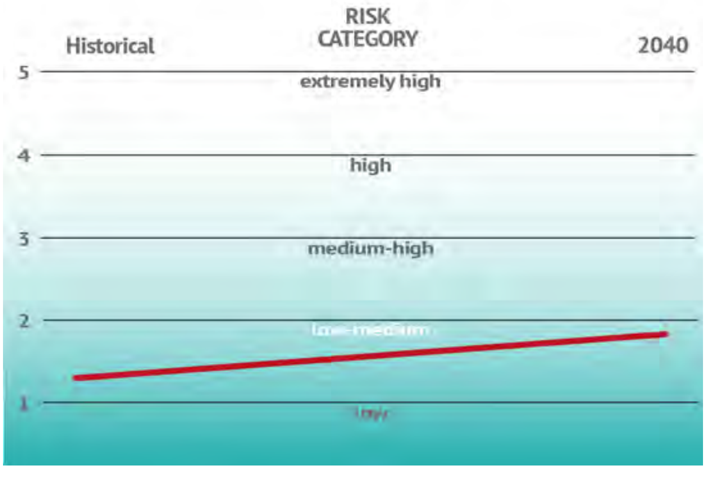


RISK INDICATORS

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

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



RUSSIA
AGRICULTURE

OVERVIEW

Agricultural land occupies 13% of the Russian territory and employs 9.7% of the active population, contributing to almost 4% of national GDP. Russia is the world's top wheat exporter, supplying between 20 and 23% of total global demand.

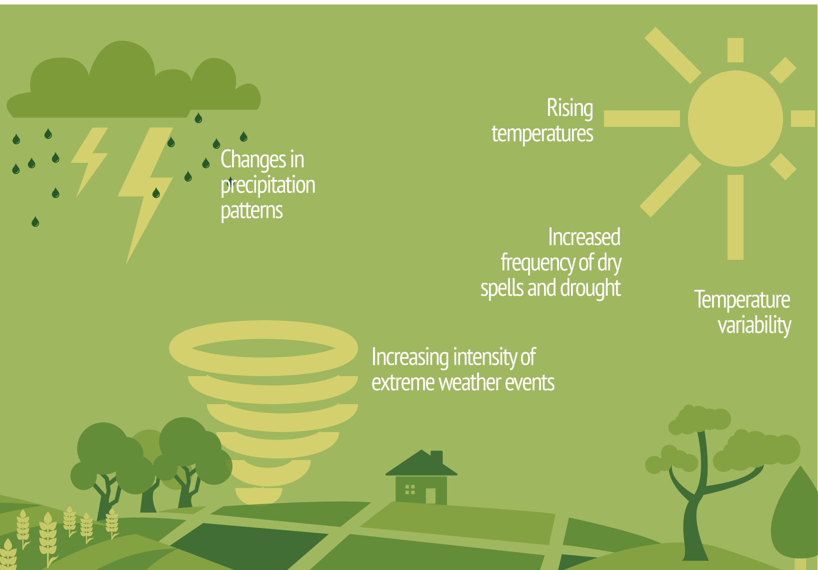
Wheat, sugarbeet, potatoes and other cereals (maize, barley, oats and rye) are the most important crops. Almost 22% of the total arable lands is dedicated to wheat. The main, and most productive, areas for wheat, sunflower and maize are: Southern and North Caucasus, Central and Volga regions, and the south-western part of the country (Central Chernozem Economic Region). Russia is the third largest potato producer in the world, after China and India, with the Republics of Bashkortostan and Tatarstan leading potato production. Irrigated agricultural land corresponds to less than 5% of the total arable land.

72.1 Mt	Wheat
42 Mt	Sugarbeet
22.4 Mt	Potato
17 Mt	Barley
12.8 Mt	Sunflower
11.4 Mt	Maize

	Added Value of Agriculture, Forestry and Fishing	Share of Agriculture Value added in Total GDP	Agricultural land	Area Equipped for Irrigation
2000	37,963 USD Million	4.8 %	126,238 Thousand HA	4,606 Thousand HA
2018	53,639 USD Million	3.8 %	123,442 Thousand HA	4,300 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.

2.7 **Wheat** tons / ha
9.2 (3.4)%
10.5 (0.2)%

43 **Sugarbeet** tons / ha
28.6 (20.3)%
31.6 (na)%

1.7 **Sunflower** tons / ha
32.9 (22.1)%
38.4 (na)%

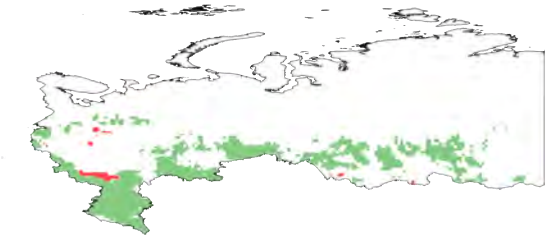
5.2 **Maize** tons / ha
14.2 (12.2)%
14.7 (-2.6)%

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

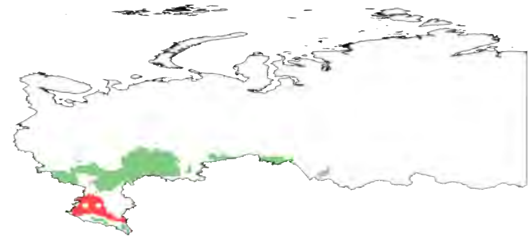
🟥 − = 🟩 +



The impact of global warming is currently assessed as very advantageous, as it reduces the lowest temperatures threatening winter crops, thus allowing for an expansion in favorable agricultural land. In high and middle latitudes, global warming would expand the growing season by an average of 5 to 10 days, although the positive effects could be reduced by abnormal droughts. Climate change will benefit wheat productivity, expanding cultivation areas particularly in Siberia. However, wheat yield productivity will suffer in the Central Chernozem region due to a significant increase in aridity.

CHANGE IN MAIZE

🟥 − = 🟩 +



Sugarbeet and sunflowers are expected to be the most favored crops, with their yields increasing by up to 30%. Maize production could suffer in the southern-west regions due to increasing temperature, balancing yield increases for the rest of the country. Thanks to the longer growing season and the possibility of expanding traditional areas of cultivation, potato production can increase in some regions, such as southern Siberia, whereas a decreasing yield is expected in the Central Chernozem Region.

ADAPTATION IN AGRICULTURE AND WATER RESOURCES

Climate change may have positive effects on several widely used crops. However, higher temperatures will generally require an increase in irrigation demand due to increasing evapotranspiration. Although overall water resources are projected to increase in Russia, these are associated with significant increased frequency of high runoff events in central Russia, and more frequent low runoff events in the South. Droughts in 2010 caused severe grain-harvest losses, leading the Russian government to ban wheat exports. Southern regions will become more vulnerable to droughts and other extreme weather, and more reliant on irrigation.

CHANGE IN WATER DEMAND

🟩 − = 🟥 +

Agriculture Water Demand
% of change

+9.2%
+9.3%

2050

Over half of irrigation systems, mostly concentrated in the South and North Caucasus federal districts, will require work for reconstruction and technical re-equipment in order to cope with climate risks.

RUSSIA FORESTS

FORESTS IN RUSSIA

Russia is home to the largest area of forest in the world and contains around 64% of the world's occupied and intact forests. More than 90% of Russian forests are boreal forests, with a huge diversity and several forest types. Conifers play the dominant role, but there are many deciduous trees (both softwood and hardwood). Floristic diversity of forests increases from north to south.

FORESTED AREA AND CARBON STORAGE

Forests cover about half of the Russian territory, with a slight increasing trend in recent decades. With Canada and Fennoscandia, Russia hosts 90% of the world's boreal forest carbon stock. Half of the estimated terrestrial global carbon sink is located in Russian forests which are a net carbon sink with almost 175 million tons per year, although experiencing a reducing trend. Climate change is expected to increase permafrost melting, which on the one hand favours the establishment of new forests and on the other reduces the overall carbon sink effect.

1990

809 Mln ha
Million hectares
Forested area

158 Tons/ha
Tons of Carbon per hectare
Carbon stock

2020

915 Mln ha
Million hectares
Forested area

164 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

+0.64

+0.50

Increase expected to be widespread and patchy in the whole country

+ Fertilizing effect of increasing atmospheric CO_2, nitrogen deposition, rising temperatures, increasing length of growing period, and permafrost melting promote productivity

Decrease particularly pronounced in the north-east, mainly Yakutia

+ Increasing risk of drought stress due to modifications in the water regime reduces productivity

KEY SPECIES UNDER CLIMATE CHANGE

SHIFTING
SPRUCE
Potential eastward shift of the spatial range of spruce

CHANGES
DOMINANT
Major changes in dominant forests are expected across the southern portion of the Central Siberian Plateau and the southern Far East

THREATENED
BETULA
Betula species should be impacted negativley

EXPANSION
NORTHERN
Pronounced northward shift of forest limit also due to melting permafrost

FIRES IN RUSSIA

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 two decades, the total land area affected by fires was approximately 41.8 million hectares of which 77% involved forests.

BURNING
41.8 MILLION HECTARES

EMITTING
140.3 TERAGRAMMES OF CARBON PER YEAR

FOREST FIRE EMISSIONS CONTRIBUTED TO 75% OF TOTAL FIRE RELATED EMISSIONS

COSTING
106 MILLION USD IN FIRE SUPPRESSION COSTS ACROSS SIBERIA AND OTHER REGIONS IN 2019 ALONE

FUTURE BURNED AREA

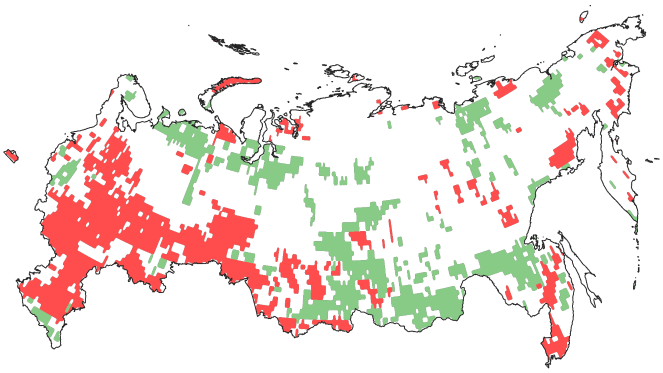
Under a low emissions scenario, models project a general increase in burned area over western areas dominated by temperate broadleaf and boreal forests. This trend might be emphasized under a medium emissions scenario, particularly along the eastern Siberian taiga. A potential decrease in burned area is expected over some southern areas of the Siberian taiga.

Burned Area
km² per year

2050

+969

+580



Decrease in burned areas for a medium low scenario

Increase in burned areas for a low emissions scenario
+ Prolonged fire season, also at the end of the century, especially in central and western regions, as well as increased fire exposure due to weather conditions considered conducive to fires

WHERE DO FIRES OCCUR?

The types of vegetation most affected by fires are the temperate and boreal forests, as well as the southern steppes.

The Asian part of Russia, mainly in its southern half, is the most affected by fires. 2010 was an exception, with catastrophic fires occurring in the central regions of European Russia.

VARIATION OF SPECIFIC FIRE INDICATORS

days
Moderate-to-high fire danger days in western and southern federal districts

2090-2099

+12-17

+6-11

days
Fire-risk days in western Russia and South Siberia

2041-2060

+15-19

Million US$ per year
Cost of forest fire management

2090-2099

+3.4

+2.8

FUTURE FIRE EMISSIONS

Fire emissions follow a similar spatial pattern as burned area. Greater changes are projected over the eastern Siberian taiga under a low emissions scenario and over the European boreal forest under a medium emissions scenario.

Fire Carbon emission
Teragrams of Carbon per year

2050

+75.1

+56.8

RUSSIA
URBAN

OVERVIEW

The rate of Russian urbanisation in 2020 was 74.8%. This is expected to increase to 83% by 2050.

Just two urban areas account for more than 5 million inhabitants: just above 10% of the urban population lives in the Moscow area and a further 5% in the second biggest city, St. Petersburg. The majority of the urban population live in settlements with less than 300,000 inhabitants.

Built up areas cover only 0.32% of Russia (54,082.59 square kilometers).

Population in Urban Areas

2020	107,486,269
2050	110,604,995

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

Urbanization Rate

2020	74.8%
2050	83.3%

OVERVIEW OF KEY CLIMATE IMPACTS IN URBAN AREAS

The Russian Federation's major cities are vulnerable to heatwaves, and intense rainfall events.

HEATWAVES AND HEAT STRESS

In Russia, extreme temperatures often come with wildfires that impact air quality in urban areas. The 2010 heat wave in the western part of Russia registered daytime temperatures of 40°C and extensive wild fires. The overall death toll was of 55,000 and damages amounted to 400,000 USD.

In Moscow, extremely high temperatures and pollution from the forest fires caused over 10,000 deaths, 40% of which connected to temperatures and the rest caused by the combined effect of air pollution and heat, or air pollution alone. Wildfire smoke exacerbates already high levels of pollution in Russian cities. On average, 91.6% of urban residents are exposed to unsafe air pollution levels above WHO thresholds.

Rising temperatures and increased frequency and intensity of future heatwaves are expected. Summer temperature increases are expected to be higher in southern areas compared to northern ones with an increasing frequency and intensity of heatwaves.

2050

Cooling Degree Days

% of change

+495.0%

+233.0%

+183.0%

2050

Heatwave frequency

% of change

+80.9%

+28.1%

+16.7%

2050

Heatwave duration

% of time

+21%

+5%

+3%

HEAT AND AIR POLLUTION

For Russian cities in the arctic region, impacts on the stability of around 30% to 60% of buildings and infrastructure has ocurred due to changes in permafrost which could reach critical levels by 2040. Under a high emissions scenario, losses from impacts on residential buildings alone are expected to reach 20.7 billion USD by mid century.

During heatwaves, often leading to wildfires, air quality in cities of western Russia is reaching critical values due to smoke. Overall, more than 90% of the Russian population is exposed to pollution levels above WHO thresholds.

2017

Population exposed to air pollution

91.6%

COASTAL FLOODING

In Russia, approximately 1% of the population lives in areas situated below 5 metres from sea level and some cities and urban settlements are exposed to sea level rise and increasing erosion. In 2011 the city of St. Petersburg realized a 25 kilometer system of dams for flood control, which aim to protect the low lying city against frequent catastrophic flooding.

Projected sea level rise

2050

0.23 m

0.18 m

2100

0.77 m

0.38 m

FLOODING

Cities are vulnerable to flooding from intense precipitation events because urban sewage systems are unable to cope with the large amounts of water run-off caused by artificial surfaces. Moscow's urban area is regularly impacted by flooding.

In 2016, after 88 millimetres of rain fell in 24 hours, more than 200 people had to be evacuated. Increasing precipitation and flood events expected over most of the country will impact urban settlements more frequently and with more intensity.

2050

Runoff increase
% of area

+42%

+24%

+12%

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.

SOIL SEALING AND FLASH FLOODS

In densely built urban areas, runoff from intense precipitation events will lead to more frequent flash floods due to high rates of soil sealing.

2010

% of urban population
Population living in slums

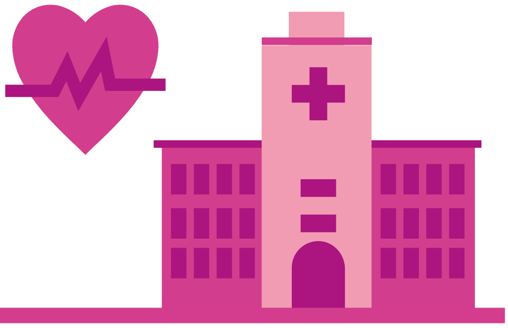
0%

2018

% of total population
Urban population living in areas where elevation is below 5 meters

0.9%

RUSSIA
HEALTH



OVERVIEW

Although climate change may bring some warming related benefits to Russia, thermal stress will increase incidences of infectious, respiratory, and cardiovascular diseases in the country. Climate warming and increased numbers of anomalously hot and cold days will affect mortality, especially among the elderly. Climate changes in Russian will also affect the prevalence of infectious diseases and has already increased the incidences of tick-borne diseases. Warming has also improved the habitat conditions for mosquitoes that are carriers of West Nile fever, albeit in small numbers.

HEAT RELATED MORTALITY

Additional mortality from heatwaves in some regions in Russia (e.g., Arkhangelsk) will increase by as much as 80% by 2050 under a high emissions scenario.

In 2018, there was a 15% increase in heat-related deaths compared to the 2000 to 2004 baseline, down from a 31% increase in 2014. Incidences of heatwaves are also increasing in the country, and 11,000 excess deaths from non-accidental causes have been attributed to the 2010 heatwaves.

Heat-related mortality

% change with respect to 2000-2004

IMPACTS ON LABOUR

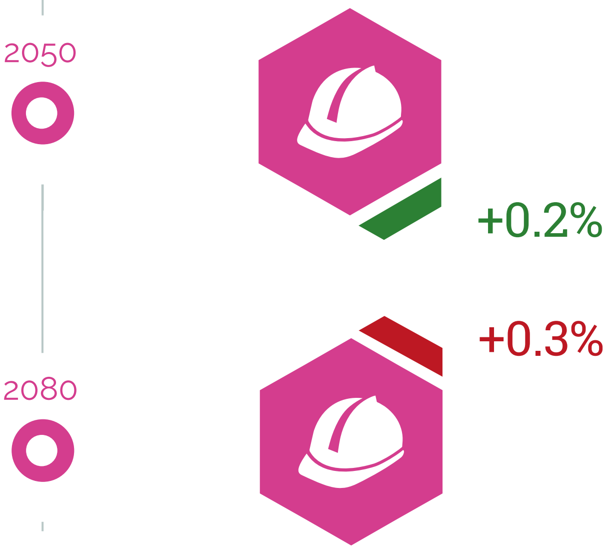
Labour is directly affected by changes in environmental conditions. Warming affects both the number of hours worked (labour supply) and on the productivity of workers during their working hours (labour productivity). Both labour supply and productivity are projected to decrease under future climate change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

Russia is one of the few countries projected to make some gains in terms of labour due to future warming. Total labour in Russia is expected to increase slightly due to future climate change: 0.2% under a low emissions scenario and 0.3% under a medium emissions scenario.

Impact on total labour

% change with respect to 1986-2005 baseline



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

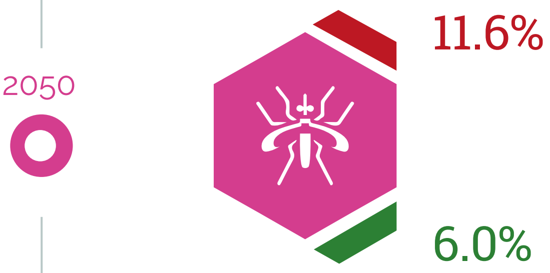
Zika virus has spread to at least 49 countries and territories since 2013. Climate change impacts on transmission suitability risk have increased over the years and future warming over 1.3 billion additional people could face suitable transmission temperatures for Zika by 2050.

CLIMATE CHANGE AND MALARIA

The distribution and occurrence of malaria is expected to increase due to climate change. This is partially due to both warming and higher parts of the country becoming habitable. 6% of the Russian population will be at risk of malaria under a low emissions scenario in 2050, whereas 11.6% will be at risk under a high emissions scenario.

Malaria suitability

% of population at risk



POLLUTION AND PREMATURE MORTALITY

Under a medium emissions scenario, annual premature deaths due to long-term exposure to near-surface ozone and heat will decrease slightly in Russia from 826 per million in 2010 to 809 per million in 2050.

RUSSIA ENERGY

ENERGY SYSTEM IN A NUTSHELL

Russia is the largest country in the world, and also home to some of the coldest inhabited places. Russia is very resource-rich (it holds the largest gas reserves). High energy needs for long-distance transport, heating, and industrial use, led to a key role of fossil fuels: oil and gas dominate the energy mix and are Russia's main exports.

The Russian strategy is to maximize the economic value of its fossil fuel endowments, while improving energy efficiency to halve energy intensity by 2030.

0.20
ktoe/US$
Energy intensity

1.5%
AC Share in electricity consumption

CLIMATE CHANGE TODAY

INCREASING TEMPERATURES

Temperatures have increased by 2°C in 2007-2016 compared to 1990-2000, roughly double the average world increase, resulting in a 15% drop in energy consumption due to lower heating needs. Cooling needs are increasing, particularly in southern regions.

HEATWAVES

Heatwaves hit Russia in 2010 and 2021 resulting in sudden surges in cooling needs. Since 2016, electricity peak demand shifted to summer. About 70% of households in the hottest or most developed regions (Krasnodar Kray, Astrakhan Oblast, and Moscow) installed air conditioning systems.

PERMAFROST THAWING

Permafrost degradation has already threatened infrastructure in 65% of the Russian territory, where 80% of natural gas extraction activities take place.

ENERGY SUPPLY

Russia's energy mix is dominated by fossil fuels (19.5% oil, 54.4% natural gas, 15.7% coal, for a total of 89.6% of total primary energy supply in 2018). Nuclear accounts for 7.1%, and renewables for 3.3%. Electricity generation relies on natural gas (57% of electricity fuel mix in 2018) and coal (19%); renewables and nuclear together hold each an 8% share. Russia is self-sufficient, and a net exporter of energy. In 2020 it ranked as the second largest world producer of natural gas (638 billion cubic metres) and oil (524 million tonnes) after the USA.

ENERGY DEMAND

Energy use is claimed by industry (42.5% of final demand in 2018, including non-energy uses accounting for 15.5% of total demand), residential (29%), transport (19.6%), followed by commercial use (7%) and agriculture and fishing (2%). Air conditioning's contribution to residential electricity demand is negligible (1.5% in 2015), while the one-off heat of 2018 brought it to 34%.

FUTURE ENERGY DEMAND

In Russia, due to the historically rigid climate of most of its territory, climate change may actually result in an improvement in living conditions and in a substantial reduction in energy demand for heating, although the frequency of heatwaves may increase in the future. Overall, heating needs will prevail, leading to an increase of about 1,000 PJ (or 277 million KWh) in 2050 under a medium emissions scenario.

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

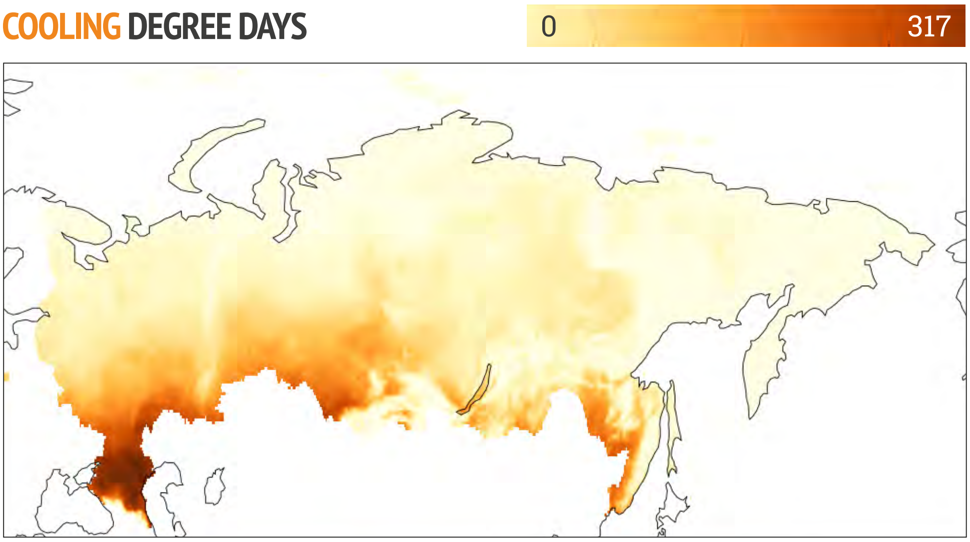
2050

-332.95

COOLING NEEDS

Strong increase in cooling needs in the central–southern areas of the country, particularly between the Black Sea and the Caspian Sea.

COOLING DEGREE DAYS



HEATING NEEDS

Substantial decreases in heating needs are expected all over the country, particularly in the northernmost areas of European Russia and Siberia.

HEATING DEGREE DAYS

FUTURE ENERGY SUPPLY

The future configuration of the Russian energy mix is likely to be determined by the evolution of energy policies and hence is outside the scope of this report. At the time of writing, Russia is focusing on maximizing the economic value of its fossil fuel resources; however it is committing to halving its energy intensity by 2030. Overall, this suggests that there will be no significant change in the nature of the vulnerabilities of the Russian energy sector in the coming decades.

Change in Hydropower generation
% of change

2050

-6.84%

-5.51%

EXPECTED IMPACTS OF CLIMATE CHANGE

Extensive damage to infrastructure from permafrost thawing as well as increasing temperatures and water scarcity may lead to a decrease in the performance of thermal plants resulting in 6 billion KWh of losses by 2050 under a medium emissions scenario. A moderate drop in hydropower potential is also expected. The opening of the Arctic transpolar route may reduce the delivering costs of fossil fuels but the route's economic viability is controversial.

RUSSIA
ECONOMY

OVERVIEW

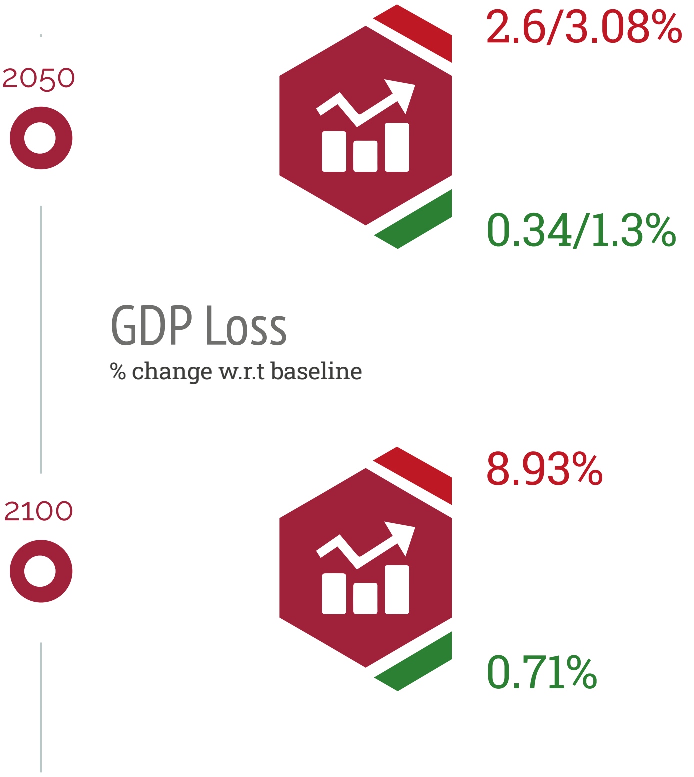
Russia ranks 13th in terms of GDP in the G20 group. The COVID 19 crisis had some impact on the economy where in 2020 real GDP declined by 3.1%. This trend has been reversed, and in 2021 real GDP has grown by 3.8%.

IMPACTS ON GDP

Estimates of the overall economic impact of climate change for Russia vary substantially according to the emissions scenarios considered, the time horizon, the direct impacts covered, and the specificities of the estimation method used.

Some studies foresee noticeable gains from climate change in the next few decades, although all studies agree that gains will turn into losses by the second half of the century.

The projected overall macroeconomic impacts for Russia range from a 6% GDP increase under a low emissions scenario in 2030, to near zero impacts on GDP in 2050, to GDP losses of almost 9% under worst case scenarios such as a high emissions scenario at the end of the century.



2050

2.6/3.08%

0.34/1.3%

GDP Loss

% change w.r.t baseline

2100

8.93%

0.71%

SECTORAL ECONOMIC IMPACTS

IMPACTS ON INDUSTRY AND INFRASTRUCTURE

The major cause of concern for Russian infrastructure is the possibility that permafrost, currently present in nearly 65% of the territory of the Russian Federation, will undergo substantial thawing in the coming decades, affecting not only the natural environment, but also any permanent human structures and hence the prospects for human activities in affected areas.

A recent study estimates, under a high emissions scenario in the 2050-2059 period, a decrease in bearing capacity of permafrost of more than 50% over the Russian regions where permafrost is present. This in turn is projected to affect from 6% to 90% of regional infrastructural endowment resulting in economic losses of 87,1 billion EUR, or 1.8% of GDP. 56,1 billion EUR in economic losses are projected by 2050.

Permafrost thawing is likely to threaten the Siberian portion of the Russian railway network, and to damage the Russian road network. It is estimated that in the period 2020-2050 19% of road infrastructure may be at risk with an associated cost ranging from 5 to 10 billion EUR. Extreme weather conditions, in particular strong winds impacting aerial cables, heavy rains, and heatwaves may pose a threat to the whole network. Transport infrastrucutre may also be threatened by sea level rise, in particular in the Sakhalin peninsula and on the Black Sea coasts.

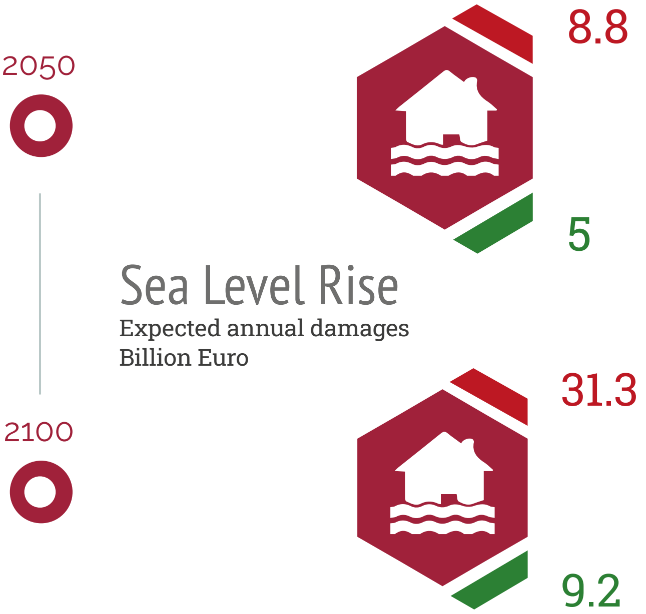
Another major consequence of climate change for transport, could be the opening of naval routes through the Arctic Sea in summer. Despite the inherent uncertainties in modelling ice patterns and dynamics in the Arctic, it appears that all routes, including the transpolar one, may become viable in summer in the second half of the century. However, factors like the riskiness of the route, fuel costs and vessel design seem to suggest that the economic attractiveness of Arctic routes is limited, at least for large container ships, while it could be viable for medium-sized tankers.

IMPACTS ON TOURISM

Before the COVID 19 crisis, Russia ranked 16th as an international destination, with 24.6 million visits in 2018. The direct impact of climate change can increase the attractiveness of Russian destinations, as the traditional harsh cold climate is expected to become milder. Hence, more and more Russian destinations could offer increasingly comfortable climatic conditions for tourist activities for a longer fraction of the year. However, this positive outlook may be dampened or even overturned by the increased incidence of extreme events such as heatwaves and forest fires.

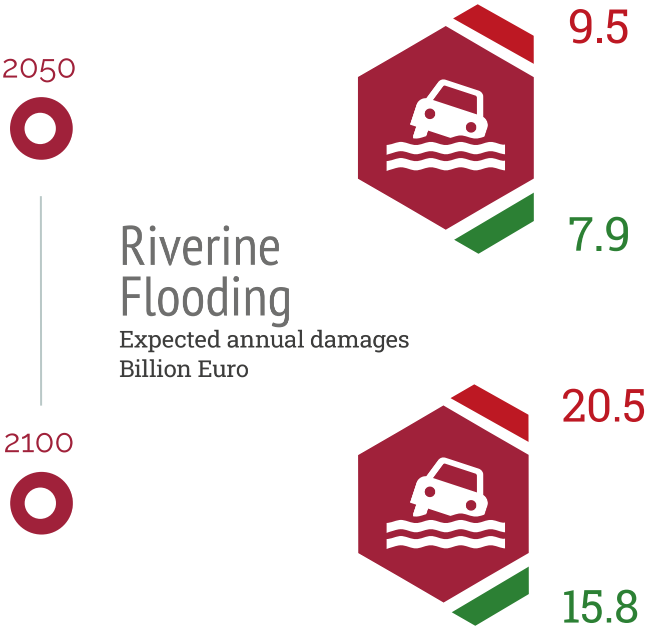
SEA LEVEL RISE DAMAGES

If coastal defenses are not upgraded to contrast increasing climate change risk, expected annual damage to coastal infrastructure is projected to be between 5 and 8.8 billion EUR in 2050 and from 9.2 to 31.3 billion EUR in 2070 under low and high emissions scenarios, respectively.



RIVER FLOODING DAMAGES

Increase in frequency and intensity of extreme weather events can generate relevant economic losses associated to riverine floods. Expected annual damages range from 7.9 to 9.5 billion EUR in 2050 and from 15.8 to 20.5 billion EUR in 2070 under low and high emissions scenarios, respectively.



IMPACTS ON AGRICULTURE

Russia is the largest country in the world with over 17 million square kilometres. It features a great variety of climates, ecosystems, crops and agricultural and silvicultural districts. Consequently, the expected impact of climate change can vary considerably across its territory.

Some studies suggest that the climate of the northern parts of Russia may become more favourable to crop production, particularly in the earlier decades of this century and under moderate climate change scenarios.

Nonetheless, the overall outlook by the end of the century for the whole country entails projected losses overtaking gains, leading to an aggregate decrease in production for higher temperature increases. For instance, wheat yields could increase by 6.7% by 2050 and 2.6% by 2100 under a low emissions scenario; however, under medium and high emissions scenarios, yield is expected to drop by 18%, 8% and 26% by mid century and by 31%, 26% and 55.4% by the end of the century, respectivley.

IMPACTS ON ENERGY

As with all other economic sectors, energy supply and energy networks in Russia will undergo more intense stress from climate-related factors, in particular permafrost thawing, floods and forest fires.

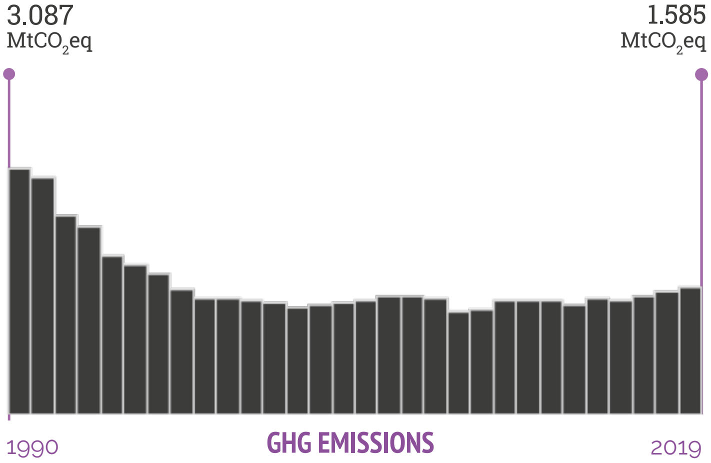
Economic impacts of shifts in household and firm energy demand (see chapter on energy) are difficult to predict and will mostly lead to redistribution effects. In the case of Russia, the magnitude of the increase in demand for cooling is much lower than the decrease in heating demand, hence significant savings on energy bills may result.

There is a lack of specific, comprehensive projections of the economic costs of all relevant climate change impacts on the Russian energy supply infrastructure. However the above-mentioned studies on the economic consequences of permafrost thawing provide an upper bound of damages to energy infrastructure, which are in any case the most relevant ones in the affected areas.

RUSSIA
POLICY

OVERVIEW

Russia is the world's largest country, with a population density of 8.4 people per square kilometre. It accounts for 5.5% of global emissions and has a high rate of GHG emissions per capita.



GHG EMISSIONS

INTERNATIONAL COMMITMENTS

The Russian Federation submitted its 2020 NDC pledging to limit GHG emissions to 70% relative to 1990 levels by 2030, or an emissions reduction target of 30%, taking into account the maximum possible absorptive capacity of forests.

CLIMATE POLICY COMMITMENTS CHRONOLOGY

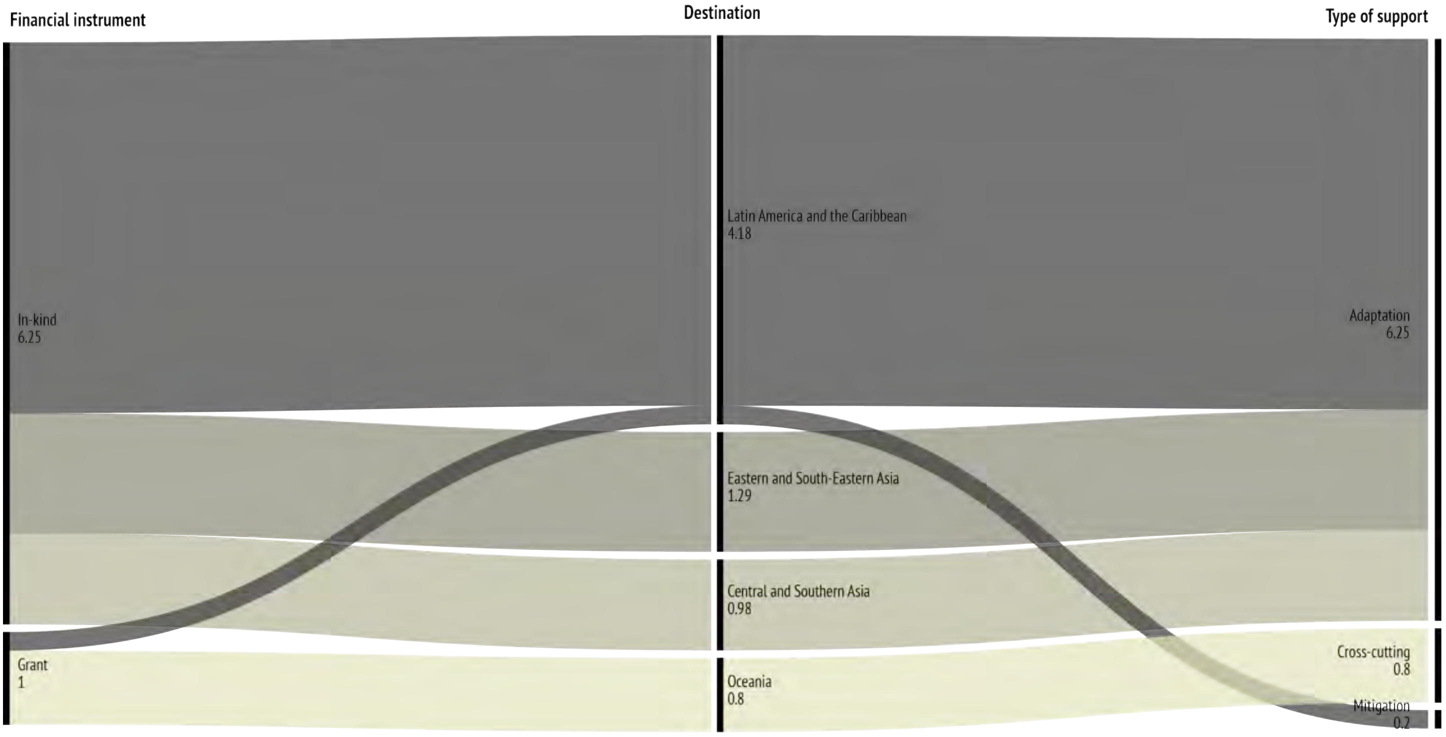
2002 — **KYOTO PROTOCOL - 1ST PERIOD**
No increase in GHG over the four year period 2008-2012, with respect to 1990 levels

2015 — **PARIS AGREEMENT - 1ST NDC**
25%-30% GHG reduction by 2030, with respect to 1990 levels

2020 — **PARIS AGREEMENT - NDC UPDATE**
30% GHG reduction by 2030, with respect to 1990 levels

INTERNATIONAL CLIMATE FINANCE ASSISTANCE

In the 4th Biennial Report, Russia reported 7 million USD for climate action in 2017-2018. The majority of these funds are in-kind contribution for climate-related disaster early response. Latin America and Central/Southern Asia are the main areas of operation.



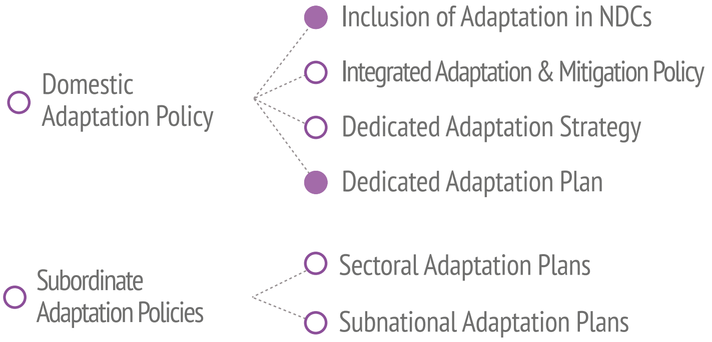
SUSTAINABLE RECOVERY POLICY

According to the Global Recovery Observatory, there was no green spending out of total recovery spending in 2020.

40.76 billion $	0.77 billion $	0 billion $
Total Spending	Recovery Spending	Green Spending

DOMESTIC ADAPTATION POLICY

In 2019 the Russian government approved a National Adaptation Plan for Climate Change which includes a first set of economic and social measures to be implemented by federal and regional authorities.



- ○ Domestic Adaptation Policy
  - ● Inclusion of Adaptation in NDCs
  - ○ Integrated Adaptation & Mitigation Policy
  - ○ Dedicated Adaptation Strategy
  - ● Dedicated Adaptation Plan
- ○ Subordinate Adaptation Policies
  - ○ Sectoral Adaptation Plans
  - ○ Subnational Adaptation Plans

○ Policy not in place ● Active policy

ADAPTATION POLICY HIGHLIGHTS

TRANSNATIONAL INITIATIVES

Climate Box

For five years UNDP has been working with young people in Eastern Europe and Central Asia to educate and empower them to take climate action

Northwest Pacific Region Action Plan (NOWPAP)

NOWPAP's main goal is to protect and sustainably manage the coastal and marine environment in the Northwest Pacific between Russia, China, Japan and South Korea

NATIONAL INITIATIVES

National Action Plan

The plan defines socio-economic measures for sub-national authorities to reduce the vulnerability of the population, the economy and natural sites to the impacts of climate change, and the seizing of the opportunities arising from such changes

National project ECOLOGY

ECOLOGY aims at restoring and protecting natural environments. In particular, the project allocates $ 2.11 billion in 2019-2024 for the preservation and restauration of forests as a way to adapt to climate change adverse effects

SUBNATIONAL INITIATIVES

Integrated Climate Change Strategies for Sustainable Development of the Russian Arctic Regions

The project assessed climate impacts in Murmansk oblast and provided recommendations to decision-makers, businesses, and the broad public

St. Petersburg's Action Plan for Climate Change Adaptation

The Plan develops a set of adaptation measures and integrates climate risks into the existing risk prevention system to protect St. Petersburg's area against dangerous weather and climate events

ENERGY TRANSITION

Russia's status as a major global oil and gas producer affects the Energy Transition performance of the country, which has not yet undertaken a structured process of transformation of its energy sector, as demonstrated by its position at the bottom of the Energy Transition indicator. In particular, this position is mainly due to poor performance in the Fossil Fuels domain, not only determined by the huge reserves available in the country, but also by the huge value of fossil subsidies in terms of GDP, as well as by their great contribution to the overall energy mix. This fact is confirmed by poor performances in the Renewables domain, a sector in which the country is moving its first steps towards greater penetration of wind power. When it comes to Emissions and Efficiency, Russia appears in the lowest part of the ranking, but it is quite close to the average of the G20 countries, while looking at the Electrification composite. Overall the country occupies a central part in the ranking, slightly above the G20 average.

G20 AVERAGE
COUNTRY

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.