Translation from Lithuanian

Lithuanian
Hydrometeorological
Service

Study on climate change risks by the middle of the 21st century

Prepared by: Climate and Research Division of the Lithuanian Hydrometeorological Service

Vilnius

2023

Subject of the Agreement:

In accordance with the provisions of the Agreement, the Service Provider undertakes to provide the following services to the Client: to prepare a report in which, based on different research reports and scientific publications on future climate change forecasts, the potential risks of climate change to Lithuania in the next 30–40 years are assessed.

The analysis was ordered by:
Association of Lithuanian Banks

The analysis was carried out by:
Climate and Research Division
of the Lithuanian Hydrometeorological Service under the Ministry of Environment

TABLE OF CONTENTS

Introduction 4
Methodology 5
1. Floods 10
2. Droughts 13
3. Forest fires 16
4. Precipitation (extreme precipitation) 19
5. Frost 25
6. Heat 28
7. Strong winds 31
8. Sea level rise 35
Summary 37
REFERENCES 39

Introduction

Ongoing global climate change is causing changing risks of various meteorological and hydrological phenomena to different economic and social sectors. These conditions both have changed in the past and will change in the future. In foreseeing future climate conditions, perhaps the most important of which are high-impact climate extremes, a variety of actions on adaptation to climate change can apply. Whereas adaptation to climate change may depend on a specific economic sector and an impact on it.

In order to predict how the climate will change in the future, various research studies are conducted based on regional realisations of different global climate models and climate change scenarios. Representative Concentration Pathways (RCP) scenarios linked to possible human socio-economic behaviour until the end of the 21st century are most frequently used to assess climate change.

The aim of this study is to comprehensively assess the potential change in extreme climate indicators by the middle of the 21st century. No specific climate change forecasts are made in this study, while the available scientific researches and studies are analysed, as agreed with the Client. Therefore, this study was carried out by evaluating and reviewing information about climate indicators posing risk referring to already conducted and available scientific researches and databases, where the change in indicators until the middle of the century is analysed, and the analysed territory includes Lithuania. Greater attention has been given to the analysis of the two most frequently used climate change scenarios (RCP4.5 and RCP8.5); however, in the absence of data, other scenarios have been also considered.

Methodology

This study assesses the following climate change risks: floods, droughts, forest fires, precipitation, frost, heat, wind, and sea level rise. Each risk indicator is presented in a separate section that assesses current and future (over the next 30–40 years) climate conditions. The current climate conditions in Lithuania are assessed based on the data measured within the network of Lithuanian hydrometeorological stations. Current climate conditions are defined as the 1991–2020 average or the 1991–2020 Climatological Standard Normal (hereinafter, the 1991–2020 CLINO). Data from 18 meteorological stations are used in total. Each of the 18 meteorological stations, depending on the municipality in which it is located, is assigned to the relevant administrative unit of Lithuania – the county. Table 1 shows the list of meteorological stations assigned to the counties.

Table 1. Counties and meteorological stations, which data was used to assess the current climate conditions in Lithuania for the 1991–2020 period.

County	**Meteorological stations**
Alytus	Lazdijai, Varėna
Kaunas	Kaunas, Dotnuva, Raseiniai
Klaipėda	Klaipėda, Nida, Šilutė
Marijampolė	Kybartai
Panevėžys	Panevėžys, Biržai
Šiauliai	Šiauliai
Tauragė	Laukuva
Telšiai	Telšiai
Utena	Utena, Dūkštas
Vilnius	Vilnius, Ukmergė

Determining risk levels for current climate conditions was based on the criteria of **dangerous** (according to the *Indicators of Dangerous Meteorological Phenomena, approved by Order No. V-80 of the Director of the Lithuanian Hydrometeorological Service of 25 November 2020*), **elemental** and **catastrophic** (according to *Order No. D1-870 of the Minister of Environment of 11 November 2011 on the approval of indicators of elemental, catastrophic meteorological and hydrological phenomena (the 9 June 2020 version of Order No. D1-344 of the Minister of Environment of the Republic of Lithuania*)) indicators or other studies that assessed the dangerousness of a certain indicator and the expert insights of the authors.

For each risk indicator, a possible future change in risk based on available scientific researches is discussed under at least two climate change scenarios for the middle of the 21st century. The level of future risk is assessed taking into account the risk posed by current climate conditions, i.e. whether the risk will increase, decrease or remain the same.

The 1991–2020 CLINO, which is currently used to assess conventional climate conditions, will be used until 2030. For this reason, when assessing the expected climate risks in the 2023–2030 period, current climate conditions are taken as a basis, i.e. the risk of meteorological events in the 2023–2030 period is regarded as the risks identified according to the 1991–2020 CLINO, without dividing into scenarios due to the short forecast period.

Where possible, the risk is distinguished by Lithuanian regions or counties. We would like to point out that the data necessary for this research (scientific publications, reports) about changes in the analysed indicators up to the middle of the 21st century under at least two scenarios is not extensive. Researches of this kind usually cover relatively large territories—on a European or global scale, thus Lithuania is reflected as a single point without differences in changes by regions. There have been problems in distinguishing the indicators, as different studies use different definitions of the indicator when forecasting the future. For example, the risk of frost can be assessed by changes in the minimum air temperature or by changes in the number of days when the air temperature is below zero. Therefore, it may be difficult to make a comparison between the studies. The analysis is also complicated by the different future forecast period. Many previous studies have been dismissed simply because they analysed the end of the century, whereas this study focuses on the middle of the century.

RCP scenarios.

In various studies, currently, different RCP (Representative Concentration Pathway) scenarios are mostly used for climate change forecasts until the end of the 21st century.

RCP scenarios are created depending on scenarios of possible human development. It is foreseen that a particular development of humanity would determine different climate change scenarios. The most important factors of human development, according to which RCP scenarios are created, are: how the human population will grow, what demographic processes will dominate, what type of fuel—polluting (fossil fuel) or non-polluting (renewable energy)—will prevail, how greenhouse gas emissions will change, how forest areas will change, what measures the states will take to reduce pollution, etc.

The main RCP scenarios used in the research are RCP2.6, RCP4.5, RCP6.0 and RCP8.5, where the number shows how the Earth's heat balance will change due to greenhouse gas concentrations in the atmosphere (i.e. the impact of greenhouse gas emissions is expressed in W/m^2). The two scenarios (RCP4.5 and RCP8.5) most relevant to this study are discussed below, as well as one additional—the mildest scenario (RCP2.6); although it should be noted that the RCP2.6 scenario is unlikely given the current rapid climate change trends.

RCP2.6 is the most optimistic climate change scenario. However, this requires that states implement ambitious international measures and adhere to commitments for emissions reductions. According to this scenario, the concentration of greenhouse gases in the atmosphere should peak in 2030, then it would start to decrease or at least stop increasing and around 2070, there would be no more emissions in the atmosphere at all. Therefore, significant reductions in current greenhouse gas emissions are necessary to achieve this level of energy impact (Keršytė et al., 2015, van Vuuren et al., 2011, klimatokaita.lt).

RCP4.5. Under the RCP4.5 scenario, energy impact (4.5 W/m^2) will stabilise by 2100 and the carbon dioxide concentration will reach ~650 ppm. In this scenario, society will widely adopt new technologies and implement various strategies to reduce emissions (Keršytė et al., 2015).

RCP8.5 is the most pessimistic scenario, according to which the global air temperature would rise the most due to the constantly increasing release of greenhouse gases into the atmosphere. This scenario is characterised by increasing greenhouse gas emissions (Keršytė et al., 2015). At the end of the century, the concentration of greenhouse gases will reach ~1,370 ppm in terms of carbon dioxide equivalent (Keršytė et al., Riahi et al., 2007, 2011). In this case, irreversible climate changes may begin on the planet, which do not bode well at all for humanity or for the Earth's ecosystems (klimatokaita.lt).

The scenarios also differ in the expected change in CO2 emissions towards the end of the 21st century (Figure 1).

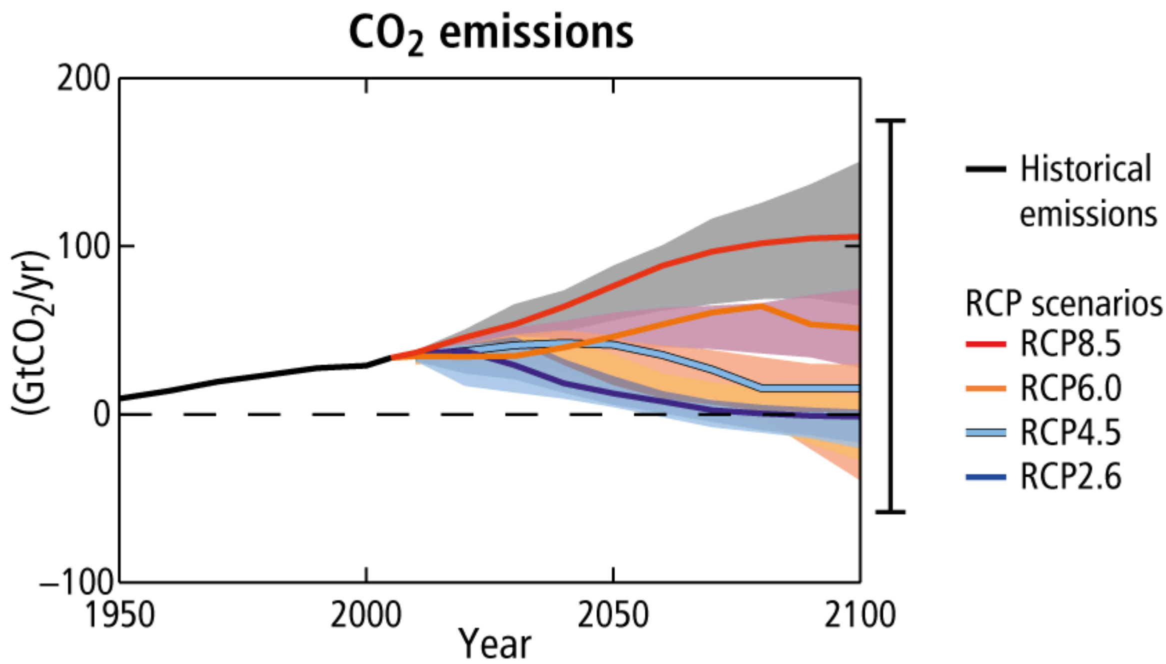

Figure 1. Projected CO2 emissions under different RCP scenarios (adapted according to IPCC, 2014).

Climate change forecasts are usually made using scenarios based on socio-economic indicators, thus the uncertainty of the forecasts lies already at the outset of the creation of the scenarios themselves. Climate change forecasts are made based on various models of global circulation and regional realisation, so uncertainties may also be related to the models used.

It is also important to note the uncertainties of this study, which has been carried out based on the results of possible climate change presented in various previous studies. As regards the above-mentioned indicators, researches on climate change for the middle of the 21st century are not abundant and more often they focus on the end of the 21st century. The methodology for calculating the assessed indicators also differs, therefore it is difficult to compare the past conditions of Lithuania and the expected changes presented in the researches. Most often, researches are conducted at the European or global level, therefore, in the context of other countries, changes in Lithuania are minimised and there is no possibility of distinguishing regional differences. In addition, the segmentation of risks into levels in this study is subjective, since risk levels are linked to the possible change in a certain indicator. However, it is not clear whether the risk levels distinguished by the change in the indicator can be directly related to the actual risk associated with the impact. The impact often depends on both the sector analysed and the sensitivity of the specific situation and environment. For example, extreme precipitation causes more damage in cities than in grasslands. For these reasons, the interpretation of mid-century changes in risks of climate change-driven indicators is limited and very general.

1. Floods

Snowmelt and accumulated water reserves in the snow are the main factors forming spring floods. If the thaw period coincides with rain, then extremely sudden, large floods occur. In spring, the size of floods is also determined by ground frost (frost of the surface layer of soil), which has not thawed after winter yet, so there is almost no infiltration and most of the surface runoff goes directly into rivers. Severe floods can occur if there is a lot of snow accumulation during the winter period and the thaw period coincides with rains. However, as winters are warming up due to climate change (winters are the season the most affected by warming), flooding is increasingly shifting to early spring or even winter.

Rivers can overflow their banks not only due to spring snowmelt but also due to intense rainfall or persistent rain. Then, due to heavy rainfall (usually during the warm season), the water level in a river rises and nearby areas can be flooded. Such a phenomenon is called a freshet. In other words, floods are mostly caused by melting snow, while freshets are caused by rain. Also, a river can flood the surrounding areas for other reasons. For example, in the city of Klaipėda, when the water level in the Danė River rises and the west-southwest wind blows for a long time, backwater from the Curonian Lagoon occurs, blocking the outflow of water in the Danė River. In Lithuania, the likelihood of recurrence of severe floods is decreasing, but the likelihood of freshets is increasing due to increasing short and heavy rainfall (especially in smaller rivers).

Current climate conditions

Currently, the lower reaches of the Nemunas River are the largest flooded areas in Lithuania during floods (Šilutė district municipality). The extent of spring floods caused by snowmelt is decreasing and the peak of a flood is decreasing and occurring earlier as a result of warming winters and fewer snow-covered days. However, in recent decades, due to intense precipitation during the warm season, river freshets, when smaller rivers suddenly flood after heavy precipitation in a short period of time, become more frequent.

Risk levels

When assessing flood and freshet risk, it should be taken into account how many residents may be affected by these phenomena. Following the study "Flood threats and risk map data update services" ordered by the Environmental Protection Agency in 2021, maps of areas inundated by floods and freshets and potentially affected population (risk to people) were updated. The probability of such floods and freshets (0.1%, 1% and 10% or once in 1000, 100 and 10 years) was taken into account when assessing the risk to population (ViaGis, 2021).

Table 1.1 shows the flood and freshet risk under current climate conditions in individual counties taking into account the aggregated risks of the three different probabilities (0.1%, 1% and 10%) and the number of potentially affected people.

However, when presenting the flood risk at the county level, the fact that the risk of floods and freshets is always present in areas near rivers should be considered. Therefore, to assess the emerging risk for individual objects, it should be done for a specific object on a case by case basis.

Table 1.1. Risk level of floods and freshets under current climate conditions (1991–2020 CLINO) and in the 2023–2030 period.

Risk level/County	N/A	Low	Moderate	High
Alytus		X		
Kaunas			X	
Klaipėda			X	
Marijampolė		X		
Panevėžys		X		
Šiauliai		X		
Tauragė		X		
Telšiai		X		
Utena		X		
Vilnius		X		

Forecast

It is expected that the annual air temperature will rise in the future, and the amount of precipitation will likely increase. However, the annual runoff of rivers will change little or even will decrease, although insignificantly (Stonevičius et al., 2017, Di Sante et al., 2021). However, runoff changes will differ in different seasons. Winter runoff will increase, while spring runoff will decrease; this trend is projected under both the optimistic (RCP2.6) and pessimistic (RCP8.5) climate change scenarios. However, although, under the optimistic mid-century scenario, spring floods will be smaller due to fewer snow days and less snow cover, however will remain, under the pessimistic climate change scenario, spring floods will almost disappear due to a significant decrease in snow cover in winter (Stonevičius et al., 2017).

V. Akstinas has analysed river floods and freshets and their predictions for the future in his doctoral thesis "Assessment of floods of rivers of Lithuania and their risk in the context of climate change". Three rivers representing different hydrological districts have been analysed.

Projections for the future are based on RCP2.6, RCP4.5 and RCP8.5 climate change scenarios for the near period (2016–2035) and for the far period (2081–2100). The findings show that in predicting maximum flow rates according to different RCP climate change scenarios, a decrease in spring floods and their size is expected. Seasonal redistribution of floods is also predicted, where part of spring floods will occur in winter. Although decreasing trends in floods and maximum flow rates are expected, it is noted that in individual years there is a rare possibility that the maximum flow rate of extreme floods will increase. According to the freshet forecasts for summer and autumn seasons, an increase in the average maximum flow rate is expected (i.e. larger freshets) and a likelihood of extreme freshets will increase (Akstinas, 2019).

Table 1.2. Risk level of floods under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	**N/A**		**Low**		**Moderate**		**High**	
	RCP4.5	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**
Alytus			X	X				
Kaunas					X	X		
Klaipėda					X	X		
Marijampolė			X	X				
Panevėžys			X	X				
Šiauliai			X	X				
Tauragė			X	X				
Telšiai			X	X				
Utena			X	X				
Vilnius			X	X				

Taking the results of researches by different authors into account, given the fact that a decrease in the annual and spring runoff of rivers and the size of floods are predicted with increasing frequency of freshets and their size, the risk of floods in the 2031–2060 period will remain the same as under current climate conditions (Table 1.2). An unchanged flood risk for the next 30 to 40 years, compared to current conditions, is also presented by other authors (Lung et al., 2012).

2. Droughts

Currently, in Lithuania a drought as a dangerous or elemental meteorological phenomenon is identified according to the temperature and precipitation index (TPI). According to this index, a drought can be registered only during the growing season of plants.

Current climate conditions

According to the CPI index, during the 1991–2020 period (within 30 years), individual meteorological stations in Lithuania recorded an average of 7.3 years with elemental droughts (24% recurrence). Droughts were more frequent in western Lithuania (Nida – 10 years with a drought or every three years), and less frequent in the south-eastern part of Lithuania (Vilnius – 4 years with a drought or every seven years).

Due to climate change, the number of droughts in Lithuania has increased. Until 1992 droughts were quite rare in Lithuania. The severest droughts which caused the most losses were observed in recent decades.

Also, as the annual air temperature rises, the growing season of plants extends as well. At the same time, the period during which an elemental or dangerous drought can develop is also increasing.

Risk levels

Despite the fact that the elemental meteorological phenomenon *drought during the growing season of plants* is intended to identify agricultural droughts, the level of water bodies may decrease, and the risk of fires may increase during droughts. However, elemental droughts in Lithuania cause the greatest damage and losses to agriculture.

Account should also be taken of the fact that summer droughts lead not only to low humidity but also to higher than usual air temperature. Droughts can be recorded not only as an elemental phenomenon but also as a dangerous meteorological phenomenon. In addition, droughts can cover small enough territories, for example, just one or a few sub-districts.

However, we can also draw attention to the fact that the period of occurrence of droughts is also important. Droughts are much more dangerous for agriculture in spring and early summer than in the second half of summer or autumn. Droughts in our region do not last the entire growing season and in most cases lead to a reduction in yield but not to its complete loss.

Table 2.1 shows the average assignment of droughts to a given risk level. The risk level has been broken down according to the current climate conditions of Lithuania (1991–2020 CLINO), taking into account the number of previous droughts in the 1991–2020 period.

Table 2.1. Risk level of elemental droughts by their number in 1991–2020.

Risk level/criterion	N/A	Low	Moderate	High
Drought	0	1–5	5–14	>15

In Lithuania, elemental droughts are more frequent in western and central Lithuania than in south-eastern or eastern Lithuania. Despite the different frequency of recurrence of droughts, all counties of Lithuania are at the level of moderate risk.

Nevertheless, taking into account the increased frequency of droughts due to climate change, the risk posed by them throughout Lithuania can be assessed as moderate (Table 2.2).

Table 2.2. Risk level of elemental droughts under current climate conditions (1991–2020 CLINO) and in the 2023–2030 period.

Risk level/County	N/A	Low	Moderate	High
Alytus			X	
Kaunas			X	
Klaipėda			X	
Marijampolė			X	
Panevėžys			X	
Šiauliai			X	
Tauragė			X	
Telšiai			X	
Utena			X	
Vilnius			X	

Forecast

Such phenomena as droughts often occur due to several complex reasons—lack of precipitation and high air temperatures. Droughts can be identified and assessed using different indices and methods; however, these indices are usually calculated using precipitation and air temperature data. This study does not make specific forecasts, and reviews changes in drought risks calculated by various indicators based on other scientists' research, therefore there is no possibility of assessing how droughts will change according to the drought index TPI used in Lithuania.

It is expected that the number of drought events will increase in all counties of Lithuania in the future. However, the possible change is not large and of little significance—up to 1 event more than usual within 30 years (EEA, 2021a; EEA, 2020). Such changes are projected under both RCP4.5 and RCP8.5 scenarios, and the potential drought risk remains moderate (Table 2.3), as it is under current conditions.

Due to the rising air temperature and the changing amount of precipitation in Lithuania, it is not entirely clear how the risk of droughts will change in the future. The fact that in the future air temperatures will continue to rise and precipitation will increase, albeit modestly, may reflect an increased risk of droughts. If precipitation does not increase enough to counterbalance the increase in air temperature, then the risk of droughts can increase by more than one event in 30 years.

Table 2.3. Expected risk level of recurrence of droughts under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	N/A		Low		Moderate		High	
	RCP4.5	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**
Alytus					X	X		
Kaunas					X	X		
Klaipėda					X	X		
Marijampolė					X	X		
Panevėžys					X	X		
Šiauliai					X	X		
Tauragė					X	X		
Telšiai					X	X		
Utena					X	X		
Vilnius					X	X		

On the other hand, the impact of a phenomenon like drought tends to be sector-specific. Most often, the impact of a drought is linked to the impact on the agricultural sector, for which the timing of drought recurrence is also important. For example, plants may be more sensitive to spring droughts than late summer or fall droughts. However, the analysis of references has not disclosed any possible seasonal change in droughts.

3. Forest fires

On average, 200 to 1600 forest fires break out in Lithuania per year.

The risk of forest fires is assessed according to 5 fire danger classes—the higher the class, the greater the risk of forest fires. The fifth class is also defined as a drought in forests and is considered an elemental meteorological phenomenon, and the fourth class is identified as a dry period in forests and is considered a dangerous meteorological phenomenon.

Current climate conditions

A drought in forests, as an elemental meteorological phenomenon, is registered by individual meteorological stations on average once every 5 years. The highest (fifth) forest fire danger class is more common in the central and eastern parts of Lithuania, and less common in the western part.

Risk levels

Table 3.1 presents the risk level of forest fires, taking into account the prevalence of the fifth forest fire danger class, i.e. the number of years during the 1991–2020 period when a certain meteorological station registered fire danger class 5.

Table 3.1. Risk level of forest fires by the number of years in the 1991–2020 period, when fire danger class 5 was recorded.

Risk level/criterion	N/A	Low	Moderate	High
1.3 Forest fires	0	1–9 years	10–15 years	>15 years

When assessing the risk of forest fires, it should also be taken into account that the potential danger of a forest fire determined by the prevailing meteorological conditions is assessed, and not the fact of the fire itself. The most common cause of fires is human activity. In the case of the highest fire danger class, restrictions prohibiting people from visiting forests or limiting their visits are introduced. Other risk management measures are also applied, such as increased watch, surveillance and vigilance to respond to a fire as quickly as possible and prevent it from spreading.

The fifth forest fire danger class is more common in central and north-eastern Lithuania, although forest areas in the respective part of the state are not large and deciduous forests prevail. Taking into account the above and the fact that the nature of our forests differs from that in those parts of the world where there are large and hard-to-reach forest areas, the risk of forest fires in Lithuania in all counties could be considered low (Table 3.2). The prevailing species composition of trees should also be taken into account—fires start and spread faster in coniferous forests than in deciduous forests.

Table 3.2. Risk level of forest fires under current climate conditions (1991–2020 CLINO) and in the 2023–2030 period

Risk level/County	N/A	Low	Moderate	High
Alytus		X		
Kaunas		X		
Klaipėda		X		
Marijampolė		X		
Panevėžys		X		
Šiauliai		X		
Tauragė		X		
Telšiai		X		
Utena		X		
Vilnius		X		

Forecast

Based on various conducted studies, it is predicted that the risk of forest fires should not change (Table 3.3). The risk of forest fires is related to the flammability of forests. Flammability, like droughts, is related to a complex of reasons—lack of precipitation and high air temperatures. Also, forest fires are related to specific forest characteristics, which is why the already poorly defined assessment of a future change becomes complicated due to the unclear use of forests and changes in forest species composition.

Table 3.3. Expected risk level of recurrence of forest fires under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	N/A		Low		Moderate		High	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Alytus			X	X				
Kaunas			X	X				
Klaipėda			X	X				
Marijampolė			X	X				
Panevėžys			X	X				
Šiauliai			X	X				
Tauragė			X	X				
Telšiai			X	X				
Utena			X	X				
Vilnius			X	X				

Forest fire danger is assessed by various indices, and there are not many studies on how any index will change in Lithuania in the future due to climate change. Most of the found literature sources state that the risk of forest fires in Lithuania both in the 2021–2040 and by the middle of the century (2041–2060) will change insignificantly (CDS, 2020; EC and EEA, 2022a) and may even decrease by the end of the century (EEA, 2020). No significant possible change between the different scenarios has been distinguished either, therefore the potential risk of forest fires in the future in all counties of Lithuania for the next 30 to 40 years can be assessed as low (Table 3.3)

The risk of forest fires in the future may change depending on changes in air temperatures and precipitation, therefore, as with the assessment of changes in the risk of droughts, it is quite difficult to predict possible changes in such complex phenomena.

4. Precipitation (extreme precipitation)

Both short, but very abundant (torrential downpour), and long-lasting precipitation can be dangerous. Precipitation of different phases can be dangerous: liquid (rain), mixed (sleet), solid (snow). However, the criteria of a dangerous, elemental or catastrophic phenomenon are usually applied to liquid precipitation (rain). All criteria of precipitation as a dangerous, elemental and catastrophic phenomenon are presented in Table 4.1. Days are regarded as days of heavy precipitation where daily precipitation is 10 mm, 20 mm or 30 mm.

Table 4.1. Criteria for dangerous, elemental and catastrophic rain.

Indicators		
Measurement unit		Rating, amount, critical limit
Dangerous meteorological phenomenon		
Heavy rain, mixed precipitation	rainfall (mm); duration (h.)	≥15–<50; ≤12
Long-lasting heavy rain	rainfall within 5 days or less exceeds the monthly climatological standard normal (by times)	1–1.9
Heavy snowfall	snowfall (mm); duration (h.)	≥7–<20; ≤12
Elemental meteorological phenomenon		
Extremely heavy rain	rainfall (mm); duration (h.)	50–80; ≤12
Long-lasting extremely heavy rain	rainfall within 5 days or less exceeds the monthly climatological standard normal (by times)	2–3
Extremely heavy snowfall	snowfall (mm); snow cover increase (cm); duration (h.)	20–30; 20–30; ≤12
Long rainy period	period; beginning: the day on which the rainfall in the preceding 60 days exceeds the multi-annual (1971–2020 period) average rainfall (standard deviation) for the same period; end: the phenomenon criterion for 30 consecutive days is lower than the multi-annual rainfall average (standard deviation) for the same period	1 May – 31 October; ≥2.8; <2.8
Catastrophic meteorological phenomenon		
Extremely heavy rain	rainfall (mm); duration (h.)	>80; ≤12
Long-lasting extremely heavy rain	rainfall within 5 days or less exceeds the monthly climatological standard normal (by times)	>3
Extremely heavy snowfall	snowfall (mm); snow cover increase (cm); duration (h.)	>30; >30; ≤12

Current climate conditions

In Lithuania, on average per year (1991–2020 CLINO), there are 16 days when daily precipitation exceeds 10 mm. More such days were recorded in the western part of Lithuania, and fewer in central and eastern Lithuania. The average number of days with more than 20 mm of precipitation per year is 3.4 days and varies from 2.4 days (in Panevėžys) to 4.7 days (in Telšiai) per year. Days with more than 30 mm of precipitation per day are quite rare. On average, only 1 such day per year occurs in Lithuania.

Elemental precipitation is recorded by individual meteorological stations on average once every 11-12 years. Such precipitation is more common in central Lithuania and in the Samogitian Highlands (once in 7–8 years), and less common in eastern and south-eastern Lithuania (once in 15 years). Dangerous or elemental rains are recorded every year in one or another part of Lithuania. However, these are rather approximate statistics. It is also necessary to draw attention to the fact that very heavy (extraordinary) precipitation is almost always very local and may simply not be registered by the meteorological stations, although a very large amount of precipitation fell near the station.

Damage can be caused by both torrential downpours and continuing precipitation. Long-lasting precipitation is recorded by individual meteorological stations 2 to 5 times in 30 years or once in 6–15 years. Precipitation risk based on the number of events of heavy precipitation, elemental rain, and a long rainy period per year is presented in Table 4.2.

Table 4.2. Assignment of the average number of days/events of precipitation posing risk per year (1991–2020 CLINO) to a given risk level.

Risk level/criterion	N/A	Low	Moderate	High
Precipitation >10 mm per day	0	0.1–15	15–30	>30
Precipitation >20 mm per day	0	0.1–3	3.1–8	>8
Precipitation >30 mm per day	0	0.1–0.9	1–2	>2
Precipitation >50 mm per 12	0	1–2 per 30 years	3–9 per 30 years	>10 per 30 years
Long-lasting rain	0	1–2 per 30 years	3–9 per 30 years	>10 per 30 years

Dangerous and elemental precipitation is one of the most frequently recorded dangerous, elemental, catastrophic meteorological phenomena. Due to climate change, heavy precipitation is becoming more frequent in Lithuania. Not all heavy precipitation is recorded by meteorological stations.

Precipitation risk under current climate conditions is presented in Table 4.3 and ranges from low to moderate.

Table 4.3. Risk level of rain under current climate conditions (1991–2020 CLINO)

Risk level/County	N/A	Low	Moderate	High
Alytus	10 mm		14.5–16.2	
	20 mm		3.5–3.8	
	30 mm		1.1–1.3	
	>50 per 12 hours		2–6	
	Long rainy period		2–5	
Kaunas	10 mm		11.8–15.5	
	20 mm		2.7–3.2	
	30 mm		0.8–1	
	>50 per 12 hours		1–5	
	Long rainy period		2–4	
Klaipėda	10 mm		19.4–20.7	
	20 mm		3.6–4.3	
	30 mm		0.9–1.5	
	>50 per 12 hours		2–4	
	Long rainy period		3–5	
Marijampolė	10 mm	13.6		
	20 mm	2.7		
	30 mm	0.7		
	>50 per 12 hours			
	Long rainy period	2	3	
Panevėžys	10 mm	13.4–14.5		
	20 mm	2.4–3.0		
	30 mm	0.7–0.9		
	>50 per 12 hours		4	
	Long rainy period		4	
Šiauliai	10 mm	12.8		
	20 mm	3.0		
	30 mm		1.0	
	>50 per 12 hours		3	
	Long rainy period	2		
Tauragė	10 mm		21.5	
	20 mm		4.5	
	30 mm		1.2	
	>50 per 12 hours		3	
	Long rainy period	2		
Telšiai	10 mm		22.0	
	20 mm		4.7	
	30 mm		1.2	
	>50 per 12 hours		4	
	Long rainy period		3	
Utena	10 mm			
	20 mm	13.4–15.6		
	30 mm	2.7–3.3	0.8–1.1	
	>50 per 12 hours		2–3	
	Long rainy period		2–3	
Vilnius	10 mm		14.8–15.2	
	20 mm		3.2–3.4	
	30 mm		0.8–1.1	
	>50 per 12 hours		2–6	
	Long rainy period	2–3		

Table 4.4 provides a summary of precipitation risks based on different criteria for heavy and dangerous rain.

In Marijampolė and Šiauliai counties, the risk posed by precipitation is somewhat lower than in other counties of Lithuania. However, given the increased frequency of intense precipitation due to climate change, which is often very local and is not recorded by meteorological stations, the risk of precipitation throughout Lithuania can be assessed as moderate (Table 4.4).

Table 4.4. Aggregated risk level of dangerous rain under current climate conditions (1991–2020 CLINO) and in the 2023–2030 period

Risk level/County	N/A	Low	Moderate	High
Alytus			X	
Kaunas			X	
Klaipėda			X	
Marijampolė			X	
Panevėžys			X	
Šiauliai			X	
Tauragė			X	
Telšiai			X	
Utena			X	
Vilnius			X	

Forecast

The projections of the annual amount of precipitation in the territory of Lithuania until the middle of the 21st century under different RCP scenarios differ very little. Differences show up in a subsequent period when larger changes under RCP8.5 and stabilisation under RCP2.6 are projected. The projected changes in annual precipitation under RCP4.5 and RCP6.0 are almost identical (Studijos nustatančios..., 2015). Average annual precipitation should grow by 3.7–13.5% by the end of the 21st century (by 1.6–4.0% by 2035). The largest increase in precipitation (15–27%) is forecast in October–April. In July–September, the amount of precipitation will decrease, most in the southeast of the country, and least in the western part (Studijos nustatančios..., 2015).

Global climate change will inevitably affect precipitation extremes. It is projected that the number of heavy precipitation events should increase in all seasons in Northern and Central Europe, while trends for Southern Europe vary by season and location (Beniston et al., 2007; Kovats et al., 2014). Rising air temperatures can hold more moisture, so along with the projected rise in air temperature, an increase in the occurrence and magnitude of extreme precipitation events is also expected (La[en]derink, van Meijgaard, 2010).

The conducted studies show that in Europe and its northern part, which also includes Lithuania, the number of extreme precipitation events will increase both under RCP4.5 and RCP8.5 climate change scenarios (Rajezak J. Schar C. 2017). An increase in the number of extreme precipitation events is also expected in the Baltic Sea region (Christensen at al., 2022). The maximum amount of precipitation falling in five consecutive days will also increase in the coming decades. This increase is projected to be greater under the RCP8.5 climate change scenario than under RCP4.5 or RCP2.6 (EEA, 2021b).

In the future, the annual maximum daily precipitation in Lithuania will increase. Only north-eastern Lithuania stands out: based on the results of model calculations, under the RCP2.6 scenario, the annual maximum daily precipitation in this part of Lithuania in 2016–2035 should slightly decrease, and in the rest of Lithuania it will increase by 1.9–4.6% according to all scenarios (Studijos nustatančios..., 2015).

By the end of the century, daily precipitation maximums will grow more rapidly and may increase by as much as 17.4% in the central part of the country under the RCP8.5 scenario (Kilpys et al., 2017). Thus, it is expected that the number of heavy precipitation events and their share in the total amount of precipitation will increase, the number of days per year with $\geq$10 mm of precipitation per day will increase, and the annual maximum daily precipitation will increase (Studijos nustatančios..., 2015).

Table 4.5. Expected risk level of dangerous precipitation under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	**N/A**		**Low**		**Moderate**		**High**	
	RCP4.5	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**
Alytus					X	X		
Kaunas					X	X		
Klaipėda					X	X		
Marijampolė					X	X		
Panevėžys					X	X		
Šiauliai					X	X		
Tauragė					X	X		
Telšiai					X	X		
Utena					X	X		
Vilnius					X	X		

To sum up different studies, it is expected that the average number of days with heavy precipitation per year will increase, and the occurrence of heavy precipitation will become more frequent. However, until 2060 this change will not be so significant that the risk of precipitation in any county would increase from the current moderate to high. Therefore, in 2031–2060 the risk of precipitation can further be considered moderate in all counties (Table 4.5).

5. Frost

In Lithuania, a frost day is considered a dangerous meteorological phenomenon where the minimum daily air temperature drops to ≤-25°C, but is still higher than -30°C. When the minimum daily air temperature drops to ≤-30°C, the elemental meteorological phenomenon heavy frost is registered. If heavy frost lasts for more than three consecutive days, the catastrophic meteorological phenomenon very heavy frost is recorded.

Current climate conditions

In Lithuania, on average, there are only 0.7 severe cold days (Tmin ≤-25 °C) per year (1991–2020 average). Most often, such days occur in south-eastern Lithuania (on average, 1.6 days in Varėna) and least often in the Curonian Spit (0.1 days in Nida).

Heavy frost days are very rare in Lithuania, and there has not been a single event of very heavy frost in the last 30 years throughout Lithuania.

Risk levels

Table 5.1 shows the assignment of the average number of frost days per year to a given risk level. The risk level has been broken down according to the current climate conditions of Lithuania (1991–2020 CLINO), taking into account the average number of such days per year. In some years, the number of frost days may be higher or lower than the average number of [frost] days per year according to CLINO, however, the risk level is assessed based on the average number of such days in the 1991–2020 period rather than individual year fluctuations.

Table 5.1. Risk level of the average number of frost days per year (1991–2020 CLINO).

Risk level/criterion	**N/A**	**Low**	**Moderate**	**High**
1.5 Frost	0 day	1–5 days	5–9 days	>10 days

Due to climate change, the number of frost days in Lithuania has decreased. The probability of frost days is higher in eastern or south-eastern Lithuania than in coastal or western Lithuania. However, due to the small number of such days (which do not occur every year), the whole of Lithuania can be considered a single unit, since the average number of frost days per year does not exceed 2 days in any county or meteorological station (Table 5.2).

Table 5.2. Recurrence and risk level of frost days under current climate conditions (1991–2020 CLINO) and in the 2023–2030 period.

Risk level/County	N/A	Low	Moderate	High
Alytus		0.6–1.6 days		
Kaunas		0.4–0.6 days		
Klaipėda		0.1–0.3 days		
Marijampolė		0.8 days		
Panevėžys		0.9 days		
Šiauliai		0.7 days		
Tauragė		0.4 days		
Telšiai		0.3 days		
Utena		0.9–1.3 days		
Vilnius		0.4–1.4 days		

Forecast

The change in cold and extreme minimum air temperatures during winter will follow similar trends as in recent decades. Alongside rising average air temperatures, both the minimum (frost decreases) and the maximum (heat increases) air temperature values increase. In the future, a decrease in the number of days with negative air temperature according to both RCP4.5 and RCP8.5 is expected throughout Lithuania. However, the most significant change will be marked in those parts of Lithuania where such days happen most often–the eastern part of Lithuania and the Samogitian Highlands (on average, 20 days less per year) both in 2011–2040 and in 2041–2070 (CDS, 2022).

Table 5.3. Expected risk level of frost recurrence (extreme minimum air temperature) under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	N/A		Low		Moderate		High	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Alytus			X	X				
Kaunas			X	X				
Klaipėda			X	X				
Marijampolė			X	X				
Panevėžys			X	X				
Šiauliai			X	X				
Tauragė			X	X				
Telšiai			X	X				
Utena			X	X				
Vilnius			X	X				

Under the mildest climate change scenario, RCP2.6, the minimum winter air temperature may increase by 1–2°C by 2035, and by 2–3°C by 2050 (Price et al, 2018). Such projected frost changes in winter determine not only a predicted low risk of frost in the future, but this risk is decreasing compared to past conditions (Table 5.2).

6. Heat

In Lithuania, a *heat day* is a day where the daily maximum air temperature reaches or exceeds 30°C. Such a phenomenon is considered a dangerous meteorological phenomenon. When the daily maximum temperature reaches or exceeds 30°C for three consecutive days, the elemental meteorological phenomenon—*heat haze (heat stress)*—is recorded.

Current climate conditions

In Lithuania, on average, there are 4.2 heat days (Tmax ≥30 °C) per year (1991–2020 CLINO). Most often, such days occur in south-eastern Lithuania (6.8 days in Varėna) and least often in the Curonian Spit (1.3 days in Nida) and in the Samogitian Highlands (2.5 days in Laukuva).

In different years, the number of heat days in individual meteorological stations can vary quite significantly. For example, not a single heat day was registered in Vilnius in 1993, while in 1994 as many as 15 such days were registered.

Heat hazes do not occur in Lithuania every year, but during the longest heat waves, a period of more than 10 consecutive days of heat may occur.

In recent decades, the number of both heat days and heat hazes has increased throughout Lithuania.

Risk levels

Table 6.1 shows the assignment of the average number of heat days per year to a given risk level. The risk level has been broken down according to the current climate conditions of Lithuania (1991–2020 CLINO), taking into account the average number of such days per year. In some years, the number of heat days may be higher or lower than the average number of [heat] days per year according to CLINO, however, the risk level is assessed based on the average number of such days in the 1991–2020 period rather than individual year fluctuations.

Table 6.1. Risk level of the average number of heat days per year (1991–2020 CLINO).

Risk level/criterion	N/A	Low	Moderate	High
1.6 Heat	0 day	1–5 days	5–15 days	>15 days

Due to climate change, the number of heat days and heat hazes (waves) in Lithuania has increased. The probability of heat days and heat hazes (waves) is higher in southern or south-eastern Lithuania than on the coast or in the Samogitian Highlands.

Currently, the risk of heat days in Lithuania ranges between low and moderate. A moderate risk level is assigned to the counties in south and south-east Lithuania (Alytus, Marijampolė, Vilnius), and the remaining counties are classified as low risk (Table 6.2).

However, the account could also be taken of the fact that heat often has a greater impact on a person than on infrastructure, so the risk of this phenomenon could still be classified as low throughout Lithuania.

Table 6.2. Recurrence and risk level of heat days under current climate conditions (1991–2020 CLINO) and in the 2023–2030 period.

Risk level/County	N/A	Low	Moderate	High
Alytus			X	
Kaunas		X		
Klaipėda		X		
Marijampolė			X	
Panevėžys		X		
Šiauliai		X		
Tauragė		X		
Telšiai		X		
Utena		X		
Vilnius			X	

Forecast

Climate change causes changes, in particular, in air temperature indicators. Extreme air temperatures, which have increased in the past and will continue to increase in the future, are no exception. The indicator 'heat', like 'frost', can be assessed through several parameters. One of them is the increase in the maximum air temperature. It is predicted that the air temperature in Lithuania will rise by 1–2°C by 2035, by 1–2°C by 2050, and even more—by 2–3°C—in eastern Lithuania by 2050, even under the mildest RCP2.6 scenario, compared to current conditions (Price et al., 2018). The number of extreme temperature events is also important. In Lithuania, heat conditions are characterised by the number of days where the maximum air temperature reaches at least 30°C. Under both RCP4.5 and RCP8.5, the number of such days is projected to increase up to 5 days per year in the 2011–2040 period. Meanwhile, by 2041–2070 according to the RCP4.5 scenario, [an increase of] up to 5 days per year is expected, and 5 to 10 days in southern Lithuania, and according to the stricter RCP8.5 scenario, there should be 5 to 10 days more in central and southern Lithuania (CDS, 2022).

Table 6.3. Expected risk level of heat under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	**N/A**		**Low**		**Moderate**		**High**	
	RCP4.5	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**
Alytus					X	X		
Kaunas					X	X		
Klaipėda					X	X		
Marijampolė					X	X		
Panevėžys					X	X		
Šiauliai					X	X		
Tauragė					X	X		
Telšiai					X	X		
Utena					X	X		
Vilnius					X	X		

Based on past conditions (Table 6.2), the heat risk is likely to reach a moderate level in all counties by the middle of the 21st century.

7. Strong winds

In Lithuania, when wind speed reaches 15 m/s and more, but does not exceed 28 m/s, the dangerous meteorological phenomenon *strong winds* is recorded. When wind speed is 28–32 m/s, it is considered an elemental meteorological phenomenon (*very strong wind*), and when it reaches 33 m/s or more, it is considered a catastrophic meteorological phenomenon (*hurricane*).

Current climate conditions

In Lithuania, on average, there are 24 days per year when the maximum wind speed during a gust is ≥15 m/s. The largest number of such days is registered on the coast of Lithuania (in Klaipėda, 52 days per year), and the least number of days in eastern Lithuania (in Dūkštas, 7.3 days per year).

In most of Lithuania (except for the coastal region), an elemental or catastrophic wind speed is rarely recorded—just a few events in 60 years (1961–2020 period). In the western part of Lithuania and the coastal region, elemental wind events are more frequent: here more than 20 days of very strong winds were recorded in the 1961–2020 period. Despite the relatively small number of dangerous and elemental wind events (except for the coastal area), the damage it causes to infrastructure and various sectors of the economy can be quite considerable. It should also be noted that a complex of strong winds and other meteorological phenomena (for example, strong winds in combination with sleet (snowy rain) or freezing rain) can cause damage even without reaching the criterion of a dangerous phenomenon.

Risk levels

Table 7.1 shows the assignment of the average number of days of moderate wind per year to a given risk level. The risk level has been broken down according to the current climate conditions of Lithuania (1991–2020 CLINO), taking into account the average number of such days per year. In some years, the number of days of strong winds may be higher or lower than the average number of days [of strong winds] per year according to CLINO, however, the risk level is assessed based on the average number of such days in the 1991–2020 period rather than individual year fluctuations.

Table 7.1. Risk level of the average number of days per year, where a maximum wind speed is ≥15 m/s, ≥28 m/s (1991–2020 CLINO).

Risk level/criterion	N/A	Low	Moderate	High
Strong wind (≥15 m/s)	0	1–30	31–80	>80
Strong wind (≥28 m/s)	0	1–5	6–14	>15

With climate change, notwithstanding that the average annual wind speed does not increase, an increase in the number of stormy events with gusts of strong wind is noted. The probability of strong winds is higher on the coast of Lithuania than in the rest of Lithuania, and the lowest probability of such winds is in eastern and south-eastern Lithuania.

Currently, the risk level of strong winds in most parts of Lithuania can be assessed as low, and on the coast as moderate (Table 7.2). Table 7.2 summarises the risk level of strong winds exceeding 15 m/s and 28 m/s for individual counties under current climate conditions.

However, it should be noted that severe storms can cause major damages. Also, the wind, even if it has not reached the criterion of a dangerous phenomenon, in combination with other meteorological phenomena (e.g., sleet (snowy rain), freezing rain, etc.), can cause quite significant losses.

Table 7.2. Risk level of strong winds under current climate conditions (1991–2020 CLINO) and in the 2023-2030 period

Risk level/County	N/A	Low	Moderate	High
Alytus		X		
Kaunas		X		
Klaipėda			X	
Marijampolė		X		
Panevėžys		X		
Šiauliai		X		
Tauragė		X		
Telšiai		X		
Utena		X		
Vilnius		X		

Forecast

According to various scientific studies, future predictions of wind changes remain mixed. It is expected that by the middle of the century, according to the realistic RCP4.5 climate change scenario, the average wind speed in Lithuania will decrease by about 7–9% compared to the 1981–2010 climatological normal. The largest negative change in the average wind speed is expected in Kaunas, Marijampolė, Šiauliai, as well as in some parts of Klaipėda and Panevėžys counties—0.16–0.32 m/s on average. This decrease can be explained by changes in atmospheric circulation. Warm air masses and cold air masses move to northern and southern latitudes, respectively. The intensity of this process (in other words, the wind power) is determined by the temperature difference between different latitudes. Due to climate change, the temperature rise in northern latitudes is significantly faster than in southern latitudes. Such different trends in temperature rise lead to a decrease in wind speed (Jankevičienė et al., 2022). However, other research articles report an unchanged or slightly increasing average wind speed and wind power density (Carvalho et al., 2017). In summary, by 2050, in general, the average wind speed in Lithuania will change slightly, and a decreasing trend is most likely.

The uncertainty is even greater in assessing changes in extreme wind speeds. Scientific publications note that the density of storm trajectories (intense cyclones) may slightly increase in the autumn and winter months in the Northern Europe region and Lithuania, however, the intensity of storms will not change or will decrease slightly. Often the changes are not significant statistically. Considering these results and the fact that there is no clear trend of increasing storminess in recent decades (Stankūnavičius et al., 2020), it can be said that the number of extreme wind events and their risk will not change significantly in the cold seasons of the year by 2050.

Table 7.3. Expected risk level of strong winds under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	**N/A**		**Low**		**Moderate**		**High**	
	RCP4.5	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**
Alytus			X	X				
Kaunas			X	X				
Klaipėda					X	X		
Marijampolė			X	X				
Panevėžys			X	X				
Šiauliai			X	X				
Tauragė			X	X				
Telšiai			X	X				
Utena			X	X				
Vilnius			X	X				

In the warm seasons of the year, strong wind events (squalls, whirlwinds) usually occur due to intense atmospheric convection rather than due to cyclones. Such strong winds are usually local and cover relatively small areas. The mechanism of their formation is complex, and the prediction of such phenomena is mainly based on the assessment of environmental conditions favourable for strong winds. This factor makes it extremely difficult to predict future changes. Recently, the number of [periods with] conditions favourable for summer convection (and extreme winds) has been increasing by about 1 to 2 events per decade (Taszarek et al., 2021). According to the RCP4.5 scenario, the number of events of such favourable conditions may increase by approximately 20% by 2050 (Pučik et al., 2017). However, such an increase does not necessarily mean that the number of strong wind events will increase to the same extent. Thus, there is a possibility of an increase in the number of local strong wind events, however, the complex mechanism of the formation of summer convection prevents from giving reliable conclusions.

Table 7.3 summarises the risk level of strong winds in individual counties under the climate conditions of the next 30–40 years according to RCP4.5 and RCP8.5 climate change scenarios.

8. Sea level rise

On the coast of Lithuania, the water level of the Baltic Sea has risen by almost 20 cm in the last 60 years. Currently, coastal cities or settlements are not directly and permanently flooded, however, under the conditions prevailing in Lithuania, sea level rise has an effect of a complex phenomenon, where storms (intense cyclones) create backwater (flooding) caused by wind. Therefore, due to the rising water level, the width of beaches potentially decreases, and the coastline and dune ridges are eroded more intensively. In addition, there is also a risk of flooding of some parts of cities or settlements. Further, sea level rise has an effect when water levels in the mouths of the rivers flowing into the Curonian Lagoon or the Baltic Sea rise in parallel for various reasons. As a result, floods are significantly higher than before, especially if it rains heavily.

Currently, the threat of sea level rise can only be assessed as low in Klaipėda county, which is near the sea. There is no direct threat of sea level rise in the rest of Lithuania (Table 8.1).

Table 8.1. Risk level of sea level rise under current climate conditions (1991–2020 CLINO) and in the 2023–2030 period.

Risk level/County	N/A	Low	Moderate	High
Alytus	X			
Kaunas	X			
Klaipėda		X		
Marijampolė	X			
Panevėžys	X			
Šiauliai	X			
Tauragė	X			
Telšiai	X			
Utena	X			
Vilnius	X			

Forecast

When assessing future sea level changes, it is expected that the level of the Baltic Sea along the coast of Lithuania will rise (Table 8.2). Based on SSP2–4.5 and SSP5–8.5 climate change scenarios, which are essentially equivalent to the RCP scenarios used in this analysis (RCP4.5 and RCP8.5, respectively) (Meinshausen et al., 2020), the sea level near Klaipėda is expected to rise approximately 0.27–0.28 m ± 0.09–0.11 m by 2050, compared to the 1995–2014 average (Masson–Delmotte et al., 2021). It is noteworthy that there are virtually no differences between sea rise forecasts for different climate scenarios. According to the scenarios with higher emissions, the uncertainty is slightly greater, but insignificant.

Table 8.2. Expected risk level of sea level rise under future climate conditions according to RCP4.5 and RCP8.5 climate change scenarios (2031–2060).

Risk level/County	N/A		Low		Moderate		High	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Alytus	X	X						
Kaunas	X	X						
Klaipėda			X	X				
Marijampolė	X	X						
Panevėžys	X	X						
Šiauliai	X	X						
Tauragė	X	X						
Telšiai	X	X						
Utena	X	X						
Vilnius	X	X						

It has been established that from 1960 to 2020 in the southern part of the Baltic Sea, the number of backwater (flooding) caused by wind increased almost 2 times, and the duration of high-water levels increased even 2.5 times. These trends are associated with higher average sea levels (Wolski T. and Wisniewski B., 2021). Taking into account the fact that the sea level rise is expected to continue and given the mixed trends of changes in storms (see section 'Strong winds'), it can be said that the risk of sea level rise will slowly increase by 2050, but will still remain low enough due to the complex effect, and the territory of the spread of risk will not change, i.e. the impact will persist in those territories of Klaipėda county where there is still a low probability of flooding.

Summary

Due to the uncertainty of climate forecasts, it is difficult to predict risk levels that await in the future, as they depend not only on changing climate conditions but also on the possible future climate adaptation measures.

Due to climate change, the risks of different phenomena will change in the future. The risk of changes in 2023–2030 is expected to be the same as under CLINO (Table 2). According to available literature sources, no significant difference in changes between the RCP4.5 and RCP8.5 scenarios by the middle of the 21st century has been established. Due to climate change, a low flood risk is expected in the majority of Lithuanian counties, and a moderate flood risk in the rest (Table 3). Due to rising air temperatures and increasing volatility of precipitation, the risk of drought is expected to be moderate and the risk of forest fires is expected to be low. The extreme precipitation risk is expected to be moderate. Rising air temperatures will lead to more frequent occurrences of heat (moderate risk) and less frequent occurrences of frost (low risk). The risk of strong winds will remain low in almost all of Lithuania and only Klaipėda will be exposed to moderate risk, while the risk of sea level rise, relevant only for Klaipėda county, is expected to be low.

Table 2. Expected level of different risks under future climate conditions (2023–2030).

NUTS	County	Floods	Droughts	Forest fires	Precipitation	Frost	Heat	Strong winds	Sea level rise
LT001	Alytus	low	moderate	low	moderate	low	moderate	low	N/A
LT002	Kaunas	moderate	moderate	low	moderate	low	low	low	N/A
LT003	Klaipėda	moderate	moderate	low	moderate	low	low	moderate	low
LT004	Marijampolė	low	moderate	low	moderate	low	moderate	low	N/A
LT005	Panevėžys	low	moderate	low	moderate	low	low	low	N/A
LT006	Šiauliai	low	moderate	low	moderate	low	low	low	N/A
LT007	Tauragė	low	moderate	low	moderate	low	low	low	N/A
LT008	Telšiai	low	moderate	low	moderate	low	low	low	N/A
LT009	Utena	low	moderate	low	moderate	low	low	low	N/A
LT00A	Vilnius	low	moderate	low	moderate	low	moderate	low	N/A

Table 3. Expected level of different risks under future climate conditions (2031–2060).

NUTS	County	Scenario	Floods	Droughts	Forest fires	Precipitation	Frost	Heat	Strong winds	Sea level rise
LT001	Alytus	RCP4.5	low	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	low	moderate	low	moderate	low	moderate	low	N/A
LT002	Kaunas	RCP4.5	moderate	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	moderate	moderate	low	moderate	low	moderate	low	N/A
LT003	Klaipėda	RCP4.5	moderate	moderate	low	moderate	low	moderate	moderate	low
		RCP8.5	moderate	moderate	low	moderate	low	moderate	moderate	low
LT004	Marijampolė	RCP4.5	low	moderate	low	moderate	low	moderate	low	N/A

		RCP8.5	low	moderate	low	moderate	low	moderate	low	N/A
LT005	Panevėžys	RCP4.5	moderate	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	moderate	moderate	low	moderate	low	moderate	low	N/A
LT006	Šiauliai	RCP4.5	low	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	low	moderate	low	moderate	low	moderate	low	N/A
LT007	Tauragė	RCP4.5	moderate	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	moderate	moderate	low	moderate	low	moderate	low	N/A
LT008	Telšiai	RCP4.5	low	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	low	moderate	low	moderate	low	moderate	low	N/A
LT009	Utena	RCP4.5	low	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	low	moderate	low	moderate	low	moderate	low	N/A
LT00A	Vilnius	RCP4.5	low	moderate	low	moderate	low	moderate	low	N/A
		RCP8.5	low	moderate	low	moderate	low	moderate	low	N/A

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