BEST PRACTICES IN CLIMATE CHANGE POLICY IN THE EUROPEAN UNION MEMBER STATES

Best practices in climate change policy in the European Union member states

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Foreword

Climate change is one of the most pressing and complex global challenges of our time, directly affecting all Member States of the European Union. The transformation of the climate system is not just an environmental issue, but a systemic problem with economic, social and political dimensions that requires coordinated, scientifically sound and sustainable responses.

Over the past decades, the European Union has taken a leading role in mitigating climate change and developing adaptation strategies. At the same time, the implementation of common objectives takes place at Member State level, with different geographical, economic and social conditions. This diversity also presents an opportunity: different national solutions, innovative measures and best practices offer inspiration and learning opportunities for each other.

The aim of this volume is to compile, in a systematic manner and by country, the good practices developed by the Member States of the European Union in their response to climate change. The measures listed include not only steps to reduce greenhouse gas emissions, but also initiatives to promote adaptation, increase energy efficiency, expand renewable energy sources, encourage green innovation and shape social attitudes.

We trust that this volume will contribute to strengthening professional dialogue, sharing experiences and informing future policy decisions. Identifying and sharing good practices will help Member States learn from each other's achievements and implement more effective and ambitious climate protection measures.

Austria

Introduction

Austria is one of the leaders in European climate policy, placing equal emphasis on reducing greenhouse gas emissions and adapting to climate change. Its strategic approach is based on science-based policy, cooperation with provinces and municipalities, and strengthening public participation.

1. National adaptation strategy

Austria recognised early on that adaptation is just as important as mitigation. The national adaptation strategy provides a comprehensive framework for managing climate risks.

Key features:

- multi-level governance (federal, provincial, local)
- sector-specific measures
- regular strategy updates

National Climate Adaptation Strategy (NAS)

Austria adopted *its* first *National Climate Adaptation Strategy* (NAS) in 2012, which has since been updated several times based on the latest scientific findings and political developments. The latest, third version was adopted in April 2024. The strategy aims to integrate climate adaptation into all relevant planning and decision-making processes, both at national and local level, involving the public sector, the private sector and individuals. The NAS covers 14 areas of expertise and contains more than 120 specific recommendations, including energy, mobility, construction, agriculture and tourism. The individual measures directly affect local communities and various economic sectors, such as avalanche protection, flood prevention, water management, and climate adaptation in construction and transport infrastructure. [1]

Avalanche protection and protective forests in Vorarlberg:

In Alpine regions such as Vorarlberg, protection against avalanches and landslides is a key issue, particularly due to extreme weather events that are becoming more frequent as a result of climate change. The *Schutzwaldsanierung Montafon* project involves the restoration of protective forests in several stages:

- more than 120 hectares of forest have been restored,
- tree species that are better adapted to climate change (such as larch) are being used,

- natural root zones are being created to stabilise the soil.

The aim of the project is to reduce the risk of avalanches and stabilise the soil, thereby protecting populated areas and transport routes. The results show that the restored areas have become more stable at 20 avalanche-prone sites, reducing the risk of disasters. The success of the project is reinforced by the active participation of local communities in its implementation, thus ensuring sustainability.

Digital flood prevention system in Salzburg

The Hochwasser-Frühwarnsystem flood prevention system operates in the floodplains of the Salzach River and aims to reduce the risk of flooding by measuring and forecasting water levels. The system has the following key features:

- The digital sensor network takes 2,880 measurements per day in real time.
- The data is automatically forwarded to the provincial disaster management authority.
- The population and authorities receive notifications and warnings via a mobile application.

In 2021, the system helped prevent major damage in 14 municipalities by reducing flood losses through the timely placement of protective barriers and other pre-determined measures. The application is constantly evolving and will be available for even wider applications in the future.

KLAR! (Climate Change Adaptation Model Regions)

The programme was launched in 2016 with the aim of supporting Austrian municipalities and regions in effectively adapting to climate change. As part of the initiative, participating regions develop location-specific adaptation strategies that include at least ten concrete measures. These measures represent practical responses to the consequences of climate change, such as reducing heat stress, flood risk or ecosystem vulnerability. By May 2023, 89 regions had already participated in the programme, representing a total of more than two million inhabitants. As a result of the KLAR! programme, more than 1,500 projects have been implemented, focusing on heat protection, protection against natural hazards, ecosystem restoration and awareness raising.

The Austrian *KLAR!* programme (Klimawandel-Anpassungsmodellregionen) aims to help local authorities and communities develop and implement adaptation plans. The Hartberg

region in Styria is a prime example:

- cooling public spaces have been created, such as partially underground rest areas,
- installed green roofs on public buildings,
- rainfall collection systems have been set up for agricultural purposes,
- and introduced night-time irrigation to reduce water loss.

As a result of the project, water consumption has been reduced by 20-30% by 2023, while improving the thermal comfort of the population and contributing to the creation of a sustainable urban environment.

KLIMAFIT – Development of climate-resistant plant varieties

The objective of the **KLIMAFIT** I–III projects (2017–2026) is to breed plant varieties that are more resistant to environmental stress caused by climate change, such as heat waves, droughts, frosts and extreme storms. Austrian plant breeding and seed production companies are participating in the programme, and research and development activities cover various arable crops, such as cereals, maize, oil and protein crops, and potatoes. These projects contribute significantly to increasing the adaptability of Austrian agriculture, with a particular focus on yield stability and food security, even in the face of increasing climate challenges.

2. Urban climate adaptation innovations: examples from Vienna

Cool Streets

As part of a pilot project launched in 2019, car-free streets were created in three districts of Vienna (3rd, 10th and 16th districts), where water misting systems, shade-providing green spaces and furniture serving as community spaces were installed. Based on direct feedback from 518 residents during the four-week programme:

- 87% rated its role in reducing heat stress as positive;
- 66% said that the temperature in their homes had improved;
- 92% supported the continuation of the project, despite the temporary loss of 10% of parking spaces.

Climatological measurements confirmed a temperature reduction of between 1.3 and 5°C, demonstrating the effectiveness of microclimatic interventions.

Green roofs and urban garden initiatives

In Vienna, following the example of the roof of the Hundertwasserhaus building, which has been covered with 250 trees and shrubs since 1980, many new buildings are integrating green spaces. According to a 2018 study by the city administration, covering flat roofs entirely with greenery could reduce the number of heatwave days by up to 30%. The urban gardening programmes run by the Operation Grüner Daumen association in the Mariahilf district not only reduce CO_2 emissions but also have a community-building effect. Participants experience the effects of climate change first-hand, which encourages the development of sustainable behaviours.

Nature-based water management and flood protection Rehabilitation of floodplains along the Danube

The example of the Lobau National Park shows how flood risk can be managed at the same time as biodiversity protection and drinking water production. By reconnecting historical bends:

- Flood retention capacity increased by 15-20%;
- Water quality indicators improved, enhancing ecosystem services;
- Recreational use of the area has increased by 40% since 2020.

Austrian regulations stipulate that nature-based solutions should be given priority over traditional engineering interventions if the direct benefits are equivalent. [2]

3. Green infrastructure and green roofs

Austria, and Vienna in particular, pays special attention to nature-based solutions. Key elements [3]:

- Green roofs
- Urban afforestation
- Shaded public spaces Effects:
- Temperature reduction
- Rainwater retention
- Increased biodiversity

4. Nature-based water management

Austria prioritises nature-based flood protection.

Measures:

- Rehabilitation of floodplains
- Restoration of wetlands
- Increasing water retention

Benefits:

- Reduction of flood risk
- Improvement of ecosystem services
- Increased recreational value

Water management adaptation strategies

Austrian water management is also actively responding to the challenges posed by climate change, with regards to fluctuations in water yields, increasing glacier melt and rising water temperatures. Accordingly, comprehensive adaptation strategies have been developed for flood protection, groundwater management and long-term water quality preservation.

As a result of glacier retreat, summer water yields in the directly affected Alpine regions are expected to increase temporarily. At the same time, groundwater recharge may decrease in low-precipitation regions in eastern and southern Austria, which could lead to water shortages in the long term, particularly for agriculture and municipal water supply. These changes highlight the importance of climate adaptation measures in water management, particularly in the development of region-specific solutions. [1]

5. Agricultural and forestry adaptation

Austria is taking an integrated approach in climate-sensitive sectors.

Main directions:

- Soil protection
- Climate-resilient plant varieties
- Increasing forest resilience

- Monitoring invasive species

Climate change is also affecting Austrian agriculture, especially in the eastern provinces. The family-run organic farm Biohof Lechner in the Neusiedl am See region has successfully implemented the following methods:

- Soil cover reduces evaporation,
- deep loosening increases water retention,
- they grow drought-tolerant crops (quinoa, sorghum),
- and uses its own compost and mulch to strengthen soil life.

In 2022, despite extreme drought, the farm maintained its average yield, while other, more intensive farms suffered losses of 25-40%. Biohof Lechner successfully applies regenerative farming methods that contribute to sustainable agriculture and climate change adaptation. This contributes to food security and ecosystem stability.

6. Climate-friendly transport and infrastructure

Austria is developing low-emission mobility systems. Measures [4]:

- Development of public transport
- Cycling infrastructure
- Promotion of electromobility
- Heat-adapted urban transport spaces

7. Austrian Climate Bonus Support

The Austrian Climate Bonus is a financial support scheme provided by the Austrian government to households to encourage sustainable energy use and reduce greenhouse gas emissions. The aim of the Climate Bonus is to encourage households to adopt energy-efficient solutions, such as green energy heating systems, changing transport habits and using climate-friendly household appliances. As part of the programme, residents receive annual financial support to help them reduce their environmental footprint.

This support is closely linked to KLIMAaktiv and initiatives aimed at improving energy efficiency, as the Austrian government uses this bonus to encourage households to adopt environmentally friendly solutions. The programme aims to improve the sustainability of

residential and other buildings, thereby supporting climate adaptation efforts.

Summary

Austria's good practices in climate protection clearly show that a combination of mitigation and adaptation, the use of nature-based solutions and urban innovations can provide an effective response to the challenges of climate change.

Austria's climate adaptation strategy is based on the synergy of science, community participation and innovative technologies. Vienna's Cool Streets, green roofs and Danube rehabilitation projects not only provide solutions to local problems, but also serve as models for other European regions. Continuous strategy updates and multi-stakeholder cooperation ensure that the country is able to respond to the dynamically changing challenges of climate change.

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Belgium

Introduction

Belgium has a temperate oceanic climate, which is mainly influenced by its proximity to the Atlantic Ocean and the North Sea. The country's climate change challenges and adaptation framework are also described in detail in the Climate-ADAPT country profile [1]. Belgium's climate policy is multi-level due to its federal structure. Adaptation is integrated at national, regional (Flanders, Wallonia, Brussels) and local levels. The national adaptation strategy and plan are coordinated by committees involving representatives from different levels of government [1].

Heat waves and health protection

Belgium has established the "Ozone and Heat Plan" to address heat waves and ozone pollution [2]. The plan sets thresholds for temperature and ozone concentration and operates in three phases: alert, warning and alarm. The aim of the system is to minimise health risks and protect the population.

Green-blue infrastructure

Several cities in Belgium, particularly Brussels, have established green-blue networks, which involve the creation of parks, green roofs and nature-based water retention systems [3,4]. These solutions simultaneously reduce water runoff, mitigate the urban heat island effect and promote biodiversity conservation.

Blue Deal – water management

The Blue Deal programme, established by the Flemish government, is a comprehensive strategy consisting of 70 measures to address water scarcity and drought [3]. The programme encourages local authorities, businesses and farmers to introduce innovative water management solutions.

Agriculture and nature conservation

Within the framework of the Common Agricultural Policy (CAP) for 2023-2027, Wallonia has developed its own strategic plan that supports climate-conscious farming, the transition to more sustainable agriculture and the preservation of rural stability [5].

Energy infrastructure and offshore wind energy

A significant part of Belgium's energy supply is based on nuclear energy, but the country is

also one of Europe's leading producers of offshore wind energy. There are nine operational wind farms, which play an important role in achieving the EU's renewable energy targets [6,7]. The installed capacity of offshore wind farms exceeds 2200 MW, generating around 8 TWh of electricity per year [7]. Wind energy significantly reduces greenhouse gas emissions [8].

Belgium is building an artificial energy island in the North Sea called Princess Elisabeth Energy Island, which will serve to distribute offshore wind energy more efficiently [9]. What makes this project unique is that it also integrates biodiversity protection into its design.

Summary

Belgium's climate adaptation practice is based on a complex, multi-level management system. The country relies heavily on nature-based solutions, water management reforms and the development of offshore wind energy. At the same time, due to its federal structure, coordination between different levels of government is a constant challenge [1].

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Bulgaria

Introduction

Bulgaria faces various climatic risks due to its long Black Sea coastline, continental interior and mountainous regions: heat waves, droughts and intense precipitation events have become more frequent in recent decades, posing challenges for both agriculture and water management [1]. Climate change also affects ecological systems, human health, drinking water supplies, infrastructure and natural resources [2].

The aim of climate adaptation measures in Bulgaria is to reduce climate vulnerability, ensure sustainable management of natural resources and increase economic and social resilience in changing climatic conditions.

National climate adaptation strategy and legal framework

Bulgaria's national climate adaptation strategy is summarised in the document entitled **'Clima 2050' National Strategy and Vision**, which sets out the country's long-term responses to the effects of climate change [1]. The strategy emphasises the need for cross-sectoral integration and the incorporation of adaptation into planning and investment processes.

The European Union legal framework, such as the EU Climate Adaptation Strategy, also has a binding effect on Bulgaria, encouraging adaptation planning and cooperation at national, regional and local levels [3].

Agricultural resilience and water management

Bulgaria's agriculture is particularly vulnerable to droughts and high temperatures, which lead to reduced crop yields, soil degradation and water shortages [2]. Adaptation measures include:

- **the use of drought-tolerant seed varieties and crops**,
- the application of **precision farming technologies** to optimise water and nutrient use,
- **soil moisture conservation tillage techniques** and increasing soil biological activity.

Water management strategies aim to ensure the sustainable use and conservation of surface and groundwater resources, with a particular focus on increasing the capacity of small watercourses and reservoirs and promoting water conservation [4].

Protection of coastal ecosystems and biodiversity

Bulgaria's long coastline and Black Sea ecosystems are particularly vulnerable to the effects of sea level rise and coastal erosion [5]. Adaptation practices include:

- **development of coastal protection and nature-based infrastructure**, such as sand dune replanting and coastal habitat restoration,
- **water management projects** to reduce the impact of inland flooding and storms.

Monitoring and rehabilitation programmes are being introduced in protected areas to preserve biodiversity, strengthening the climate stress resistance of species and habitats.

Urban climate adaptation

Bulgarian cities, especially Sofia and Plovdiv, are increasingly integrating climate adaptation into their urban development [6]. The objectives of urban adaptation are:

- increasing **green infrastructure**: creating green roofs, green walls and landscaped walkways
- **reducing the heat island effect** by creating shaded spaces and public areas covered with vegetation,
- using **permeable pavements** to allow rainwater to infiltrate more quickly.

In addition, local authorities have developed their **Sustainable Energy and Climate Action Plans (SECAP)**, which contain specific adaptation and emission reduction measures until 2030 [6].

Energy efficiency and renewable energy

Bulgaria's energy sector remains partly dependent on fossil fuels, but the share of renewable energy sources, particularly solar and biomass capacities, is growing [7]. Increasing energy efficiency and expanding renewables not only serve emission reduction goals, but also provide **climate adaptation benefits** through energy supply stability in extreme weather situations.

Social awareness and research

In Bulgaria, social acceptance and awareness of climate adaptation is gradually increasing. According to a national survey, the population is increasingly concerned about heat waves, droughts and flood risks, and supports educational, scientific and community-based adaptation initiatives [8].

Summary

Bulgaria's climate adaptation strategy is multi-level: it implements an integrated adaptation plan at the national level in line with the 'Clima 2050' document, while also increasing resilience at the city, agricultural and community levels through regional and local initiatives. Water, coastal and biodiversity management, as well as urban climate adaptation and energy transition, are all key areas.

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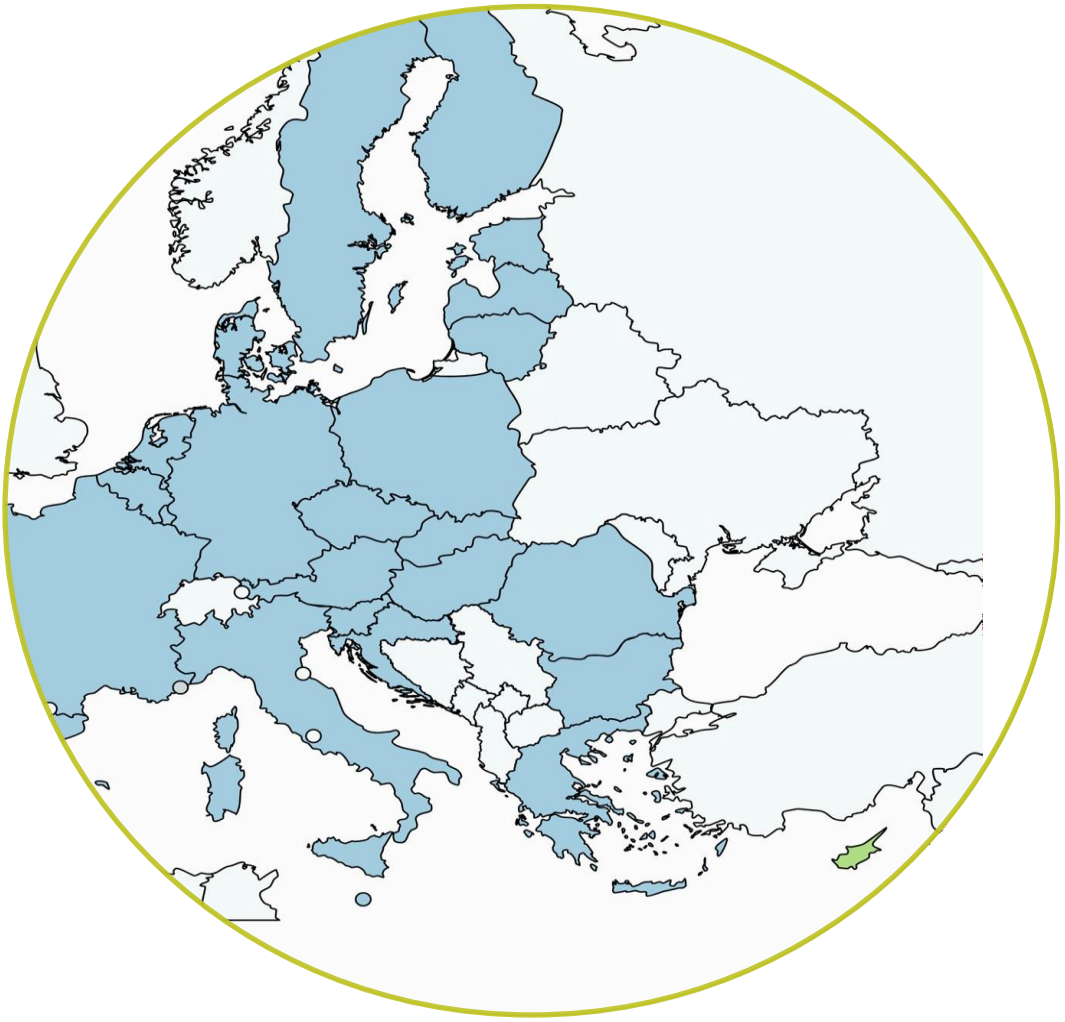

Cyprus

Introduction

Cyprus' geographical location in the Mediterranean makes the country particularly vulnerable to the effects of climate change. In recent decades, rising temperatures, longer periods of drought and a downward trend in precipitation have led to severe water shortages and extreme weather events [1,2]. As a result of climate change, agriculture, water management, biodiversity, tourism and health systems are facing increasing challenges [1].

Climate adaptation is crucial not only from an environmental perspective, but also from an economic and social point of view, as longer heat waves and declining water resources can cause population movements, agricultural losses and a decline in tourism [1].

The Cypriot government and professional organisations have therefore developed a **National Climate Change Adaptation Strategy**, which sets out the most important adaptation priorities and measures.

Developing and revising the national adaptation strategy

Cyprus developed and updated its climate adaptation strategy in several stages. The first **National Climate Change Adaptation Strategy** was created in 2017 and was later revised and updated to better reflect new scientific knowledge and EU expectations [2].

The public and stakeholders were also involved in the revision of the strategy – for example, in 2025, a **public consultation process** took place in Nicosia, Larnaca, Limassol and Paphos to incorporate the opinions, experiences and suggestions of local communities into the final document [3].

The strategy includes a comprehensive risk and vulnerability assessment that identifies the most affected sectors – agriculture, biodiversity, cultural heritage, public health, water management, tourism, infrastructure and energy – and sets out targeted adaptation measures in each area [2].

Adaptation measures for agriculture and water management

Cyprus already has a very dry climate, and the downward trend in rainfall is further exacerbating agricultural water supply and soil moisture problems [2]. In agriculture, water-efficient irrigation practices are recommended, **the reuse of treated water**, and **the use of** soil moisture conservation techniques and **drought-tolerant crop varieties** are recommended as adaptation strategies [2]. Due to extremely dry conditions, Cyprus is increasingly relying

on desalination and purification of water, installing mobile and fixed desalination units to secure water supplies [4,5].

Support programmes and community adaptation initiatives

The **Grant Scheme for Strengthening Resilience and Adaptation of Communities to Climate Change** aims to increase the resilience and adaptability of local communities. Funded under **the** European Union's **National Recovery and Resilience Programme (NRRP)**, the initiative has provided more than €2.9 million in support for investments aimed at, among other things, mitigating high temperature and flood risks and developing sustainable mobility [6,7].

The Cyprus Energy Agency has provided technical support to communities in developing **Energy and Climate Plans**, which help with planning and cooperation in the face of climate change risks [6].

Public awareness and research feedback

According to a 2024 survey, the vast majority of the Cypriot population – around 98% – recognise that climate adaptation is a national priority, and 93% believe that urgent action is needed to avoid longer-term damage [8]. This shows that climate adaptation is supported not only by policy measures but also by society.

Summary

Cyprus' climate adaptation strategy is tailored to regional characteristics: it focuses on water management and drought management, increasing agricultural resilience, supporting community investments and raising public awareness. EU funding mechanisms, such as the NRRP, and the revised national strategy are important tools for ensuring the country's climate-adaptive future.

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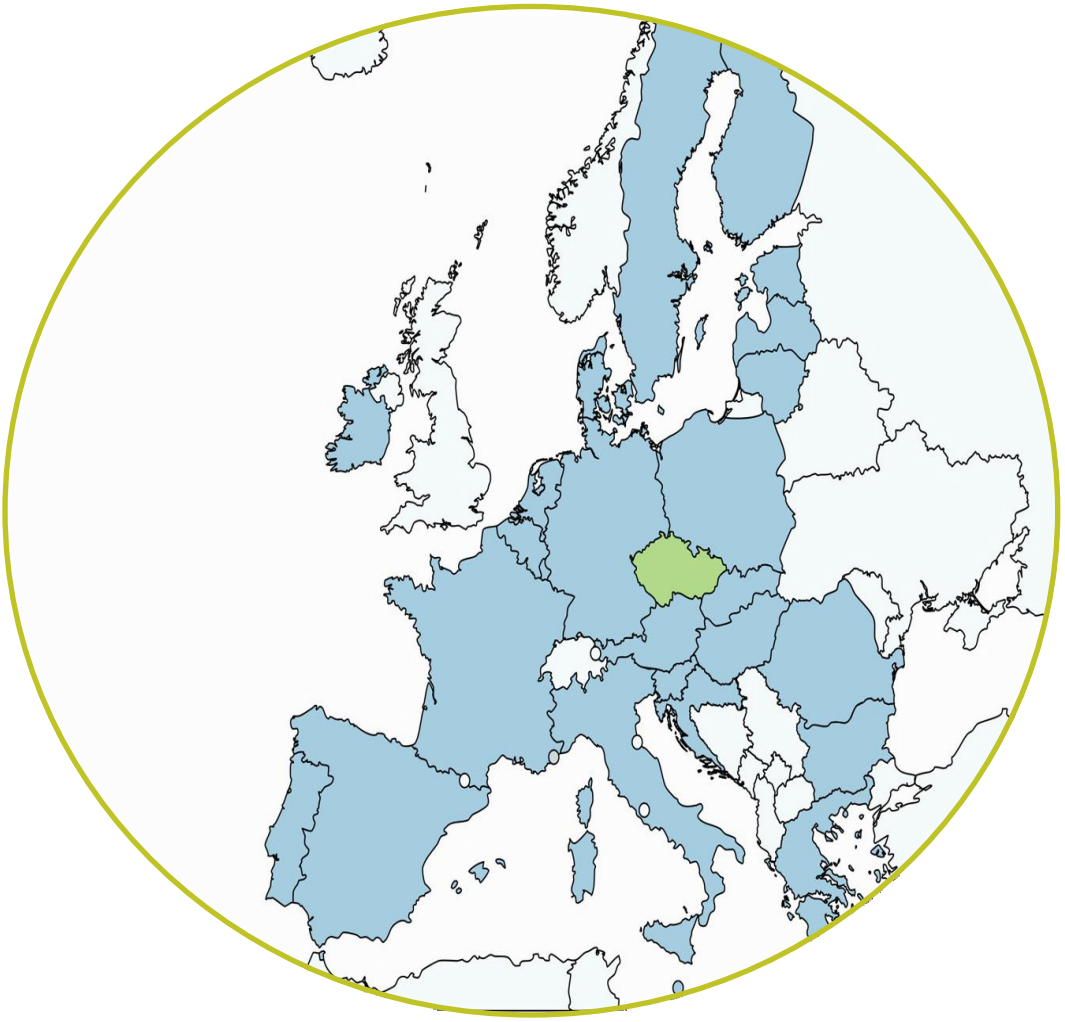

Czechia

Introduction

The Czech Republic is in the heart of Europe, with an area of approximately 79,000 km² and a population of nearly 11 million [1]. The country's basic data is also confirmed by the official website of the European Union (European Union – Czechia) [1]. As a result of climate change, the average temperature could rise by up to 3.5 °C in the future, which could cause significant ecological changes [2,3]. The vulnerability of forests and the uncertainties of climate scenarios are described in detail in the study *Expected impacts of climate change on forests: Czech Republic as a case study* [2] and the research *Uncertainties in climate change scenarios for the Czech Republic* [3].

National strategic framework

The Czech Republic adopted its National Adaptation Strategy (Strategy on Adaptation to Climate Change in the Czech Republic) in 2015, which was updated in 2021 [4].

The main objectives of the strategy are:

- to reduce climate risks,
- strengthening water management,
- increasing the resilience of ecosystems,
- ensuring the climate resilience of infrastructure.

Implementation will take place in several sectors, including agriculture, forestry,

water management, healthcare and urban planning [4].

Good practices

The revitalisation of Rakováček Park in Rokycany is a good example of ecosystem-based adaptation. The expansion of the stream with pools serves both flood protection and the protection of the habitat of a rare local crayfish, as demonstrated by the Life Tree Check project [5]. In the city of Brno, the water steps created in Denis Park aim to reduce the urban heat island effect by increasing air humidity and improving the microclimate. A detailed description of the project can be found on the UNA.city website [6].

Among the national tree planting movements, the "Sázíme budoucnost" initiative stands out, which has set a goal of planting millions of trees to mitigate climate change [7].

The spread of green roofs and green facades is supported by the ZeS programme, which plays a role in reducing the urban heat island effect and increasing biodiversity. The results of the programme are presented in the study *Urban Resilience Best Practices of the Czech Republic* [8].

Urban agriculture, such as the Herba Fabrica and GreenBox initiatives, uses vertical and hydroponic systems, achieving significant water savings, which are also detailed in the *Urban Resilience Best Practices of the Czech Republic* document [8].

The Liko-Noe office building in Brno operates with a self-sustaining energy supply using heat pump and photothermal systems. Details of the project can be found in the official presentation of LIKO-NOE [8].

The Czech start-up MIWA has achieved a significant 71% reduction in its environmental impact by introducing a packaging-free retail model, as described on the company's official website [10].

The municipality of Troskotovice uses a data-driven methodology to prioritise adaptation measures, as presented in a case study on the Climate-ADAPT platform [11].

In the Brdy Landscape Protection Area, a beaver colony has created a natural water retention system, as reported by Index.hu [12].

Summary

The Czech Republic's climate adaptation model:

- is based on drought-focused water management reforms
- supports residential water retention,
- integrates nature-based solutions,
- strengthens forest and agricultural resilience,
- develops urban green infrastructure.

The Czech practice is particularly relevant for countries in Central Europe with a continental climate.

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Denmark

Introduction

Denmark is one of the most prepared and innovative countries in the European Union in terms of climate change adaptation. Due to its geographical characteristics – flat terrain, long coastline, numerous islands – it is particularly vulnerable to sea level rise, storm surges and intense precipitation [1]. The Danish government has therefore not only set emission reduction targets (70% reduction by 2030, climate neutrality by 2050) but has also developed a comprehensive adaptation policy [2]. Denmark is a particularly interesting example among the member states of the European Union, as its geographical characteristics make it highly vulnerable to the effects of climate change. The country has a long coastline, several large cities are in low-lying areas, and extreme precipitation events have become increasingly frequent in recent years.

The 2011 downpour in Copenhagen marked a turning point: the sudden, extreme rainfall caused billions of Danish kroner in damage and made it clear that traditional urban drainage systems were inadequate [3]. From then on, Denmark not only formulated strategies, but also embarked on concrete, large-scale investments. In the following, I will present some of these good practices, which are truly effective solutions and may also be useful for other countries.

Climate adaptation in Denmark is not just an environmental issue, but also a spatial development, economic and social strategy.

1. Copenhagen – Cloudburst Management Plan

The extreme cloudburst in 2011 caused billions of euros in damage in Copenhagen. In response, the city developed the **Cloudburst Management Plan** programme [3]. The basic idea behind the plan was that it was not possible to expand the underground sewer system alone, as this would be extremely costly and might not be sufficient in the long term. The city therefore also incorporated surface areas into its water management. The programme comprises more than 300 specific projects [3].

Specific solutions:

- Some streets have been redesigned to function as controlled drainage channels during extreme rainfall.
- Parks and squares were excavated to serve as temporary reservoirs.
- Large underground tunnels have been built to store and regulate water drainage.

- Rainwater is channelled towards the harbour, minimising the burden on residential areas.

This approach is considered a good solution because it not only provides protection but also integrates climate adaptation into urban planning. The investments were significant, but they can be considered economically justified due to the reduction in expected future damage. Several studies in Denmark confirm the increase in extreme precipitation intensity, so the problem is not just theoretical. The plan consists of more than 300 projects and aims to be able to handle extreme rainfall events with a frequency of up to 100 years.

Main elements:

- Creation of drainage streets
- Operating parks as temporary reservoirs
- Installation of green roofs and rain gardens
- Creation of surface channels and green corridors

Enghaveparken – climate park

Enghaveparken can temporarily store 22,600 m^3 of water [4]. Normally a public park, it becomes a huge water basin during extreme rainfall.

Tåsinge Plads – climate-adapted urban space

Tåsinge Plads is Copenhagen's first square designed specifically for climate adaptation [5].

- Rainwater retention
- Underground reservoirs
- Increasing biodiversity
- Community space function

2. Østerbro Climate Quarter and Blue-Green Infrastructure

The Østerbro district is one of the world's first climate-adapted residential areas [6]. The project uses integrated blue-green infrastructure:

- water retention systems
- green space expansion

- surface drainage
- resident involvement

Local residents were involved as early as the planning stage [7].

The essence of blue-green infrastructure is that water management and green space development are treated together.

Specific examples:

- Rainwater collection parks (water squares), which function as community spaces during normal weather conditions and store water during heavy rainfall.
- Green roofs, which reduce direct runoff and mitigate the heat island effect.
- Use of permeable pavements in new developments.
- Conscious urban afforestation.

These solutions address the problems of flash floods and heat waves at the same time. Mitigating the urban heat island effect is not only a matter of comfort, but also an economic issue, as heat waves increase healthcare costs and reduce labour productivity.

Blue-green infrastructure therefore offers a double benefit: climate adaptation + improved quality of life.

3. Coastal protection and the Lynetteholm project

Sea level rise is one of the greatest threats [1]. The government has launched the first National Climate Adaptation Plan with a budget of DKK 1.3 billion [2]. The **Lynetteholm** artificial peninsula project in Copenhagen harbour serves two purposes [8]:

- as flood protection
- as a residential construction area
- transport infrastructure.

4. Aarhus – separation of rainwater and wastewater

Aarhus has introduced a new water management strategy to separate rainwater and wastewater [9]. Objective:

- to reduce overflows

- improve water quality
- to mitigate flood risk

5. Agricultural adaptation and carbon tax

Denmark will introduce an agricultural CO_2 tax from 2030 [10].

- 300 DKK/tonne (2030)
- 750 DKK/tonne (2035)

The revenue will be used for green investments. In addition [11]:

- Planting 1 billion trees
- 250,000 hectares of new forest
- restoration of wetlands

6. Renewable energy and energy islands

Denmark is one of the world's leading offshore wind power countries.

The **Thor offshore wind farm** will have a capacity of 1.1 GW [12].

The goal is to increase energy independence and energy security.

7. Leading role in water technology

Denmark is a global leader in water technology [13]. Goal:

- to double water technology exports by 2030
- energy- and climate-neutral water sector

8. Tåsinge Plads

Tåsinge Plads is a large urban park with rain gardens, canals and a water treatment basin. Rainwater from heavy rainfall is stored under the park and used to irrigate the landscape during prolonged periods of drought. During heavy downpours and extreme rainfall, the green corridors transport the excess water to other climate change projects downstream, such as the integrated system in Bryggervangen and Skt. Kjelds. The Tåsinge Plads project was completed in 2014. The total budget was DKK 16,000,000 (approximately USD 2 million). The total area is 4,000 m2. The project was implemented by the City of Copenhagen with the

participation of Malmos A/S, GHB Landscape Architects A/S, Orbicon A/S, VIA Trafic Counseling A/A and Feld Studio for Digital Craft. [14,15]

9. Bryggervangen and Skt. Kjelds Plads

Bryggervangen and Skt. Kjelds Plads collect and treat rainwater from more than 4,000 m² of pavement and roof surfaces, preventing it from entering the sewer system. Some areas also store rainwater in pavement slabs designed for temporary storage and large underground reservoirs, which store rainwater for later use and irrigate urban climate adaptation landscapes during prolonged periods of drought

Other areas channel excess water through greenways into lakes, and the water eventually flows into the ocean during heavy rainfall and cloudbursts [16]. The Bryggervangen and Skt. Kjelds Plads project was completed in 2018. The total budget was DKK 48,450,000 (approximately USD 7 million). The total area is 34,900 m2 (Skt. Kjelds Plads alone is 8,000 m2). The project was implemented by the City of Copenhagen in collaboration with SLA Nature-Based Design Studio, Third Nature Architects, NIRAS and HOFOR [15].

10. The Blue Edge (Den Blå Kant)

In Denmark, the city of Sendborg has also taken action against climate change with a comprehensive urban development and climate protection project. The Blue Edge (*Den Blå Kant*) is a long-term project consisting of several initiatives. The city of Svendborg is located at a high altitude. In the southern part of the city is the port of Søndre, which is low-lying and densely built-up. In the event of heavy rainfall - which are becoming increasingly frequent - large amounts of water flood the harbour area, and the area is often exposed to storm surges. The entire project consists of storm surge protection, cloudburst protection and the comprehensive redevelopment and beautification of the entire urban area of the harbour. Once completed, the project will cost approximately 700 million kroner [17]. Implementation will take place in phases, with four phases planned, including a harbour park.

The first phase includes the renovation and redevelopment of the intersection of Jessens Mole and Havnepladsen, the Frederiksbroen pedestrian bridge, Frederiksø and the Udrustningskajen area. This was completed in the summer of 2021. Phase 2 focuses on protecting the southern harbour area (*Søndre Havn*), with plans to build a lock and pier system and install mobile barriers that can protect against water levels rising by up to 2.5 metres. The project is expected to be completed in 2026–2027. Phase 3 involves plans for new urban

spaces, promenades and a modern pumping station in the northern part of the harbour (*Nordre Kaj*). In 2017, the municipality of Svendborg provided DKK 4 million in funding for an architectural competition, followed by DKK 24 million for the implementation of the first phase. In 2020, the city council allocated DKK 37 million for the second phase [18,19].

Summary

Denmark's climate adaptation model rests on several pillars:

- Urban water management (Cloudburst Plan)
- Nature-based coastal protection
- Agricultural reform
- Renewable energy
- Community involvement
- Innovation and design integration

The country is planning proactively rather than reactively for the expected effects of climate change. The Danish model proves that adaptation is not a cost, but a long-term economic and social investment.

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Estonia

Introduction

Estonia's northern geographical location, long Baltic Sea coastline and significant forest and marshland areas make it particularly vulnerable to climate change. According to the national adaptation plan, climate change will lead to ‘an increase in the frequency of extreme weather events, including heavy precipitation and heatwaves [1]. The European Environment Agency’s country profile confirms that Estonia is particularly vulnerable to coastal flooding and water management extremes [2].

National climate adaptation strategy and legal framework

Estonia's national adaptation framework is defined in the *National Climate Change Adaptation Development Plan 2030* (KOHANEMISKAVA 2030) document, which was developed by the Estonian Ministry of the Environment. The aim of the strategy is "to reduce vulnerability of natural and socio-economic systems to climate change impacts" [1].

The adaptation policy is in line with the EU Adaptation Strategy adopted by the European Commission, which emphasises that adaptation must be "be smarter, more systemic and faster" [3]. This integrated approach is also reflected in Estonian policy documents.

Coastal adaptation and sea level rise

Estonia has more than 3,700 km of coastline, which is vulnerable to sea level rise and storm surges [2]. According to the EEA, "coastal flooding risk is expected to increase due to sea-level rise and storm surges" in the northern region [2].

One of the most vulnerable areas is Pärnu, where significant flooding events have been recorded in the past [2]. The Climate-ADAPT country profile highlights nature-based solutions such as dune rehabilitation and coastal habitat restoration [4]. The national plan emphasises the role of land use planning regulations in reducing flood exposure [1].

Forest management and ecosystem-based adaptation

More than half of Estonia's territory is covered by forests, which offer significant carbon sequestration and adaptation potential [5]. According to a FAO report, "Estonia is one of the most forested countries in Europe" [5].

Near-natural forest management methods are used in Lahemaa National Park [1]. The national strategy supports the development of mixed-species stands and forest health monitoring systems [1]. The EEA points out that pests and extreme weather events pose an increasing risk

to northern forests [2].

The rehabilitation of wetlands and peatlands contributes to reducing flood risk and increasing water retention capacity, while also providing climate mitigation benefits [4].

Agriculture and water management

Changes in precipitation patterns and rising temperatures increase the risk of droughts and floods in Northern Europe [2]. The national adaptation plan encourages the use of precision farming systems and soil moisture monitoring [1].

Restoring natural floodplains and rehabilitating wetlands play a key role in integrated water management [4]. The flood risk planning documents of the Estonian Environmental Board emphasise the importance of prevention and land use planning [6].

Urban climate adaptation

Tallinn has integrated climate adaptation into its sustainable urban development documents, particularly within the framework of the SECAP [7]. Urban adaptation must address emission reduction and adaptation measures within an integrated framework [7]. Green infrastructure, localised stormwater retention and the reduction of the heat island effect are key tools.

Energy and infrastructure resilience

The energy system is undergoing a transformation, and renewable energy sources are playing an increasing role in the energy mix [8]. Modernising network infrastructure and developing decentralised systems increases resilience to extreme weather events [8].

Practical examples

LIFE Peat Restore – rehabilitation of degraded peatlands

Estonia has participated in several international LIFE projects to restore drained peatlands. The aim of the LIFE Peat Restore project was to rewet degraded peatlands and reduce greenhouse gas emissions [9]. Climate-ADAPT emphasises [4] that rewetted areas increase water retention capacity, reduce drought sensitivity and moderate flood peak flows.

Flood risk management investments in the city of Pärnu

Pärnu is one of Estonia's most vulnerable coastal settlements. The storm surge of 2005 caused significant damage, after which complex flood protection investments were launched. According to the European Environment Agency, "the risk of coastal flooding in the Baltic

Sea region is expected to increase due to sea level rise and storm surges." [2]. The city has combined technical defences (mobile barriers, embankment reinforcement) with nature-based solutions, such as the rehabilitation of coastal green spaces [6]. This hybrid approach increases long-term resilience.

Tallinn green infrastructure and stormwater management

Tallinn has integrated adaptation measures into its *Sustainable Energy and Climate Action Plan* (SECAP) [7]. Rain gardens, permeable pavements and urban water retention parks have been created in several districts of the city. According to the Covenant of Mayors guidelines, urban climate adaptation should 'combine mitigation and adaptation measures within an integrated framework' [7]. Green infrastructure reduces the risk of flash floods and mitigates the urban heat island effect.

Lahemaa National Park – nature-friendly forest management

Lahemaa National Park is a model area for adaptive forest management. The national adaptation plan supports the development of mixed-species stands and the natural regeneration of forests [1].

According to the FAO, "Estonia is one of the most forested countries in Europe" [5], which highlights the strategic importance of forest management. Adaptive forest management reduces damage caused by pests and storms [2].

Flood risk mapping and digital monitoring

Estonia's digital public administration system enables the spatial modelling of flood and storm risks. According to the EU's adaptation strategy, adaptation must be "smarter, more systemic and faster" [3]. The Estonian Environmental Board uses integrated flood risk maps in land use planning and infrastructure decisions [6]. Data-driven decision-making increases the efficiency of investments and reduces long-term risks.

Developing energy infrastructure resilience

Strengthening the energy network and developing decentralised renewable systems also involve specific investments. According to the International Energy Agency, "renewable energy sources are playing an increasing role in the energy mix" [8]. Network upgrades and underground cabling reduce supply disruptions caused by winter storms.

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Finland

Introduction

As one of the northernmost Member States of the European Union, Finland is particularly sensitive to the effects of climate change. The rate of temperature increase in the northern regions exceeds the global average, leading to a decrease in the number of frost days, shorter snow cover, melting permafrost, and the emergence of new pests and insect species. The Finnish climate adaptation strategy takes a systemic approach, which is also set out in the Finnish National Climate Change Adaptation Plan 2022–2030 [1].

One of the most important features of the Finnish model is that adaptation is not a separate policy, but an integrated part of forest management, urban planning, infrastructure development and support for indigenous communities.

1. Climate-adaptive urban planning – Helsinki, Espoo and Tampere

Over the past decade, Finnish cities have consciously integrated climate adaptation into their urban planning documents. Helsinki, for example, has incorporated rainwater management into its land use regulations since the 2010s [2].

As part of the Viinikkala programme, nature-based drainage systems have been developed:

- bioswale ditches,
- rain gardens,
- temporary water retention basins,
- green roofs and permeable pavements.

These systems not only reduce the risk of flooding, but also improve the urban microclimate and increase biodiversity.

Espoo's 'Kaupunki vihertyy' programme focuses on greening school and public institution courtyards [3]. The goal is twofold:

- to mitigate the heat island effect and
- strengthening environmental education.

Tampere uses green infrastructure development programmes based on similar principles, which are designed to retain and naturally filter rainwater locally. The basic principle of the Finnish urban development model is that water should be seen as a resource rather than a

problem.

2. Sustainable and climate-resilient forest management

Approximately 75% of Finland's territory is covered by forests, making forest management a key area of adaptation. Climate change is transforming the species composition of forests, with spruce stands becoming more vulnerable to pests and storms.

Metsähallitus, the Finnish state forestry company, applies climate-adaptive forest management practices [4].

Measures include:

- planting mixed-species forests,
- soil moisture monitoring,
- LIDAR-based forest inventory,
- gradual regeneration cutting instead of clear cutting,
- creating climate-resistant forest stands.

The aim of Finnish forest management is not only to sequester carbon, but also to maintain ecosystem stability and increase resilience to extreme weather events.

3. Adaptation of indigenous Sámi communities

The lifestyle of the Sámi communities in Finland is closely linked to the cycles of nature. Due to climate change, reindeer herding has become more predictable, snow cover has become more unstable, and the thickness of lake ice has decreased.

The Sámi Climate Council and the SnowChange Cooperative have established a community-based monitoring system [5].

The system is unique in that

- data collection by local herders,
- integration of traditional ecological knowledge (TEK),
- supplementing scientific modelling with local observations,
- flexible decision-making on reindeer migration routes.

This model demonstrates that adaptation is not only a technical issue, but also a cultural and social one.

4. Infrastructure in melting northern regions

In northern regions, the melting of permafrost is threatening the stability of roads and railways. In northern Finland, for example in the Ivalo and Inari regions, new infrastructure is already being designed to be climate-adaptive [6].

The solutions applied are:

- thermally insulated road base,
- soil temperature and moisture sensors,
- digital forecasting models,
- more flexible structural solutions.

The data-driven monitoring system enables preventive maintenance, which is more cost-effective in the long run than corrective maintenance.

5. Water management and agricultural adaptation

Due to changing precipitation patterns, water retention and soil moisture conservation are becoming increasingly important in Finland. The National Adaptation Plan has a separate chapter on the water management challenges facing agriculture [1].

The main measures are:

- creation of natural water retention areas,
- increasing the organic matter content of soil,
- using climate-resistant plant varieties,
- precision farming.

The aim is to reduce the risk of drought and nutrient leaching.

Summary

Finland's climate adaptation practices are integrated, scientifically based and strongly community-focused. Key factors for success:

- nature-based urban planning,
- climate-resilient forestry,
- involvement of indigenous communities,
- data-driven infrastructure planning,
- water retention-based agricultural adaptation.

The Finnish model shows that adaptation is not just a technical issue, but a process based on social cooperation, scientific data and long-term strategic thinking.

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France

1. Introduction

Due to its geographical diversity – Atlantic coastline, Mediterranean region, Alpine mountains, continental interior regions – France is particularly complex in terms of climate change impacts. The following are becoming increasingly common in the country:

- intense heat waves (especially in urban areas),
- severe droughts in southern France,
- heavy rainfall and flash floods,
- coastal erosion and sea level rise,
- the retreat of Alpine glaciers.

The 2003 heatwave, which caused more than 15,000 deaths in France, marked a turning point in the development of adaptation policy. France launched its first National Climate Adaptation Plan (PNACC) in 2011, which has since been updated several times. The current strategic direction is PNACC3, which already anticipates a +4°C warming scenario [1].

2. National strategic framework

PNACC3 – Preparing for +4°C

PNACC3 is based on five strategic pillars:

1. Protecting the population (heat waves, floods, extreme events)
2. Increasing territorial resilience,
3. Adaptation of economic sectors,
4. Protecting natural and cultural heritage,
5. Social mobilisation and education.

The plan stipulates that all territorial development documents must consider the +4°C climate scenario [1].

Green budget

In 2021, France introduced a 'green budget' system, which assesses all government spending from an environmental perspective. In the 2024 budget, €7 billion has been earmarked for environmentally friendly investments [2].

This tool ensures that climate adaptation is not an isolated project, but part of budgetary policy.

3. Urban climate adaptation

3.1 Paris – Reducing the heat island effect Cool Islands programme

More than 800 'cool islands' (îlots de fraîcheur) have been created in Paris in the form of parks, water features, public buildings and shaded areas. These are 2-4°C cooler than the surrounding streets [3].

Oasis Project – Schoolyard Transformation

670 schoolyards were examined and the areas that overheated the most were greened: water-permeable pavements, trees and shade were used [4].

15-minute city concept

The aim of the 'Ville du Quart d'Heure' is to make all essential services accessible within 15 minutes on foot or by bicycle. This reduces transport emissions and increases urban resilience [5].

3.2 Toulouse – 'Toulouse + Fraîche'

The city has introduced more than 30 adaptation measures:

- installation of shade structures,
- water-permeable pavements,
- planting 100,000 trees by 2030,
- urban temperature monitoring system.

Data-driven urban planning helps to reduce the heat island effect [6].

3.3 Rouen – Luciline eco-neighbourhood

The Luciline neighbourhood uses an integrated water management system:

- open rainwater drainage,
- water-permeable pavements,
- green roofs,
- geothermal energy,

- solar panels.

The project was part of the EU Future Cities initiative [7].

3.4 Grenoble – EU Green Capital

Grenoble was awarded the title of EU Green Capital in 2022. The city:

- reduced its emissions by 25% between 2005 and 2016,
- expanded its cycling infrastructure,
- carried out energy-efficient renovations [8].

4. Nature-Based Solutions

Lez river basin (Montpellier region)

In the Lez river basin:

- green roofs,
- rain gardens,
- water-permeable pavements,
- restoration of natural floodplains

help reduce the risk of flooding and drought [9].

5. Regional adaptation

Météo-France – Climadiag tools

The Climadiag Commune and Climadiag Agriculture tools provide location-specific climate data to local authorities and farmers [10].

Mediterranean region – Drought management

In southern France:

- water restrictions,
- modernisation of irrigation systems,
- use of drought-tolerant crops.

The community-based approach to water management is also gaining ground [11].

Coastal erosion

According to CEREMA forecasts, more than 500,000 hectares of coastal areas could be affected by 2100. Local authorities:

- building restrictions,
- natural defence systems,
- planned retreat [12,13].

6. Health adaptation – Heatwave Plan (Plan Canicule)

INSERM and public health authorities operate a heat alert system:

- drinking water points,
- media information,
- registration and support for elderly people [14].

7. Energy and adaptation – The role of nuclear energy

More than 60% of France's electricity production comes from nuclear energy [15]. Nuclear energy is:

- stable, low in carbon emissions,
- increases energy security,
- reduces import dependency.

At the same time, heat waves can pose a challenge to cooling water systems, which is why new cooling technologies and SMR developments are underway [16].

Summary

France's climate adaptation policy operates on several levels:

- National Strategy (PNACC3),
- Green budget,
- Urban innovation (Paris, Toulouse, Rouen, Grenoble),
- Nature-based solutions,

- Regional water management,
- Health protection,
- Energy security.

The French model takes an integrated, science-based and regionally differentiated approach. Planning for a +4°C scenario is particularly forward-looking.

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Greece

Introduction

Greece is one of the European Union member states that is particularly vulnerable to the effects of climate change due to its geographical location. In recent years, prolonged heat waves have become increasingly common – in 2021, for example, temperatures of 47 °C were recorded – as have droughts, water shortages, forest fires and floods associated with intense rainfall, as well as sea level rise [1].

In 2016, Greece adopted its National Climate Management Strategy, which aims to identify climate risks and define specific measures [2]. The main elements of the strategy are also detailed in a document published by the Bank of Greece [3]. Adaptation to climate change has been planned not only at national level but also at regional level, taking into account the vulnerability of each region.

Climate risks have also been incorporated into the preparation of public investments. When planning new ports, roads or energy supply systems, future temperature and environmental risks are assessed in advance, in line with the guidelines of the European Environment Agency [4].

Water management

A significant part of Greece is threatened by drought and water shortages. The country has launched integrated water management projects to make more efficient use of water resources [5]. Smart water monitoring systems use digital tools to track water consumption and losses. One important tool for managing water scarcity is seawater desalination, which provides drinking water on several islands. According to the OECD's economic analysis, these investments contribute to maintaining economic stability [6].

Agriculture

In agriculture, the spread of climate-resilient crop varieties, such as olive trees and grapes, has reduced crop losses due to drought. The FAO's climate-smart agriculture guidelines also support such adaptation solutions [7]. These measures have improved the competitiveness and income security of the sector, as highlighted in the OECD report [6].

Forest fire protection

Greece uses the European Union's Copernicus satellite monitoring system for rapid detection and prevention of forest fires [2,4]. It also operates drone reconnaissance and early warning

systems, with an emphasis on prevention.

Urban adaptation – Athens

Athens was one of the first cities in Southern Europe to develop an independent urban climate adaptation strategy [8]. The heatwave action plan aims to reduce the urban heat island effect through the use of green roofs, green walls and cooling pavements [9].

Coastal protection and health

To protect against sea level rise, coastal protection barriers and sand buffer projects have been implemented, as discussed in the European Parliament's analysis [10]. Heat alert systems have been introduced in the healthcare system and cool shelters have been set up. According to a report by the European Investment Bank, these types of climate-resilient investments increase social and economic resilience [12].

Summary

Greece's climate adaptation strategy is based on an integrated, multi-sectoral approach. The monitoring systems, forecasts and targeted investments that have been implemented have contributed to reducing water shortages, maintaining agricultural stability, preventing forest fires and making tourism more sustainable.

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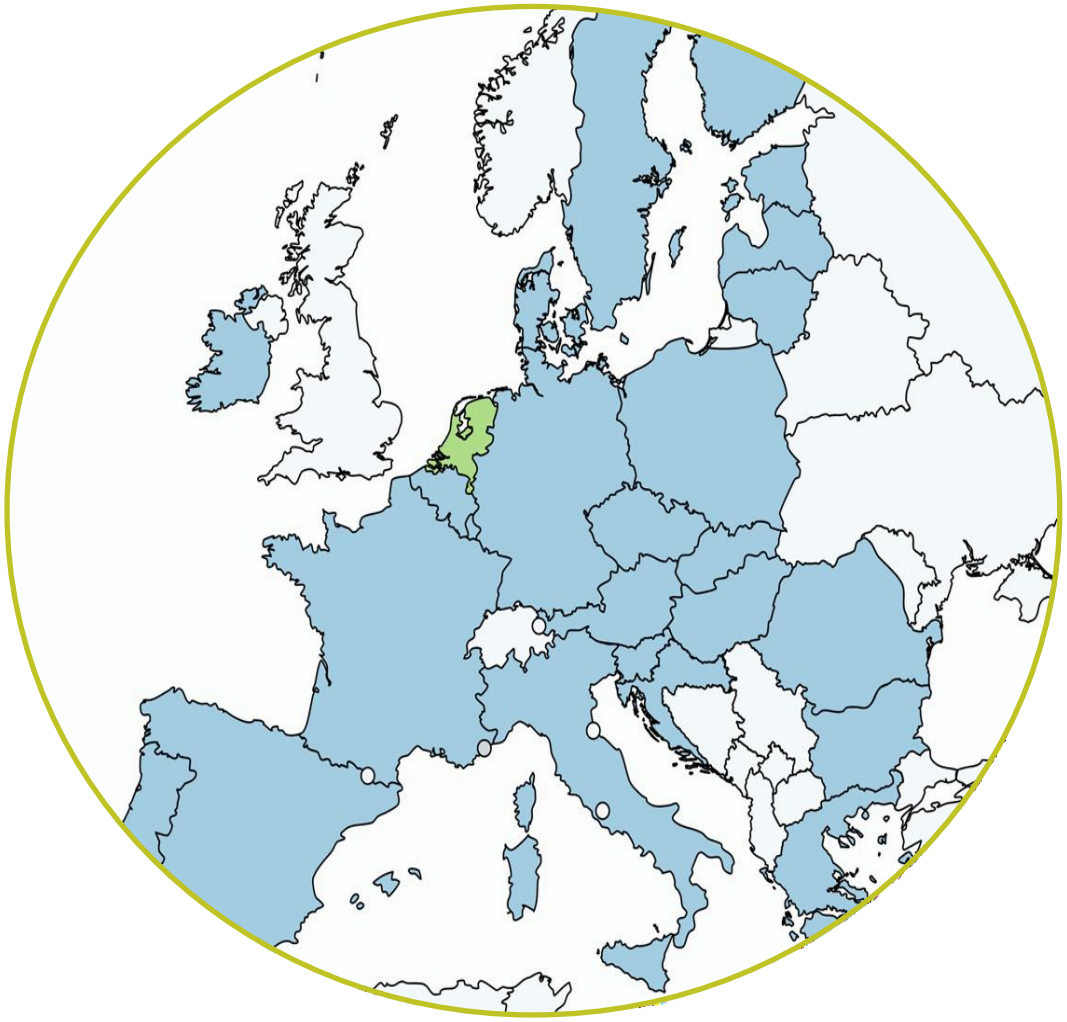

Netherlands

1. Introduction

The Netherlands is one of Europe's most climate-vulnerable countries, with around one third of its territory below sea level and a further significant proportion located in flood-prone delta regions [1]. Located in the Rhine-Main-Scheldt delta region, the country is particularly vulnerable to sea level rise, storm surges and river flooding.

As a result of climate change, the frequency of extreme precipitation events, heat waves and droughts is also increasing in Western Europe [1]. The Netherlands therefore treats adaptation not only as an environmental policy issue, but also as a national security, economic and social priority.

2. National strategic framework: Dutch Delta Programme and NAS

2.1. Delta Programme

A central element of the Netherlands' climate adaptation policy is the **Delta Programme**, a long-term flood protection and water management strategy looking ahead to 2100 [2].

The programme has three main objectives:

1. Ensuring flood safety
2. Sustainable management of freshwater resources
3. Climate-resilient land use and urban development

The Delta Programme aims to strengthen the country's flood protection, secure freshwater supplies, prepare for sea level rise and make the whole country climate-proof by 2050. The programme is part of a strategy that responds to the effects of climate change (floods, droughts, heat waves, extreme weather). Its tools include modern flood gates, flexible water level control and the integration of nature-based solutions.

Movable barriers – Deltawerken

The flood prevention project was designed to last 200 years and, although officially completed in 1997, it is constantly being improved. Under the Delta Plan/Delta Works, launched after the 1953 disaster, approximately 4,600 km² of land was reclaimed from the 6,000 km² that had previously been covered by water. The aim of the plan was, on the one hand, to protect south-western Holland and, on the other hand, to improve the distribution of sea and river water through the construction of dams in order to prevent salt concentration, which is harmful to

agriculture and human needs.

The most important and the most expensive part of the Delta Plan was undoubtedly the construction of the Oosterschelde dam (a total of 13 dams were built), for which the most modern technology was used. The dam was completed in 1986 after 10 years of work. However, the most interesting feature is undoubtedly the Maeslantkering, a movable barrier connected to the storm surge barrier at Hoek van Holland. The three-part "ecological" storm surge barrier is almost 3 km long and has 63 movable gates, each 240 metres wide. The gates generally remain open but can be closed in adverse weather conditions. Moreover, there is no other barrier in the world that consists of such huge movable parts.

The barrier was designed to serve generations for the next 200 years. Its handover also marked the official completion of the Delta works. Its annual operating cost is €17 million, which is the price of the safety of hundreds of thousands of people. The Delta Programme includes annually updated reports and a financial framework (Delta Fund) that provides stable funding for adaptation investments [2].

The Dutch government regularly reviews and updates the country's water management and regional plans to ensure that people and infrastructure are safe in the event of sea level rise and extreme weather. The programme is based on cooperation between local, county and national organisations and involves scientific institutes, civil society organisations and companies. This example illustrates how a country can build a systematic, practical adaptation mechanism to address the effects of climate change, not only through theoretical plans but also through concrete measures [3].

The Delta Programme includes annually updated reports and a financial framework (Delta Fund) that provides stable funding for adaptation investments [2].

2.2. National Climate Adaptation Strategy (NAS)

The *National Climate Adaptation Strategy (NAS)* aims to integrate climate risk management into infrastructure, agriculture, nature conservation and health care [4]. The strategy emphasises the principle of "climate-proofing", i.e. that all new investments must take future climate risks into account.

The Netherlands has not only introduced specific solutions but has also built a knowledge base for climate adaptation. The Climate Adaptation Platform Netherlands knowledge transfer portal contains a wealth of case studies, practical examples and tools on climate impacts,

floods, droughts, heat waves and urban drainage. This reflects the fact that the Netherlands not only implements projects, but also continuously learns and shares knowledge that can be useful to other countries.

3. Flood protection and delta management

3.1. Room for the River programme

One of the best-known Dutch examples is the national programme called 'Room for the River', which was launched after the major floods of the 1990s. Instead of further increasing the height of the dykes or further narrowing the riverbeds, the Dutch government introduced a radically new approach: they gave the rivers back their space. The aim of the project was to allow rivers to overflow their banks in a controlled manner during periods of high-water flow, thereby preventing catastrophic flooding. During implementation, dykes were moved, new floodplains were created, some buildings were relocated, and areas were freed up that could be used as temporary reservoirs during rainfall. The initiative not only increased safety but also improved the ecological condition and created new recreational green spaces. The long-term social and economic benefits of the project are significant, and other European countries have since adopted the principles of the programme.

The *Room for the River* programme represented a paradigm shift from traditional dyke reinforcement. Instead of simply strengthening the dykes, space was provided for rivers during flood waves [5].

The measures included:

- widening floodplains
- opening upside branches
- moving dams further back
- creating flood reservoirs

As a result of the programme, flood risk has been reduced while the ecological condition of the landscape has improved [5].

3.2. Room for the River programme

Another spectacular practice in the Netherlands is the development of floating infrastructure, which represents an innovative rethinking of urban space use. Due to climate change, rising

water levels are becoming more common, so one response to adapting to water is to create residential areas that do not fight against water, but live with it. The best-known example is in Amsterdam, where the **Schoonschip community lives on about thirty energy-independent houseboats.** These homes run on solar energy, collect rainwater, compost waste, and organise their infrastructure on a community basis. The concept of floating neighbourhoods not only provides a housing solution but also allows for flexible adaptation to changes in water levels in the long term. The Dutch approach to architecture and urban planning is based on cooperation with water rather than rejection of it, which represents a paradigm shift compared to the classic, defence-based approaches of other countries.

One example of green innovation in the Netherlands is the Floating Farm Rotterdam in the port of Merwe, the world's first floating farm. The floating farm's feed is provided by organic waste from the city of Rotterdam, rain provides the necessary water, and solar and wind energy provide electricity. The work is done by robots. The manure is loaded onto barges and transported to the fields. This is the world's first floating farm to operate with minimal emissions.

3.3. Maasvlakte 2 and coastal protection

The Maasvlakte 2 project in the Rotterdam area has implemented innovative coastal protection and sand replenishment solutions that integrate natural breakwater systems [6].

4. Innovative coastal protection solution: Sand Motor

One of the unique elements of the Netherlands' climate strategy is the use of nature-based solutions. An increasing number of projects in the country are based on the principle that nature's self-regulating capacity should be supported rather than artificially replaced. One such example is the Sand Motor project embodies a new approach to coastal protection. Instead of carrying out expensive and energy-intensive sand replenishment on the beach every year, a huge amount of sand was placed at once in a protruding, peninsula-like formation near the coast. Currents and wind then gradually spread this sand mass along the surrounding coastline, naturally strengthening and shaping the shoreline. This innovative method is cost-effective, sustainable and environmentally friendly, as it reduces the need for mechanised interventions while adapting to the dynamics of nature.

The *Sand Motor* (Zandmotor) is a nature-based coastal protection intervention in which large quantities of sand were deposited along the coast and then left to be distributed by natural

currents [7].

The aim of the project is to

- to reduce coastal erosion
- restore the ecosystem
- creation of recreational areas

The solution is a cost-effective and ecologically sustainable alternative to traditional engineering interventions [7].

5. Urban climate adaptation

5.1. Rotterdam Climate Initiative

Rotterdam is one of the world's leading cities in climate adaptation. As part of the *Rotterdam Climate Initiative*:

- water plazas
- green roofs
- floating buildings
- flood-resistant infrastructure have been implemented [8]

Water plazas function as community spaces during normal periods, while serving as temporary reservoirs during periods of heavy rainfall.

Climate adaptation is also a particular focus at the urban level in the Netherlands, primarily through the example of Rotterdam. The city is one of Europe's largest seaports and is therefore particularly affected by sea level rise and increased precipitation intensity. Rotterdam has developed a comprehensive programme called "Climate Proof", which aims to make the city fully resilient to the effects of climate change by 2025.

Part of this, the city is placing great emphasis on the installation of green roofs, which can retain rainwater, improve air quality and cool the urban microclimate. In addition, special water collection areas have been created: these public spaces function as sports fields or community spaces during dry periods but serve as reservoirs during heavy rainfall. One of the best-known examples of this is the Benthemplein water area, which offers a spectacular and useful solution for water utilisation in an urban environment. Rotterdam's good practices

prove that climate adaptation is not just a technological or engineering issue, but a complex strategy that considers urban planning, community and environmental considerations.

5.2. "Sponge City" – Making cities sponge-like [9]

The Sponge City concept is also an important climate adaptation practice in the Netherlands, as it offers practical, nature-based solutions for dealing with sudden rainfall and flooding in urban areas. The use of urban green spaces, permeable pavements and rainwater retention systems helps to mitigate the extreme weather effects caused by climate change.

The aim is for cities not to quickly drain away rainfall, but to retain it locally, allow it to seep away and make use of it. This is particularly important due to the sudden, heavy rainfall that is becoming increasingly common as a result of climate change, which can cause urban flooding.

Several cities in the Netherlands, such as Rotterdam and Amsterdam, are implementing elements of the sponge city as part of their climate adaptation measures. In practice, this means solutions such as water-permeable pavements, green roofs, rain gardens (which mitigate flash floods and the heat island effect), and the creation of public spaces that also function as temporary water reservoirs. These measures reduce the risk of flooding, relieve the burden on the sewerage system and help to mitigate the urban heat island effect.

The advantage of the sponge city approach is that it is not only environmentally friendly but also economically efficient, as it reduces the long-term costs of flooding and infrastructure damage. The Sponge City concept is therefore an important and effective element of climate adaptation practice in the Netherlands.

In the Netherlands, rising sea levels, the sustainability of the food industry, the housing needs of the population and the limited space available have all encouraged city leaders in recent years to develop new, sustainable urban solutions and green city concepts.

In a figurative sense, the "greening" of cities often begins with greening in the literal sense, i.e. increasing the amount of vegetation, which also helps to reduce the problems caused by climate change and the public health effects of global warming. The overheating of cities is an increasingly well-known problem. In response to this global issue, the Netherlands is attempting to physically break the dominance of artificial surfaces.

Amsterdam and Rotterdam are good examples of greening efforts. The two cities have started replacing paving stones and decorative coverings in public spaces with vegetation: in 2021,

46,484 paving stones were removed in Amsterdam to make way for greenery, while Rotterdam won the competition with 47,942 paving stones. Rotterdam plans to create 20 hectares of green space by the end of 2022, of which the removal of paving stones accounts for only half a hectare. Therefore, the city has to find the "hardest metres" elsewhere – and they already have a proven practice for this: rooftops.

DakAkker, Europe's first real rooftop farm, was launched in 2012. It is located on the roof of an L-shaped building in the city centre, covered with 10-40 cm of soil. The "smart roof" is equipped with environmental sensors and water storage systems, and the farm produces a range of vegetables, has a beekeeping operation and even keeps chickens above the city.

One of Eindhoven's pride and joys is the Strijp-S district, which has been converted from a former Philips industrial park into an urban community and residential area.

In Tilburg, the goal is to "turn the grey city green". The Rosmolen neighbourhood, for example, has been completely renovated in recent years: many flats in the former working-class neighbourhood have been modernised and the spaces in between have been transformed into green corridors. In addition to its green industrial area renovation programme, Tilburg also has a "blue" project: the former industrial park around Piushaven (Pius Harbour) was also a typical, abandoned rust belt area. But here too, the transformation into a liveable residential area has already begun, with land use planning and new architectural solutions.

In Rotterdam, the Benthemplein "water space" has created a pioneering, metropolitan artificial water system with its cleverly designed, pool-like solutions: in dry weather, it is a community area and basketball court, but during heavy storms and lightning strikes, the depressions immediately transform into reservoirs, and the rainwater flows directly into the reservoirs under the square, from where it can be used for a variety of purposes on dry days.

Roof gardens and other green areas are naturally much more suitable for water retention than paved and asphalted spaces. Rotterdam is now launching the Dakdorpen ("Roof Village") programme: compact, sustainable residential buildings will be installed on reinforced roofs alongside gardens. The aim here is for water-retaining roof gardens to also generate income, thus putting urban greening on a more stable financial footing.

5.3. Climate-adaptive urban planning

The faster-than-average global warming in the Netherlands and the increasing urban heat island effect pose significant health risks, increasing energy demand and economic burdens,

which complicate the situation for the state and businesses. Climate risks, such as sea level rise, extreme precipitation, drought and heat waves, threaten the country's economic resilience not in isolation but in combination. Addressing these complex challenges is not only a matter of national environmental policy but also a fundamental condition for maintaining international economic stability and competitiveness.

Dutch cities, particularly Rotterdam, are implementing several innovative solutions, such as green roofs, water retention systems and the creation of multifunctional urban spaces. Furthermore, the city of Arnhem has set a pioneering example with a ten-year plan to remove 10% of the city's asphalt surfaces and replace them with grass, trees and water-permeable surfaces. This

The "broken concrete" strategy not only helps to retain 90% of precipitation locally, but also significantly cools the surrounding air through evaporation, directly mitigating the heat island effect. Green roofs and water-retention surfaces help to reduce the risk of flooding and mitigate the urban heat island effect, which is particularly important during summer heatwaves. These measures not only bring environmental benefits, but also improve the quality of urban life and increase investor appeal, which can translate into long-term economic benefits. Another strength of the Dutch model is the stability of its institutional and financial background.

Another exciting project in Amsterdam is the RESILIO (Resilient City Living Infrastructure) programme, which aims to install smart green roofs. Under the programme, roofs are designed to collect data on soil moisture and weather conditions using sensors and then use algorithms to control when stored water is drained or recycled to vegetation. The technology is also capable of "prepare" for heavy rainfall, for example by automatically releasing previously stored water to make room for new precipitation. The smart roofs work together as a network, coordinated at the city level, which takes adaptability to a new level.

In 2020, the city of Utrecht embarked on a major greening project. They began planting greenery on lower roofs and installing solar panels on higher ones. The first step was to plant vegetation on the roofs of bus stops. The local government offered significant grant support to homeowners for these green projects, covering 50 per cent of the costs up to €20,000 per application.

The most spectacular feature was the "vertical forest" created from a tower block near the railway station. The walls, balconies and roof of the building were covered with around 10,000

plants, representing approximately one hectare of forest. According to the investors, it can absorb 5.4 tonnes of carbon dioxide and produce 41 tonnes of oxygen per year. The technical handover took place in October 2024, and the official opening was held on 13 February 2025. In March 2025, it won the prestigious MIPIM Award in the category of the world's best mixed-use building.

Amsterdam has also taken similar steps towards greening. Tens of thousands of square metres of "blue-green" roofs help to store rainwater and cool the environment. The essence of this is that rainwater storage tanks have been installed alongside the vegetation, thus making double use of the area. Carbon dioxide absorption purifies the city's air, while the plants produce oxygen and the rooftops also function as bee pastures.

Significant innovations have also been introduced in the field of housing. The first **so-called "amphibious houses"** were built in the town of Maasbommel**.** These are houses that function as traditional buildings under normal circumstances, but when flooding reaches the area, the building is able to rise above the water. The structure rests on a concrete platform supported by vertical piles, so that the building remains stable even when it rises. This type of housing can be particularly useful in areas where regular flooding is unavoidable in the long term and where the costs of traditional flood defences are no longer justifiable. The Dutch water authorities and local governments not only support the implementation of such projects, but also actively participate in their planning and development to ensure social acceptance as well as housing security.

What makes the Dutch approach unique is that it does not provide isolated, ad hoc responses to problems, but takes a systemic approach to climate change. Water management experts, urban planners, engineers, community organisers and political decision-makers work closely together to ensure that adaptation measures are not only technically effective but also meet the needs of local communities. Social participation is emphasised:

Before every major project, extensive consultations are held with residents, civil society organisations and businesses.

5.4. Amsterdam Rainproof

The *Amsterdam Rainproof* programme aims to retain rainwater locally through green roofs, permeable pavements and resident participation [10].

6. Heatwave adaptation

Heat waves have become increasingly common in the Netherlands, especially in urban heat islands [1]. The National Heat Plan ensures coordinated action by the health system and local authorities [11].

7. Climate-resilient agriculture and water management

There are also notable examples of good practice in agriculture. Dutch agriculture is technologically advanced on a global scale and, in the spirit of adaptation, is increasingly moving towards sustainable, water-efficient and energy-efficient production. Greenhouse cultivation, for example, not only increases crop yields, but also enables water recycling, rainwater harvesting and heat energy optimisation. Precision farming allows farmers to use satellite and sensor data collection to accurately monitor crop needs, thereby reducing water and fertiliser use. This is particularly important in the context of climate change, as extreme weather events such as droughts or floods directly threaten food supplies.

Another dimension of Dutch practices is that climate adaptation is not just about water management. For example, Dutch horticulturalists are using new equipment that reduces harmful emissions to the plant environment and provides a more favourable microclimate.

This also shows that climate adaptation is not just about large infrastructure projects, but that practical solutions can be found in all economic sectors.

The management of freshwater resources is a key issue for the country. The Delta Programme Freshwater sub-programme aims to prevent saltwater intrusion and optimise irrigation systems [2].

'Manure as a green engine' project [12]

This project was an initiative that focused on agricultural by-products, mainly animal manure, as a renewable energy source and circular economy tool. Its aim is to ensure that manure is not considered waste, but a valuable raw material from which energy, fertilisers and other useful products can be produced using various methods, such as:

- biogas production: biogas is produced from manure through anaerobic fermentation (decomposition without oxygen)

  which is used to generate heat and electricity

- nutrient recovery: nitrogen, phosphorus and potassium are extracted from manure and

  reused as fertiliser

- **carbon dioxide reduction:** the use of manure for energy reduces carbon dioxide emissions and methane emissions.

Since methane makes agriculture one of the largest greenhouse gas emitting sectors, using manure for energy production reduces methane emissions, increases energy security (renewable energy), and reduces the use of artificial fertilisers, which also results in lower emissions.

In the Netherlands, hundreds of farms have already participated in such projects, installing small-scale biogas plants on their farms and setting up regional manure processing centres where manure is treated centrally rather than locally.

Social participation and climate awareness

Social participation also plays a prominent role in the Netherlands' climate adaptation efforts. The government has recognised that sustainable results can only be achieved in the long term if the population understands and supports the changes. To this end, various programmes, campaigns and local forums are in place to involve citizens in decision-making and encourage adaptation at the individual level. One example is the

"Operatie Steenbreek" initiative, which encourages city dwellers to replace paved surfaces around their homes with green plants. This practice helps rainwater to drain away, reduces the heat island effect and makes the urban environment more liveable. Community movements such as this raise social awareness and strengthen citizens' commitment to environmental protection.

Public involvement, open data platforms and innovation partnerships (triple helix model) play a key role in strengthening climate resilience [13].

The Dutch education system also plays an important role in laying the foundations for adaptation strategies. Schools provide environmental education from a very young age, so that the next generations will find it natural to recognise and address climate change issues. In addition, research institutes operating in higher education, such as Wageningen University, play a leading role globally in research on sustainable agriculture, food security and water

management. These institutions share their findings not only nationally but also internationally, thereby facilitating adaptation in other countries.

Summary

Based on the above, the Netherlands is not approaching climate change adaptation in isolation, but rather at a systemic level. Good practices are not just technological responses, but part of a complex social, economic and cultural transformation. One of the greatest advantages of the Dutch model is that it is not static: it is constantly evolving, experimenting and open to new solutions. This openness, flexibility and long-term thinking can serve as an example for other countries that are just beginning their own climate adaptation journey.

The Dutch climate adaptation model:

- long-term (planned until 2100),
- institutionally stable and funded,
- combines nature-based and engineering solutions,
- highly integrated into spatial planning,
- serves as a reference model at the international level.

The country's practice is particularly relevant for states affected by sea level rise.

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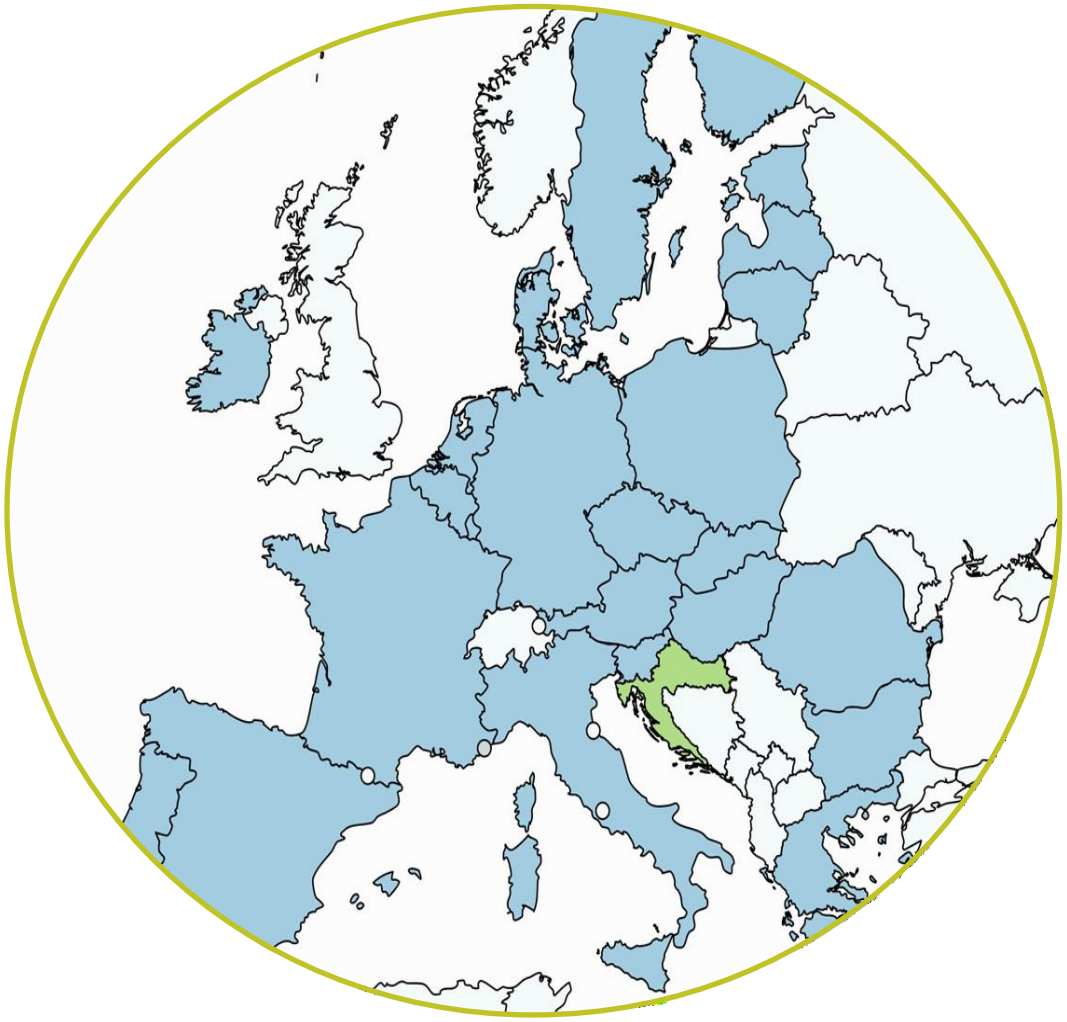

Croatia

Introduction

Croatia faces increasing frequency and severity of climate change risks, including heat waves, floods, droughts and intense precipitation. Southern European and Mediterranean climate impacts affect coastal areas, agriculture and ecological systems, while economic activities (tourism, forestry, food supply) are highly vulnerable [1]. Croatia has therefore developed a comprehensive national strategy for adaptation to climate change, which aims to increase the resilience of social, economic and environmental systems, reduce risks and promote sustainable development for the period 2040-2070 [2].

1. National climate adaptation strategy and legal framework

Croatia's first official **National Strategy for Adaptation to Climate Change until 2040 (with an outlook to 2070)** was adopted in April 2020. This strategic document provides a comprehensive overview of climate risks, assesses vulnerable sectors (agriculture, water management, energy, tourism, health) in detail and proposes a roadmap for adaptation measures [2].

Part of the adaptation strategy is the **Climate Regulation (2019)**, which requires authorities to report every two years on the impacts of climate change and to monitor relevant adaptation activities [3]. The national strategy emphasises **cross-sectoral integration**, the involvement of local communities, climate impact forecasting and a combination of nature-based and structural measures. In addition, Croatia participates in community cooperation within the framework of the EU's climate adaptation strategy, which calls for smarter, more systematic and faster adaptation in the countries concerned.

2. Climate impacts and risk assessment

According to the latest data, Croatia suffers high economic losses due to extreme weather events, mainly floods, droughts, storms and heat waves. These cause serious damage to agriculture, tourism, energy supply and biodiversity, while coastal areas are particularly vulnerable to the effects of sea level rise and storms [1]. Detailed modelling and forecasting of the effects of climate change is a central element of the national strategy, including temperature changes, changes in precipitation patterns and an increase in the frequency of extreme events for the period 2040-2070 [2].

3. Urban climate adaptation practices

Zagreb – managing heat stress with green infrastructure

A good example of combating climate heat stress and the urban heat island effect can be found in Zagreb, where the city identified the most affected areas using heat mapping analysis. As part of the strategy, experimental green infrastructure and nature-based solutions were introduced: parks, tree-lined avenues, green corridors and canopy-covered public spaces reduce urban heat while improving quality of life and air quality [3].

This project is a good example of how local urban planning can be integrated with climate adaptation goals, while also giving an important role to social participation and scientific cooperation (e.g. involving local universities).

4. Integrated spatial planning – the example of Karlovac

The Croatian city **of Karlovac** has taken an innovative approach to climate adaptation by integrating it into spatial planning: new zoning regulations have been introduced that prohibit the use of fossil fuels for heating and require connection to renewable energy sources or district heating [4].

The plan also requires the incorporation of **green infrastructure** – green roofs, rainwater retention systems, permeable pavements – which not only directly reduces flooding and heat stress, but also promotes urban biodiversity and sustainable urban development.

5. Nature-based and community-based climate adaptation tools

Croatia also has regional platforms such as **AdriAdapt**, which offers integrated climate adaptation planning tools, guidelines, examples and adaptation options for cities and municipalities in the Adriatic region [5].

These platforms are particularly useful for local decision-makers, as they provide detailed steps from risk assessment through planning to implementation, involving community actors, civil society organisations and the general public.

6. Research-oriented projects

The COMMITMENT project in the field of tourism and climate adaptation uses an effective scientific approach to examine the effects of climate change and develop the resilience of tourist destinations. The project identifies specific hazards, vulnerabilities and adaptation opportunities through measurement and assessment tasks [6]. This facilitates the coordination of climate and tourism policies, which is particularly important in Croatia, where tourism is a significant economic sector.

7. Water management and cross-border practices

Along the Drava River, a Hungarian-Croatian Interreg project, **DRAVADIKE & CLIMATE CHANGE**, aims to examine and modernise shared flood protection embankments. The project aims to reduce flood risks, protect natural habitats and develop sustainable water retention solutions, all in close international cooperation [7].

8. Summary

Croatia's adaptation strategy **is integrated, multi-sectoral and adaptable at the local level**. The national strategy, urban adaptation practices (e.g. Zagreb and Karlovac), regional tools (AdriAdapt) and EU-level cooperation all contribute to increasing the country's climate resilience. The integration of nature-based solutions, community involvement and scientific projects keeps Croatia's climate adaptation on a path that not only mitigates damage but also promotes socio-economic sustainability.

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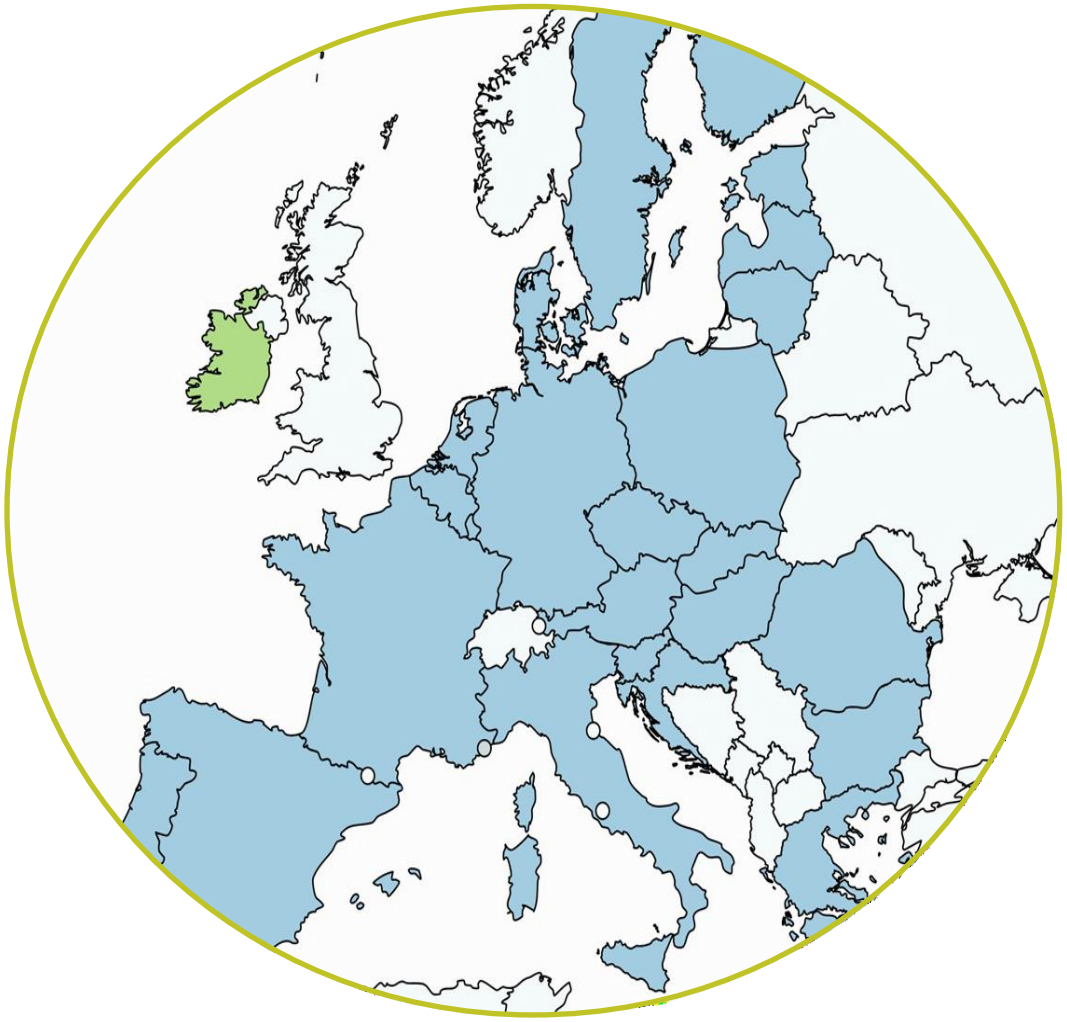

Ireland

Introduction

Ireland joined the European Union in January 1973 and has since been actively involved in joint climate policy and adaptation initiatives. The legal and strategic basis for climate adaptation was established by the Climate Action and Low Carbon Development Act (2015). This was followed by the National Adaptation Framework (NAF, 2018) and then the Climate Action Plan 2019 [1], the latest version of which was published in 2025 [2]. Sectoral adaptation plans have been approved by the Department of Climate, Energy and the Environment, ensuring that each sector is specifically prepared for the effects of climate change [3].

Due to its geographical location, Ireland is particularly vulnerable to sea level rise, coastal erosion and Atlantic storms. Expanding urban green spaces and transforming settlements in a climate-conscious manner, for example by developing green infrastructure, contributes to increasing adaptability [4].

National strategic framework

The basis for adaptation is provided by the Climate Action and Low Carbon Development Act (2015, amended in 2021), which imposes a legal obligation for long-term climate policy planning [5].

The National Adaptation Framework (NAF) sets out sectoral adaptation plans covering, among other things, the following areas [6]:

- transport infrastructure
- water management
- agriculture
- energy supply
- health
- biodiversity

Good practices

Flood protection and infrastructure development also feature prominently in national and sectoral plans approved at the government level [3]. The protection of coastal areas and energy infrastructure is a strategic priority in national climate policy [2].

Climate protection measures have been divided into 13 sectors so that each sector receives targeted measures. The main goal is to reduce greenhouse gas emissions and increase the share of renewable energy sources. The Climate Action Plan 2019 and its 2025 update set a target of 55% renewable energy by 2030 and the registration of around 500,000 electric vehicles [1,2].

During the modernisation of residential buildings, low-carbon heating systems are being installed and the use of renewable energy sources is being encouraged. These measures serve both to reduce emissions and to lower household costs [2].

In the transport sector sustainable mobility development – for example cycling infrastructure expansion – also part of the national climate plan [1].

In agriculture, Resilient Crop Systems research [7] and innovation programmes coordinated by Teagasc aim to increase the resilience of major fodder crops [7]. The farm resilience development programme also strengthens farm diversification and the resilience of agriculture [8,9]. The Pasture Innovations initiative also supports the development of sustainable agricultural practices [10].

To promote the circular economy, recycling and sustainable resource use are encouraged, which is also reflected in the national climate strategy [2].

As part of the forestry and biodiversity strategy, the National Biodiversity Action Plan 2023–2030 has been adopted, which aims to strengthen habitat protection and afforestation [11]. The Biodiversity Officer Programme provides professional support to local authorities for the implementation of nature conservation measures [12].

Summary

Overall, Ireland's climate policy focuses not only on reducing emissions, but also on adaptation, maintaining system stability and strengthening social participation. The Climate Action Plan 2019 and 2025 aims to achieve climate neutrality and ensure long-term sustainable and resilient socio-economic functioning [1,2].

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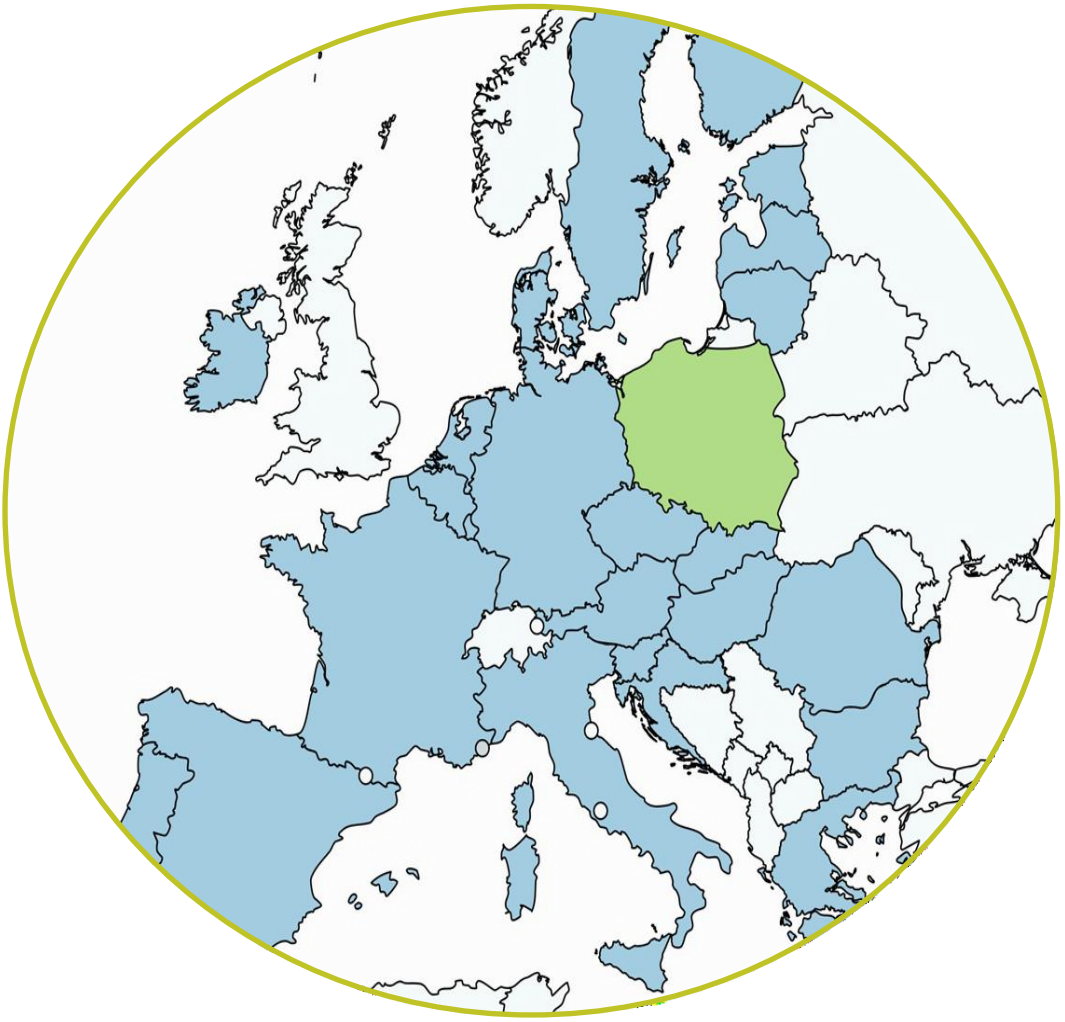

Poland

Introduction

The effects of climate change are becoming increasingly apparent in European Union countries, and Poland is no exception. The country is particularly vulnerable to extreme precipitation events, flash floods, heat waves and periodic droughts. In recent years, Poland has introduced a number of concrete, practical solutions to mitigate climate impacts. Several of these are nature-based interventions that simultaneously improve water management, the urban microclimate and the quality of life of the population.

The following section presents some of Poland's most notable and successful climate adaptation projects.

1. Moja Woda programme – residential water retention

One of Poland's most successful national adaptation programmes is the "Moja Woda" (My Water) initiative.

Under this programme, the state provides support to owners of family homes for the installation of rainwater harvesting systems.

- to install rainwater harvesting systems
- purchase of rainwater utilisation equipment,
- developing garden water retention solutions.

The aim is to reduce the effects of drought and retain rainwater locally. Decentralised water solutions help to mitigate both drought and flash floods, while enabling the population to become active participants in climate adaptation [1].

2. Rain gardens and 'climate gardens' – nature-based water management

Rain gardens and so-called "climate gardens" are becoming increasingly widespread in Polish cities.

The essence of a rain garden is

- a depression planted with plants
- collects rainwater,
- filters out contaminants,

- slowly returns water to the soil.

Advantages:

- reduces the load on the sewer system,
- reduces the risk of flooding,
- improves the urban microclimate,
- increases biodiversity,
- can be implemented on a lower budget.

This solution is a good example of the role of multifunctional nature-based infrastructure [2,3].

3. Wrocław GrowGreen project – pocket parks and green streets

One of Poland's most notable projects is the GrowGreen programme implemented in Wrocław.

In the densely built-up Olbin district, paved surfaces increased the heat island effect and the risk of flash floods. As part of the project:

- seven abandoned courtyards were converted into pocket parks,
- rain gardens and community gardens were created,
- semi-permeable pavements were used,
- A green tram stop was established. The results:
- nearly 15,000 m² of new biologically active surface area,
- improved rainwater retention,
- increasing biodiversity,
- increasing resident satisfaction.

The aim of the project was to simultaneously reduce heat stress and flood risk [3,4,5].

4. "Grey into Green" – greening schools and kindergartens

Wrocław also runs the "Grey into Green" municipal programme, which aims to green the courtyards of educational institutions.

The interventions include:

- breaking up paved courtyards,
- creating rain gardens,
- planting flower meadows and vegetable gardens

Effects:

- reduced amount of runoff,
- improved thermal comfort,
- strengthened environmental education.

The programme serves both climate adaptation and awareness raising [6].

5. The "sponge city" approach – integrated urban water retention

Some Polish cities are implementing the "sponge city" concept.

The essence of this approach is that the city should retain as much precipitation as possible:

- retain
- infiltrate,
- reuse.

To achieve this, they use:

- porous pavements,
- green roofs,
- rain gardens,
- water-retaining landscaping elements.

This integrated approach simultaneously reduces the risk of flash floods, the effects of drought

and the urban heat island effect.

Summary

Poland's climate adaptation practices offer several important insights:

- Retaining water locally is key.
- Nature-based solutions are cost-effective and multifunctional.
- A network of small-scale interventions can have a significant overall impact.
- Public participation increases the sustainability of projects.
- Education and awareness raising are essential for long-term success.

The example of Poland shows that the key to successful climate adaptation lies in the combined use of blue-green infrastructure, decentralised water management and community involvement. These solutions can also be easily adapted in Hungary, especially in the management of urban flash floods and heat waves.

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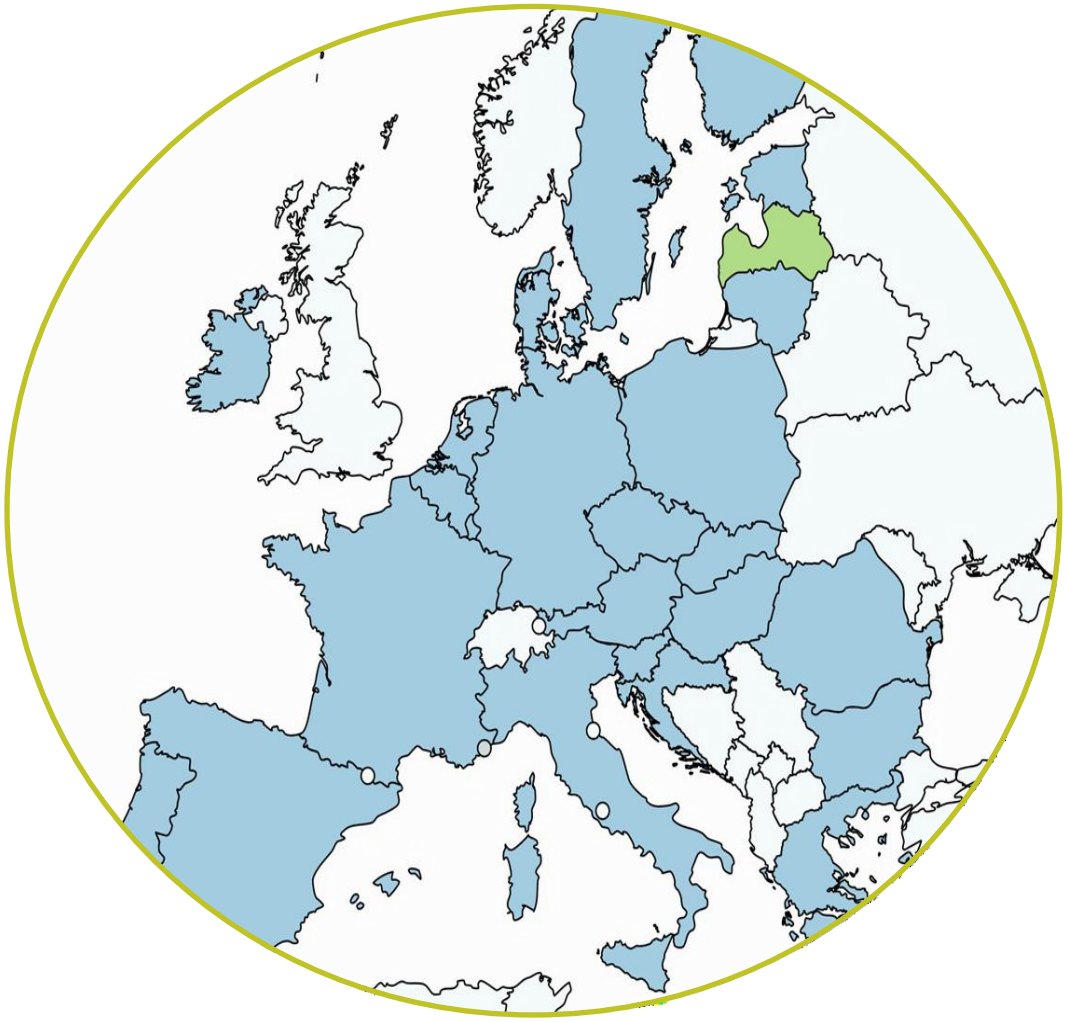

Latvia

Introduction

Due to its geographical location, Latvia is vulnerable to various effects of climate change: a long, varied coastline on the Baltic Sea, low-lying river valleys, and urban and agricultural areas that are at increased risk due to intense precipitation, spring thaws and coastal storm surges. According to the European Environment Agency [1], the risk of coastal flooding in the Baltic Sea region is expected to increase due to sea level rise and storm surges, while heat waves and extreme weather events will also become more frequent.

Latvia's climate diplomacy and policy framework is set out in the *Latvian National Climate and Energy Plan 2021–2030*, which aims to 'reduce the vulnerability of ecosystems and economic sectors to climate change' [2]. The EU's adaptation strategy emphasises that adaptation must be "smarter, more systemic and faster" [3], which in Latvia takes the form of integrated risk analysis, data-driven decision-making and the wider use of nature-based solutions.

Coastal adaptation and Baltic Sea risks

Latvia's coastal cities, such as Jūrmala and Liepāja, are particularly vulnerable to the effects of sea level rise and storm surges. The vulnerability of coastal settlements affects not only the protection of infrastructure and the population, but also the sustainability of tourism, port activities and nature conservation areas.

Good practices and specific projects:

- **Nature-based coastal protection:** Dune systems and sand replenishment programmes to stabilise the coastline, combined with native vegetation [2].
- **Coastal monitoring:** Development of digital risk maps and real-time water level monitoring systems [4].
- **Land use regulation:** The flood-prone areas, and infrastructure development and infrastructure development should be strictly regulated and integrated with local climate strategies.

These measures not only reduce immediate physical risks, but also strengthen the resilience of ecosystems and the sustainability of tourism values in the long term.

Flood management and integrated water management: Daugava River Basin

In terms of flood management, the restoration of floodplains along the Daugava River and the restoration of wetlands have yielded significant results. These nature-based solutions reduce peak flood levels, increase water retention, strengthen the resilience of ecosystems and mitigate the risk of urban flooding [1,4]. The floodplains along the Daugava River and the main catchment areas are subject to regular spring flooding. Restoring natural floodplains can "reduce peak flood levels and strengthen the resilience of ecosystems" [4].

Specific measures:

- Reconnecting floodplains to rivers to allow natural water retention.
- Natural water retention solutions in agricultural and wetlands.
- Development of hydrological monitoring systems for spring flood forecasting.
- Modernisation of flood protection infrastructure in cities and industrial areas [1].

This combination of nature-based and technical solutions improves the adaptability of settlements and agricultural areas.

Urban climate adaptation: the example of Riga

As a member of the Covenant of Mayors network, Riga has developed a SECAP document (Covenant of Mayors, 2023). The network emphasises that urban adaptation must "combine climate change mitigation and adaptation measures in an integrated framework" [5].

Good practices in urban adaptation:

- Development of green infrastructure, such as parks, green corridors and green roofs.
- Rainwater retention (Sustainable Urban Drainage Systems)
- Installation of energy-efficient buildings and means of transport.
- Usage of smart urban monitoring and digital data platforms for predicting climate risks.

These measures reduce the urban heat island effect, mitigate the risk of flash floods and increase the resilience of the population and infrastructure.

Forest management and nature-based adaptation

Latvia's forest cover exceeds 50% [6], which plays a prominent role in ecosystem-based adaptation and carbon sequestration. Adaptive forest management aims to increase the resilience of forests to extreme weather, pests and fires.

Practical measures:

- Planting mixed-species forests.
- Near-natural forest regeneration and experimental use of climate-resistant tree species.
- Restoration of wetlands and strengthening of flood protection functions.
- Integration of LIFE projects into local forest management and biodiversity programmes [7].

Energy transition and system resilience

Increasing the resilience of the energy system in Latvia is closely linked to decarbonisation and the spread of renewable energy sources. According to the International Energy Agency, "renewable energy sources are playing an increasingly important role in the energy mix" [8].

Specific measures:

- Increasing biomass and wind energy production.
- Strengthening the resilience of the electricity grid.
- Installing decentralised energy production systems, especially in coastal and rural areas.
- Diversifying energy import sources and implementing smart grid systems.

These measures will reduce dependence on fossil fuel imports, increase the stability of the energy system and support national decarbonisation goals.

Overall, Latvia's climate adaptation strategy takes an integrated approach, combining nature-based solutions, urban and rural adaptation, digital monitoring systems and the use of renewable energy sources. Coastal protection projects, the rehabilitation of floodplains and wetlands, urban green infrastructure and diversification of the energy system all contribute to increasing the country's resilience and mitigating the adverse effects of climate change [3,4,7].

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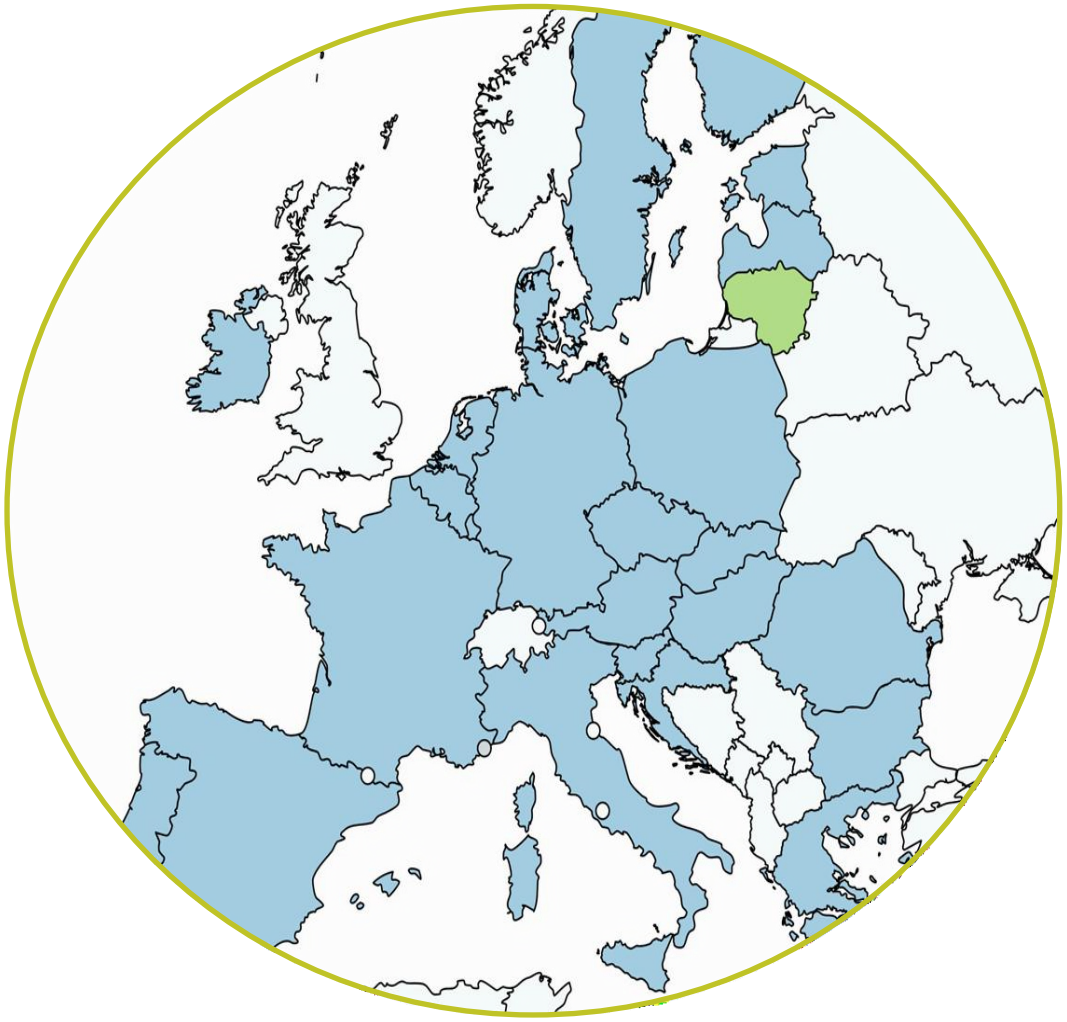

Lithuania

Introduction

Lithuania's climate vulnerability is mainly linked to the Baltic Sea coast, large river basins and the urban heat island effect. The European Environment Agency notes that the region is experiencing an increase in the frequency of heat waves, intense precipitation events and coastal flooding [1].

The Lithuanian National Climate Change Management Agenda aims to ‘reduce the vulnerability of ecosystems and economic sectors to climate change’ [2]. The European Union's adaptation strategy emphasises that adaptation must be 'smarter, more systematic and faster' [3], which in Lithuania is reflected in the strengthening of data-driven planning and the wider use of nature-based solutions.

Coastal adaptation and flood risk management

Latvia has a long coastline of around 500 km, and in the Baltic Sea region, "the risk of coastal flooding is expected to increase due to sea level rise and storm surges" [1].

Good practices:

- **Pāvilosta and Ventspils coastal protection investments:** nature-based solutions such as sand dune reinforcement and coastal wetland restoration (Latvian Coastal Protection Board, 2022).
- **Digital flood mapping:** real-time monitoring and open data platform a land use planning decision (Latvian Environmental Protection Agency, 2021).
- **Tightening of land use regulations** in coastal zones (Ministry of Environmental Protection and Regional Development of Latvia, 2018).

The Klaipėda and Curonian Spit regions are particularly vulnerable to coastal erosion and storm surges. According to the EEA, the risk of coastal flooding is expected to increase as a result of sea level rise and storm surges [1].

Specific investments and measures:

- beach nourishment programmes,
- stabilisation of dune systems with native vegetation,
- establishment of coastal monitoring systems,

- strengthening flood protection in port infrastructure [2].

In the case of the Curonian Spit, nature-based solutions play a key role, as stabilising the dune system serves both ecosystem protection and climate resilience.

Flood risk management in the Nemunas river basin

Regular spring floods occur in the **Nemunas Delta Regional Park**. According to Climate-ADAPT, restoring natural floodplains "can reduce peak flood levels and strengthen the resilience of ecosystems" [4].

In Lithuania, as part of integrated river basin management plans:

- floodplains have been reconnected to the main river channel,
- natural water retention areas have been created,
- adaptive land use systems have been introduced in flood-prone agricultural areas [2].

This approach reduces the intensity of flood waves and increases biodiversity.

Urban climate adaptation: Vilnius and Kaunas

Vilnius and Kaunas are implementing integrated climate adaptation and mitigation programmes within the framework of SECAP [5]. The Covenant of Mayors emphasises that municipal climate policy must implement mitigation and adaptation measures within an integrated, mutually reinforcing strategic framework [5].

Specific projects:

- green roofs on public buildings,
- creation of urban parks and green corridors,
- installation of rain gardens and permeable pavements,
- smart stormwater drainage systems,
- expansion of the electric bus fleet and development of low-emission transport infrastructure.

These measures reduce the heat island effect, mitigate the risk of flash floods and contribute to reducing greenhouse gas emissions.

Forest management and LIFE projects

Lithuania's forest cover exceeds 30% [6]. Adaptive forest management aims to mitigate the effects of pests, storms and droughts [1]. The aim of the projects implemented under the LIFE programme is to implement EU environmental and climate policy and to support the implementation of the European Union's environmental and climate policy [7].

Practical measures:

- planting mixed-species stands,
- near-natural forest regeneration,
- experimental use of climate-resistant tree species,
- preparation of regional climate risk maps for the forestry sector.

LIFE Integrated Project – LITAdapt

Lithuania participates in several integrated LIFE projects aimed at introducing adaptation measures at the systemic level. The aim of the LIFE programme is to "support the implementation of EU environmental and climate policy" [7].

Specific measures:

- preparation of regional climate risk maps,
- development of municipal adaptation plans,
- pilot projects in the fields of agriculture and water management

Energy transition and offshore wind energy

Strengthening the adaptability of the energy system in Lithuania is being achieved in parallel with a gradual shift away from carbon-intensive energy sources. According to the International

Energy Agency, "the role of renewable energy sources in the energy mix is constantly growing" [8].

Offshore wind energy projects in the Baltic Sea:

- increase energy independence,
- reduce dependence on fossil fuel imports,
- strengthen the adaptability of infrastructure in the event of extreme weather events.

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Luxembourg

Introduction

Despite its small size, Luxembourg is an active and ambitious player in European climate policy. The country's goals are in line with the European Union's climate neutrality aspirations, with a particular focus on energy transition, sustainable mobility and climate change adaptation. Due to its high level of urbanisation and the transport burden resulting from cross-border commuting, Luxembourg is taking an integrated, systemic approach.

Free public transport nationwide [1]

In 2020, Luxembourg became the first country in the world to make public transport (buses, trams, trains) free nationwide. The aim of the measure was to reduce car use, cut transport emissions and ease traffic congestion. The decision is also significant from a social perspective, as it improves access to mobility and promotes transport equality.

Sustainable mobility and active transport [2]

Luxembourg's transport policy is based on encouraging modal shift. This includes:

- Developing Luxembourg City's tram network
- Expansion of bicycle infrastructure
- Support for the spread of electric vehicles

The aim of these measures is to reduce fossil fuel consumption and greenhouse gas emissions from transport.

Renewable energy and energy efficiency [3]

The central elements of Luxembourg's Integrated National Energy and Climate Plan (PNEC) are to increase the share of renewable energy sources and improve energy efficiency. According to the plan, Luxembourg will:

- reduce greenhouse gas emissions by 55% by 2030 (compared to 2005)
- increase the share of renewable energy to 37%
- improve energy efficiency by 42%

In practice, this means supporting solar energy systems, developing wind energy projects and encouraging building energy upgrades.

Klimabonus support system [4]

The Klimabonus programme is a complex state support system that:

- Supports the energy efficiency renovation of residential buildings
- Encourages the installation of renewable energy technologies
- Assists in the purchase of zero-emission vehicles

This tool serves both mitigation and adaptation purposes.

Electric mobility and charging network [1]

Luxembourg is making significant investments in electric transport:

- Support for the purchase of electric vehicles
- Development of a nationwide charging network called "Chargy"
- Development of fast charging infrastructure ("Super Chargy")

Green infrastructure and urban climate adaptation [5]

Luxembourg's urban climate adaptation measures include:

- Creation of green roofs and green walls
- Urban greening
- Rainwater retention systems
- Reducing paved surfaces ('de-sealing')

These measures reduce the heat island effect, mitigate flood risk and improve the condition of urban ecosystems.

Social Climate Plan [6]

Luxembourg's Social Climate Plan aims for a just transition, with a particular focus on the social impacts of the energy transition. The programme prioritises support for vulnerable households and the reduction of energy poverty.

Summary

Luxembourg's climate protection policy is a good example of how even a small country can implement innovative and systemic solutions. Free public transport, support for sustainable

mobility, the development of renewable energy sources and the strengthening of green infrastructure are complementary measures. Together, they contribute to reducing greenhouse gas emissions, improve the liveability of the urban environment and strengthen social justice.

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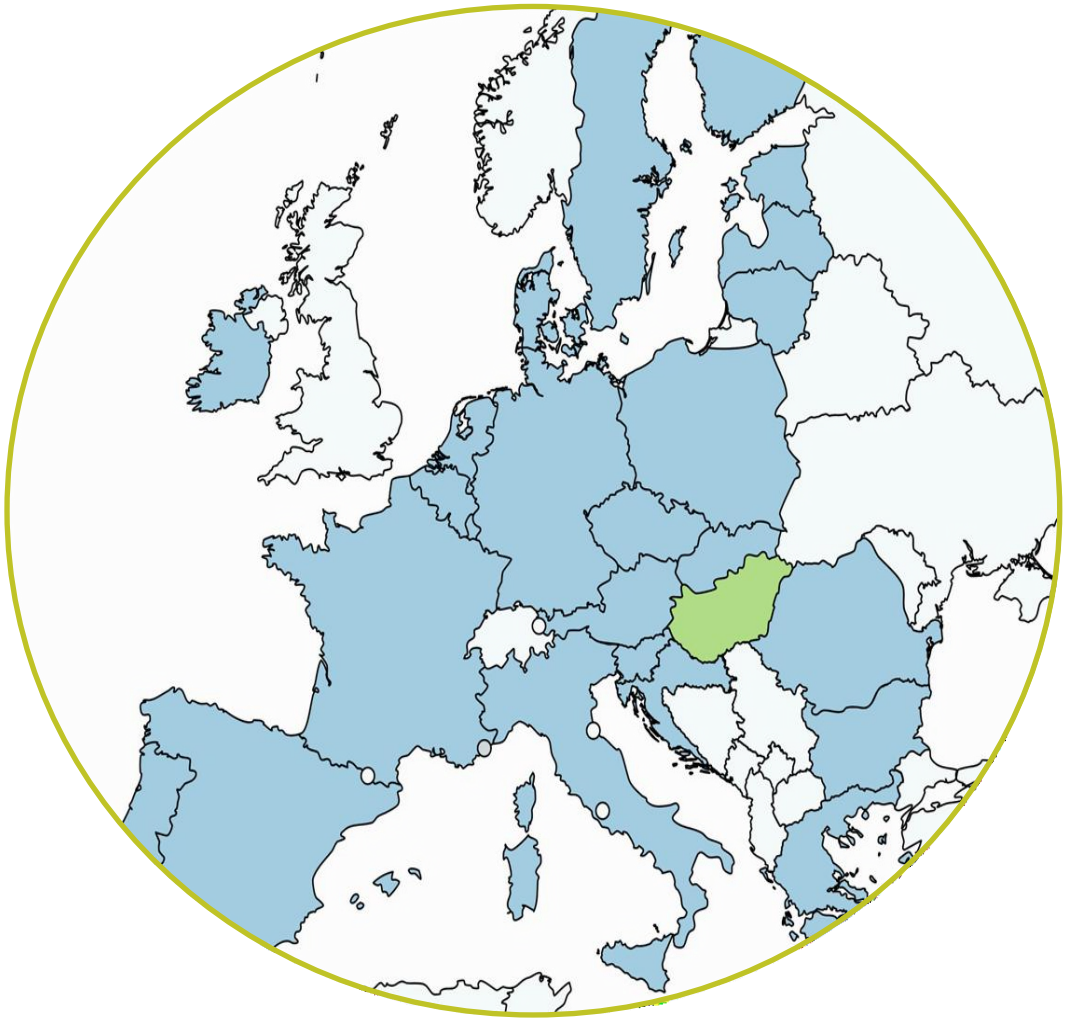

Hungary

Introduction

Due to its geographical location, Hungary is particularly sensitive to the effects of climate change. The Carpathian Basin is a closed basin region where the rate of warming exceeds the global average. According to HungaroMet data, the national annual average temperature has risen by more than 1.2 °C since 1901, and in Budapest it exceeds 1.6 °C [1]. The number of heatwave days is increasing, and precipitation patterns have become more extreme: longer periods of drought are followed by intense rainfall and flash floods.

The domestic framework for climate adaptation is provided by the National Climate Change Strategy and sectoral programmes [2]. In practice, adaptation is organised around three main areas: agriculture, water management and urban climate adaptation.

Agricultural adaptation

In Hungary, the sector most affected by climate change is agriculture [3]. Drought, spring frost damage, storm damage and heat stress cause significant crop fluctuations. Due to peak temperatures of 38–42 °C, outdoor work is changing in terms of timing: work is starting earlier and earlier, with the period between 4 and 10 a.m. becoming dominant.

Heat stress reduces not only crop yield but also labour productivity. According to Seppänen et al., the optimal temperature is between 20 and 25 °C, with productivity declining by 2 % for every 2 °C deviation from this range [4]. To counteract this, a flexible operating model, protective drinks and regulated rest periods have been introduced.

Adaptation has also shifted towards technology. Vegetable growers in the Szentes area use automated irrigation systems, nutrient solution and humidification equipment. Mechanised harvesting and the use of electric pruning shears have become widespread in the Mátra wine region. Some farmers are switching to an extensification strategy (afforestation, grassland conversion), while others are diversifying, for example by supplementing their farms with tourist activities [5].

Soil moisture retention is a key issue. Mulching, soil cover and no-till farming reduce evaporation and improve soil life [6].

Water management and the Sponge City concept

In Hungary, annual precipitation ranges from 300 to 500 mm, but a significant portion of the falling water evaporates or runs off. Water retention is therefore a central element of

adaptation.

The LIFE20 CCA/HU/001774 – LIFE in RUNOFF (Urban Rain) project laid the foundations for Budapest's rainwater strategy [7]. As part of the project:

- high-resolution climate modelling was carried out,
- hydrological-hydraulic modelling was carried out,
- vulnerability assessments were carried out,
- demonstration rain gardens and cisterns were established.

The aim of the Sponge City concept is to reduce runoff, increase evaporative surfaces and make the urban water cycle more closed [8]. Root zone water purification (phytoremediation) is a nature-based solution that uses plants and microorganisms to purify wastewater.

Urban climate adaptation and green mobility

Budapest's Climate Strategy (SECAP) highlights the importance of developing green infrastructure [9]. The capital's main cycle network is over 325 km long, having grown by more than 30% over the last decade.

Parts of the green transport transition include:

- Green Bus Programme (electric Ikarus 120e buses),
- KISS double-decker motor trains,
- more than 1,000 public electric charging points,
- REpont return system,
- ban on single-use plastics.

In the event of a heatwave, water distribution, public information and cooling points are in operation.

Renewable energy and deep geothermal developments

Hungary has favourable geothermal conditions: the geothermal gradient is approximately 45 °C/km, which is outstanding in European comparison [10].

The deep geothermal district heating system in Szeged is one of the most modern systems of its kind in Europe [11,12]. Key data of the project:

- 27 wells (production and reinjection pairs),
- 16 heating plants,
- 250 km of pipe network,
- 92–94 °C water from a depth of 1700–2000 metres,
- 50–60% natural gas replacement,
- Supply for 28,000 households and 400 public buildings.

The value of the investment exceeded HUF 22 billion, with significant KEHOP support [13.]

The system operates in a closed cycle: the cooled water is pumped back into the porous sandstone layer, allowing the resource to be used sustainably. Natural gas consumption has been reduced by more than half, improving air quality and reducing import dependency.

Summary

Hungary's climate adaptation practices are based on several pillars: agricultural adaptation, water retention, urban green infrastructure development and renewable energy. Nature-based solutions and deep geothermal energy play a key role in increasing the country's long-term resilience.

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Malta

Introduction

Malta is a small, highly urbanised island nation in the middle of the Mediterranean Sea, which is particularly vulnerable to the effects of climate change. The country faces **water shortages**, **heat waves**, **coastal erosion**, **sea level rise** and the risk of extreme marine events. All this affects not only the daily lives of the population, but also tourism and coastal infrastructure, which are of paramount importance to Malta's economy. In this context, climate adaptation means that society and the economy **prepare for the expected damage** and **mitigate** the effects that are already occurring **as much as possible**, in particular by protecting critical systems (water supply, utilities, transport, coastal protection).

The role of the European Union is clearly evident in Malta's adaptation practices: several programmes targeting specific risks have been implemented with a significant proportion of EU funding. A good example of this is the project package aimed at detecting and forecasting coastal risks, which is described in detail in the EU Cohesion Policy register [1].

1. Coastal risk monitoring and early warning

Due to Malta's island location, one of the most important areas of climate adaptation is **coastal risk** management. The aim of the 'Coastal Hazard Monitoring Early Warning System' project (2018-2021) was to **monitor and model coastal processes** and support risk reduction through forecasting. The project included the assessment of short-term wave effects, the development of risk scenarios, monitoring and GPS-based observation, and a camera network [1]. Its strategic importance lies in the fact that the stability of coastal cliffs and the hazards posed by sudden strong waves can be identified and communicated in a timely manner.

Closely related to this is the "Tsunami Risk Reduction System" project, which develops **emergency planning, alerting and cooperation protocols**. The programme has included, for example, an audible alarm solution and a rapid response equipment preparation process, as well as the creation of a data sharing platform to facilitate cross-border information exchange [2].

The C-COVER programme also strengthens the systematic assessment of coastal vulnerability by examining **the complex exposure and vulnerability** of the Maltese coastline and helping to establish a defence strategy [3].

2. Water management: the most critical area of adaptation

Malta relies on both **traditional and modern** solutions to address water scarcity.

Geographical features (wied-s, i.e. water catchment valleys; small stone dams/weirs) allow for the partial retention of rainwater, which is particularly important where groundwater resources are becoming unsustainable due to overuse. The aim is twofold: to collect rainwater and to support groundwater recharge.

Rainwater harvesting and storage, for example using cisterns, is a key tool for the public and institutions. The Water Services Corporation also publishes practical advice on this (e.g. water-saving household solutions, recycling tips) [6 – Water Services Corporation (Malta), 'Water Tips']. Water use efficiency is also key in agriculture: drip irrigation, cistern restoration and water conservation support have a direct adaptation effect because they reduce production risks arising from water shortages.

One specific, practical incentive programme is the 2019 "Water – Be the Change" campaign, in which farmers could receive support for drip irrigation systems and water retention solutions, while emphasis was also placed on raising awareness among the general public (through interactive teaching materials and everyday examples of water saving) [4].

3. Sea level rise and coastal infrastructure: exposure reduction and nature-based protection

In the case of vulnerable coastal infrastructure (tourist facilities, public utilities, coastal roads), Malta has in several cases implemented **exposure reduction** solutions, such as relocating certain elements to more protected or higher-lying areas. This logic is supported by the European Parliament's policy analyses on the exposure of the Mediterranean region and coastal risks [5].

Among nature-based solutions, the role of **Posidonia oceanica** (sea grass) is particularly noteworthy. The plant reduces coastal erosion by binding sand and dampening wave energy, while also providing habitat. Nature-based protection is not a "separate green project" here, but one of the most cost-effective and ecologically beneficial tools for coastal protection.

4. Urban heat stress and 'Grey to Green': passive cooling and greening

Due to the high proportion of paved and built-up areas in Malta's urban structure, the **urban heat island effect** and summer heat stress are major problems. To address this, the government has launched the "Grey to Green" initiative: a multi-year programme to encourage urban greening and passive cooling, which also aims to increase green spaces and improve air quality [6].

Due to the limited space available in Malta, **vertical solutions** (green walls, roof gardens) and the so-called "cool roof/white roof" principle, where light-coloured surfaces reduce heat absorption, are particularly important. A spectacular example of this in practice is the green wall along the Marsa–Ħamrun Bypass, which improves the quality of the environment and reduces noise pollution with tens of thousands of plants [7].

The transport aspect of reducing air pollution is also linked to adaptation: heat and poor air quality can together increase health risks, so making public transport more attractive and strengthening a cleaner vehicle fleet indirectly brings adaptation benefits.

5. Renewable energy despite limited space: floating solar panels and offshore wind

In Malta, the 'classic' obstacle to renewable energy is limited land area. For this reason, **floating solar parks** have emerged as a possibility for harnessing solar energy, with the water surface (if the location is favourable) freeing up land for agriculture, housing and tourism. The international press has also reported on the growing popularity of the idea of floating solar parks and the related consultations [8].

Wind energy is an even more complex issue, as traditional fixed-base offshore systems are less than ideal due to the rapidly deepening seabed. Therefore, Malta is moving towards **floating offshore** wind **turbines**. According to the summary of the European Maritime Spatial Planning Platform, the Maltese government has launched the pre-qualification process for the first offshore wind tender, with a planned capacity of around 280-320 MW [9].

6. Wave energy as a future option: lessons from Portugal

Wave energy would logically be a good fit for Malta (island nation, marine energy), but the technology is still in the experimental stage worldwide. In 2008, Portugal commissioned one of the world's first wave farm systems, which was later shut down for financial and technical reasons – a summary of this was also published in Hungarian [10]. The relevance of the topic is demonstrated by the fact that Eco Wave Power has announced developments for 2026 related to the Portuguese project, which is moving towards a more easily maintainable solution installed on breakwaters [11]. This is interesting in Malta because breakwaters not only serve to protect the coast, but can also be considered for energy integration in the longer term.

7. Energy storage: system stability is a matter of adaptation

Due to the weather dependency of renewable energies, **storage** is key to the resilience of the energy system. In this area, Malta has installed battery energy storage systems (Marsa and

Delimara) to reduce the supply risk arising from fluctuations in production. Related trends and issues of sustainable transition are also discussed in expert interviews and analyses [4].

Summary

Malta's climate adaptation practices clearly demonstrate that even a small, resource-constrained island nation heavily dependent on tourism is capable of taking **systemic** adaptation measures. The most important lessons are:

- managing **coastal risks** through monitoring and early warning systems significantly reduces vulnerability
- **water management** is not only an infrastructure issue, but also involves shaping the behaviour of the population and the agricultural sector behavioural change,
- **Urban greening** and passive cooling are key to reducing heat stress,
- **spatial constraints** force innovation (floating solar power, floating offshore wind),
- energy **storage** is the basis of a climate-resilient energy system.

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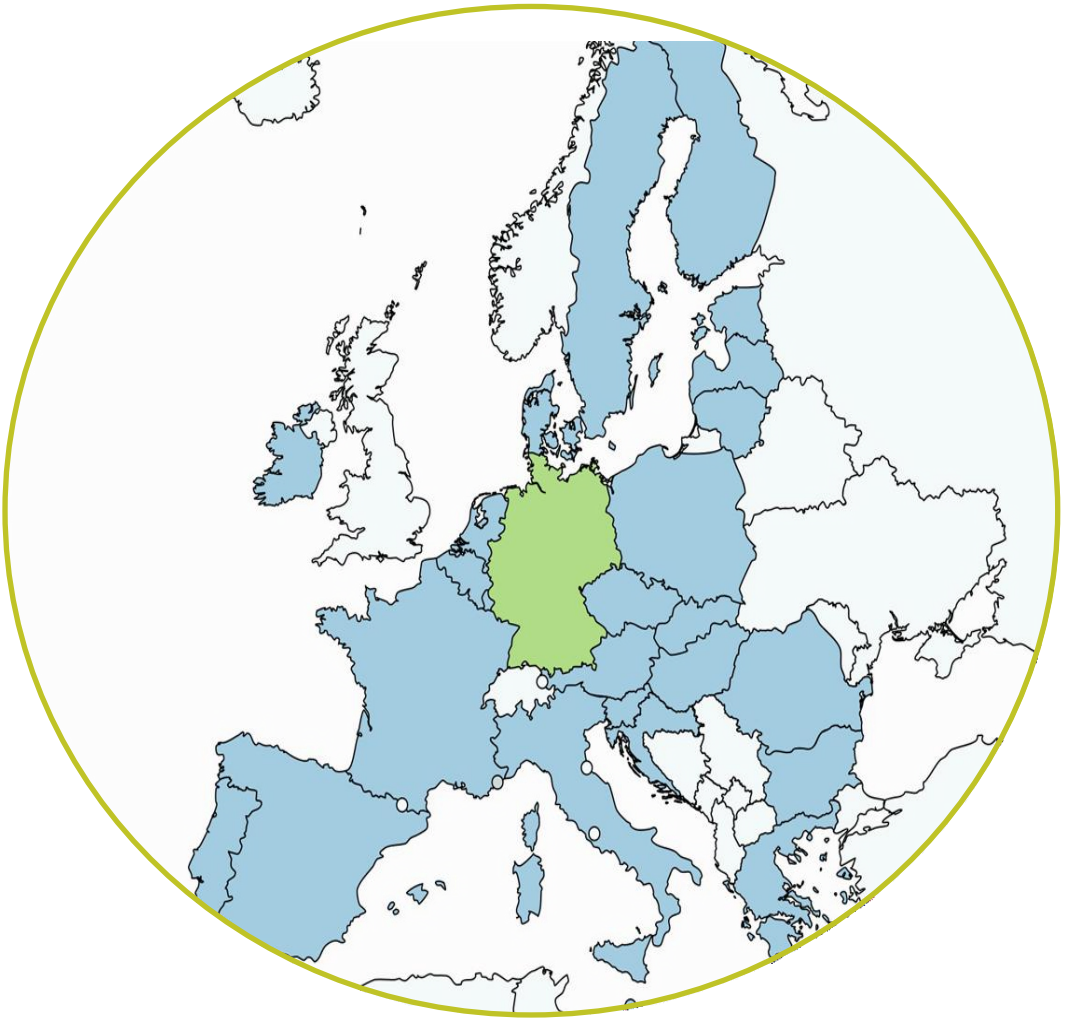

Germany

1. Introduction

Germany faces a number of climate change impacts, including increasing heat waves, extreme precipitation events, floods and droughts [1]. Under the 'Deutsche Anpassungsstrategie an den Klimawandel' (DAS), the country aims to increase the resilience of society, the economy and ecosystems through an integrated, cross-sectoral approach [2]. The strategy emphasises the importance of nature-based solutions, precision technologies and the involvement of local actors [3].

The urban, agricultural and forestry sectors, as well as health and infrastructure systems, play a key role in adaptation. The aim of climate adaptation is not only to mitigate damage, but also to introduce sustainable, liveable and economically efficient solutions.

2. Urban climate adaptation and green infrastructure

German cities are facing significant heat island effects and increasing heat stress. The **Cooling Cities programme** responds to this problem by focusing on reducing temperatures in Berlin, Hamburg and Munich through the installation of green roofs and green walls, the greening of public spaces, water features and shading systems [4].

- **Baakenpark (Hamburg, HafenCity)** provides a cooler microclimate through trees, groves, water surfaces and planters [5].
- The **Sommerstraße/München – Summer Streets** project reduces urban heat stress by making streets car-free and transforming them into green spaces [6].
- The **Vauban** district of **Freiburg** is characterised by the dominance of pedestrian and bicycle traffic and green infrastructure, mitigating the heat island effect.
- **Düsseldorf's** green tram tracks and climate-adaptive public spaces improve the microclimate and rainwater retention.

The **sponge city concept**, which is based on the retention, infiltration and evaporation of rainwater (RISA – Rainwater Infrastructure Adaptation, Hamburg, 2021), is also part of urban adaptation. Solutions include permeable pavements, rain gardens and temporary buffer zones, which reduce flood risk and improve urban liveability.

3. Nature-based water management and flood protection

Due to climate change, intense rainfall and flooding are becoming more frequent in Germany

[1]. The use of nature-based solutions – floodplain restoration, agricultural water retention practices, floodplains and water level control – contributes to risk reduction.

Specific projects:

- **Lödderitzer Forst**: relocation of former dam, restoration of 600 hectares of floodplain, integration of agricultural and ecological functions.
- **Waller Sand beach park (Bremen)**: conversion of riverbanks and public spaces into water-related recreational areas, design suitable for rainwater retention, increasing biodiversity.

Nature-based solutions are also economically beneficial, reducing flood damage, mitigating infrastructure repair costs and creating a more liveable, greener urban environment.

4. Precision agriculture and drought management

In agriculture, adaptation includes soil moisture monitoring, drone and satellite observation, and the use of adaptive crop rotation.

Good practices:

- **Bavaria**: integrated soil moisture monitoring system, resulting in 20-30% water savings while maintaining crop yields.
- Nature-based water management and plant cover, which help maintain soil water balance.

5. Heatwave warning systems and health protection

The German Meteorological Service (DWD) **Heat Health Warning** System forecasts heat waves and enables preventive measures to be taken.

Practices:

- Provision of air-conditioned public spaces, shaded public areas and drinking fountains.
- Public information, heat stress communication, protected infrastructure for the elderly and chronically ill.

The system effectively reduces the health risks of heat waves and the economic losses resulting from work absenteeism and health burdens.

6. Measures against extreme cold

To address the challenges posed by winter cold and snowfall, Germany uses strategic gas storage facilities and district heating networks and improves the thermal insulation of buildings [2].

Practices:

- Urban snow clearance, de-icing, railway infrastructure heating.
- Protection of homeless people and vulnerable groups, emergency shelters.

7. Support for local authorities and institutions

Advisory and coordination centres play a key role in local-level adaptation, providing professional and financial support [7].

Specific activities:

- Community gardens, climate education in schools, local actions in cooperation with civil society organisations.
- Preferential loans and subsidies for climate adaptation investments.

8. Summary of good practices – key projects

1. **Hamburg – Green roof strategy, das Grüne Netz Hamburg**: green roofs and interconnected green networks to reduce urban heat and flood risk.
2. **Berlin – Sponge City model**: retention and storage of rainwater in new urban areas.
3. **Munich – Summer Streets**: closing streets to cars and creating green and recreational areas.
4. **Bochum – Baum-Rigolen project**: tree irrigation and water collection ditches to reduce flooding and heat stress.
5. **Bretten – Starkregen-App**: SMS and app-based warning system for heavy rainfall and flooding.
6. **Bremen – Waller Sand beach park**: creation of water-related recreational areas for flood protection and increased biodiversity.
7. **Düsseldorf**: greening tram tracks and climate-adaptive public spaces to improve the

microclimate.

8. **Palatinate**: conversion of spruce forests into deciduous, mixed forests, creation of climate forests.
9. **Elbe floodplains and Ahr Valley floods**: restoration of floodplains, natural water retention, increasing ecological stability.

9. Summary

Germany's climate adaptation is based on integrated, multi-sectoral practices that can be measured in detail. Reducing urban temperatures, flood protection, precision farming, forestry resilience, health protection and support for local communities are linked to economic efficiency and sustainability. The lesson from these good practices is that combining nature-based, technological and social solutions increases society's resilience to the negative effects of climate change [2,8].

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Italy

Introduction

Due to Italy's geographical and climatic diversity, the effects of climate change are extremely varied across the country. In the Alps, glacier retreat and declining snow cover are affecting water resources and tourism; droughts and water shortages are becoming more frequent in the Po Valley; heat waves and forest fires are intensifying in the Mediterranean regions; while sea level rise and storm surges pose a serious risk in coastal regions. To address these complex challenges, Italy has developed the National Climate Adaptation Plan (PNACC), which sets out adaptation guidelines for each sector [1].

The country's strategy is aligned with the European Union's adaptation framework, which is also recorded in the Climate-ADAPT database [2]. The essence of the approach is integrated, multi-level adaptation: national planning, regional measures and implementation at the local government level.

1. Flood protection and sea level rise: Venice and the MOSE system

Venice is one of the best-known examples of climate-sensitive European cities. Due to its unique geographical location and its urban structure built on lagoons directly connected to the sea, Venice is particularly vulnerable to sea level rise and flooding caused by climate change. In recent decades, the city has suffered from a dramatic increase in the frequency of flood waves known as 'Acqua alta' (high water), which have caused serious damage to historic buildings, transport and the daily lives of residents. The phenomenon of acqua alta – a combination of high-water levels and storm surges – is becoming increasingly frequent and intense. To address this, the MOSE mobile barrier system was created, which temporarily closes the lagoon's inlets in the event of extreme water levels [3].

The system provides significant short-term protection for the historic city centre, but the European Environment Agency (EEA) emphasises that further nature-based solutions and adaptive management may also be necessary due to long-term sea level rise [4].

The MOSE (Modulo Sperimentale Elettromeccanico) project is a large-scale engineering and environmental initiative to protect Venice [3].

How the system works:

- Seventy-eight mobile barriers have been installed at three main entrances (Lido, Malamocco, Chioggia).

- Under normal conditions, the barriers lie flat on the seabed, so they do not interfere with natural water movement and ecological flows.
- If forecasts indicate that the water level will exceed 1.10 metres, the barrier elements fill with air and rise, blocking the path of the flood wave.

The MOSE project is not only an engineering feat, but also a complex environmental management system that takes into account the ecological characteristics of the lagoon:

- The operation of the barriers is supported by environmental monitoring systems that continuously measure water quality, currents and sediment movements.
- The system can be operated flexibly to minimise damage to the natural state of the lagoon.

Results:

- MOSE was successfully activated for the first time in October 2020, when it managed to stop a significant tidal wave that would otherwise have flooded a large part of the historic city centre.
- Between 2021 and 2023, the system prevented flooding on dozens of occasions, averting hundreds of millions of euros in damage.
- The project has stabilised Venice's economy and tourism, reducing the risks associated with flooding.

At the same time, the long-term sustainability of MOSE poses further challenges: ongoing maintenance is costly and, depending on the extent of future sea level rise, the system's effectiveness may be limited. Venice is therefore also exploring other nature-based solutions, such as the restoration of lagoon habitats and the controlled regulation of sediment movements.

This example illustrates one of the dilemmas of climate adaptation: in addition to major infrastructure investments, an ecosystem-based approach is also essential.

2. Urban heat island effect and green infrastructure: Milan

The effects of climate change on urban environments – such as the heat island effect, increased air pollution and the risk of flooding – are particularly acute in Italy's major cities. Due to high population density, concrete surfaces and limited green spaces, temperatures in cities can be

up to 5.7 °C higher than in surrounding rural areas. Milan's response to these challenges is the "ForestaMi" (English: "Let's reforest the city") programme, which aims to plant 3 million trees by 2030, in line with the city's sustainability strategy (ForestaMi, 2020). [5]. Afforestation reduces the heat island effect, improves air quality and moderates rainwater runoff.

The programme not only involves tree planting, but also represents a comprehensive urban development concept:

- Installation of green roofs and green walls: New regulations encourage the covering of building roofs and facades with vegetation, thereby reducing the energy consumption of buildings and the ambient temperature.
- Creation of new parks and expansion of existing ones: Special attention is paid to ensuring that parks not only serve an aesthetic purpose, but also provide ecosystem services such as shade, drainage and the preservation of urban biodiversity.
- Creation of green corridors: Green areas are being created between urban zones, facilitating the free movement of animals and plants, thereby increasing biodiversity.

The residential tower called "Bosco Verticale" (Vertical Forest) is one of Milan's best-known sustainable architectural solutions. The two towers contain a total of more than 900 trees, 5,000 shrubs and 11,000 perennial plants, which are planted on the façade and not only have aesthetic value, but also effectively filter polluted city air, reduce noise pollution and moderate temperature fluctuations in the buildings [7].

Results:

- In the first three years of the ForestaMi programme, around 300,000 trees were planted.
- The urban microclimate has improved: the summer temperature measured in the vicinity of green areas is 2–3 °C lower.
- Air pollutant levels (PM10, NO2) decreased by 10–15% in areas affected by greening.
- The quality of life of city residents has improved, and the usability of public spaces has increased during the hot summer months.

The example of Milan clearly shows that the conscious development of green infrastructure is key to the success of climate adaptation, not only from an environmental but also from a

social perspective.

The 'depaving' strategy – removing paved surfaces and creating water-permeable green areas – is also part of the urban resilience programme [6].

3. Drought and water management in the Po Valley

The Po River basin has experienced record droughts in recent years. Low water levels threaten irrigation, drinking water supply and energy production.

The PNACC emphasises the importance of water retention, developing storage capacity and increasing water use efficiency [1]. The aim of water management reforms is to achieve sustainable water extraction and modernise agricultural irrigation systems.

4. Agricultural adaptation

Adaptation in the agricultural sector is crucial. Precision agriculture (soil moisture sensors, targeted irrigation) reduces water use and increases production stability.

The use of drought-tolerant crop varieties and soil conservation farming are also important approaches [1,2].

5. Heatwave management and health adaptation

The Italian health system operates a heatwave alert system, which is aimed particularly at protecting the elderly and vulnerable groups. Local authorities set up cooling centres and launch public information campaigns.

Adaptation in this case is not only an infrastructure issue, but also a social and health issue.

6. Forest fire risk and monitoring

The frequency of forest fires is increasing in the Mediterranean region. Italy uses the EFFIS (European Forest Fire Information System) to monitor risks [8].

The national disaster management agency operates a coordinated alert and response system [9].

7. Building modernisation and energy efficiency

The Superbonus 110% programme has increased the resilience of buildings by encouraging energy upgrades [10]. Energy efficiency reduces energy demand during heat waves and improves comfort of the population.

Summary

Italy's climate adaptation system is based on an integrated, multi-sectoral approach.

The most important elements are:

- flood protection and coastal infrastructure (MOSE),
- urban greening and pavement reduction,
- water management reforms,
- agricultural adaptation,
- heatwave and health protection,
- forest fire monitoring,
- building modernisation.

The strength of the system lies in cooperation at institutional and EU level.

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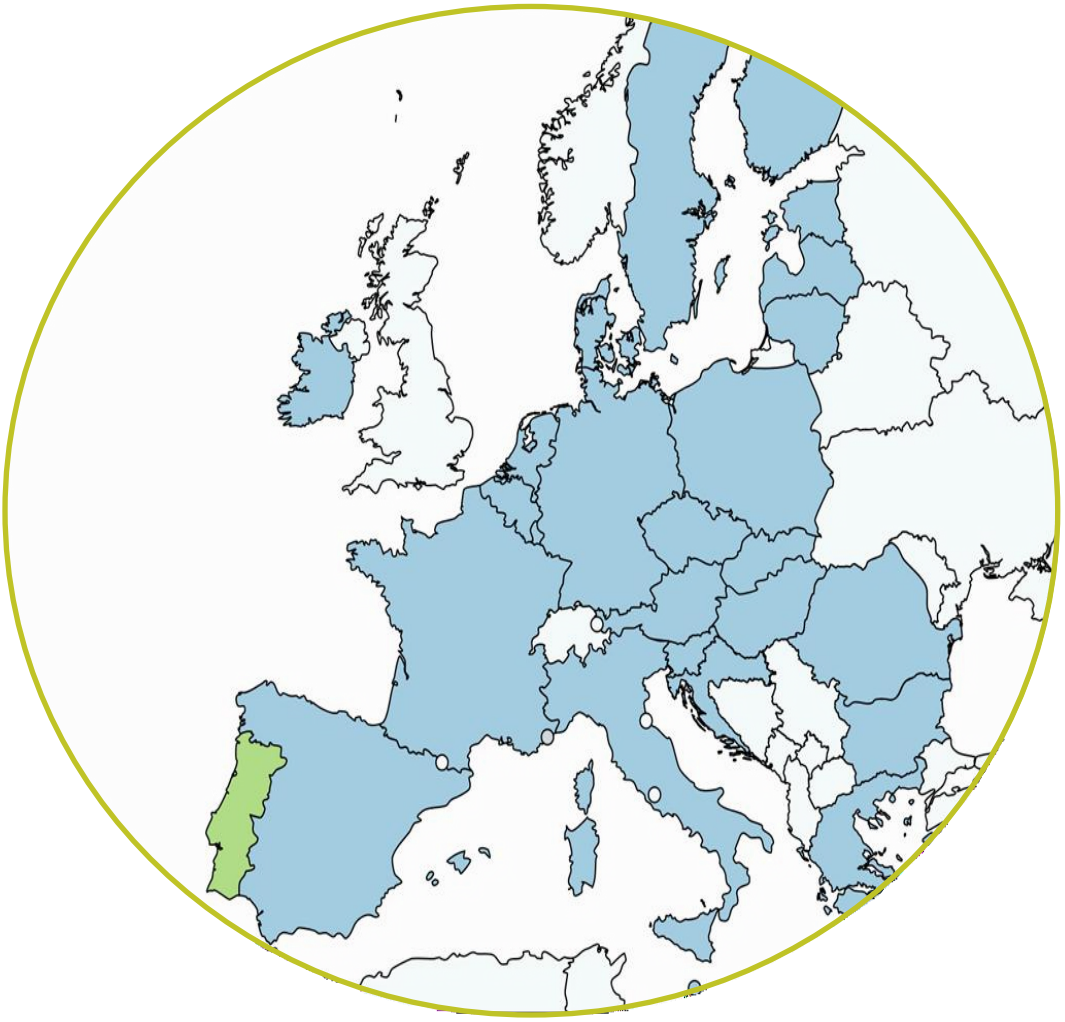

Portugal

Introduction

Due to its geographical location and Mediterranean-oceanic climate, Portugal is particularly vulnerable to the effects of climate change. The country is affected by increasingly frequent and intense droughts, forest fires, heat waves and coastal risks resulting from sea level rise. These phenomena have a significant impact not only on the natural environment, but also on the economy (agriculture, tourism, infrastructure) and the quality of life of the population.

Portugal pursues a comprehensive, multi-level strategy for adaptation. This is based on the National Adaptation Strategy (ENAAC) and the P-3AC – Action Programme for Adaptation to Climate Change (2019–2030), which sets out adaptation objectives and measures at national level [1,2].

1. Water scarcity and drought management

In the southern regions of the country, drought is one of the most serious problems, linked to declining rainfall and longer dry periods.

Good practices:

- Construction and expansion of reservoirs to store water collected during rainy periods for use during drought months.
- Wastewater treatment and reuse, primarily for agricultural irrigation, reducing drinking water consumption.
- Use of water-saving irrigation technologies (drip irrigation, sensor-controlled systems) that allow for more accurate water use and reduce waste.

These measures increase the resilience of agriculture and water supply and reduce the economic risks associated with water scarcity [2].

.2. Adaptation to forest fires

Due to long, dry summers, Portugal has an exceptionally high risk of forest fires.

Good practices:

- Transforming forest management: reducing fast-burning eucalyptus and pine plantations

  and creating a mosaic-like, mixed landscape structure.

- Creating protective strips around settlements to slow the spread of fire.
- Involving the population in prevention through the 'Aldeia Segura – Pessoas Seguras' programme.
- Development of early warning systems (drones, satellite monitoring, risk maps).
- Improving firefighting capacity, training and purchasing aerial firefighting equipment.
- Nature-based restoration in burned areas by planting drought-tolerant and less flammable species.

The measures are based on prevention, rapid response and increasing the long-term resilience of the landscape [3].

3. Heatwave management and urban adaptation

The increase in the number of heat waves, especially in urban areas, poses a serious health and infrastructure challenges.

Good practices:

- Urban greening and tree planting to reduce the heat island effect.
- Creation of shaded public spaces and use of heat-reflective surfaces.
- Operation of early warning systems in case of dangerous temperatures.
- Targeted protection and information for vulnerable groups (the elderly, chronically ill).

Urban adaptation follows an integrated approach that connects health protection, infrastructure development, and environmental sustainability [1].

4. Managing coastal risks

Sea level rise, coastal erosion and storms pose a particular threat to densely populated coastal areas. Good practices:

- Strengthening coastal protection infrastructure.
- Use nature-based solutions (restore dunes, plant coastal vegetation).
- Tightening land use regulations in vulnerable areas.

- Developing early warning systems for floods and storms.

The long-term goal is the sustainable management of coastal ecosystems and increasing the safety of the population [1].

Summary

Portugal's climate adaptation practices are a good example of an integrated, multi-level approach. The country has developed a national strategy (P-3AC), is strengthening the role of local authorities, combining infrastructure and nature-based solutions, and placing great emphasis on prevention and social preparedness. Although challenges remain significant, these measures contribute to increasing Portugal's environmental, economic and social resilience.

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Romania

Introduction

Romania's geographical features – the Carpathian Mountains, the Great Plain, and the Danube and Black Sea coastlines – expose the country to particularly diverse climate risks. In recent decades, extreme heat waves, droughts, intense precipitation events and floods have become increasingly frequent [1]. In 2016, Romania adopted its National Climate Change Strategy and Action Plan, which includes an integrated approach to adaptation and emission reduction [2]. The strategy aims to increase the resilience of infrastructure, agriculture, water management and urban systems.

1. Flood protection and water management – Danube and its tributaries

Romania is exposed to significant flood risk, particularly in areas along the Danube and in mountainous catchment areas. Following major floods in the 2000s and 2010s, the country has implemented significant flood protection investments [3]. Main measures:

- Reinforcement and modernisation of dams
- Flood risk mapping
- Development of early warning systems
- Rehabilitation of natural floodplains

Romania is participating in the implementation of the EU Floods Directive, which requires risk assessment and the development of flood risk management plans [4].

2. Danube Delta – nature-based adaptation

The Danube Delta is one of Europe's most valuable ecosystems, but it is also extremely vulnerable to sea level rise and hydrological changes. Romania is implementing nature-based solutions [5]:

- Restoration of wetlands
- Restoration of natural water flow
- Biodiversity protection

These measures simultaneously reduce flood risk and strengthen ecosystem services.

3. Agricultural adaptation and drought management

Romania's agriculture is particularly vulnerable to drought. Water shortages and soil degradation are common in the south-eastern parts of the country [6]. Main adaptation measures:

- Modernisation of irrigation systems
- Soil moisture conservation technologies
- Introduction of drought-tolerant crop varieties
- Agri-environmental subsidies

Under the EU's Common Agricultural Policy (CAP), Romania supports sustainable land use practices [7].

4. Urban climate adaptation – Bucharest and Cluj-Napoca

Heat waves and sudden downpours are becoming increasingly common in Romanian cities. Bucharest is particularly vulnerable to the urban heat island effect [8]. Adaptation solutions:

- Green space expansion programmes
- Rehabilitation of urban parks
- Tree planting programmes
- Modernisation of rainwater drainage systems

Cluj-Napoca has developed an integrated sustainable urban development strategy that gives priority to green infrastructure [9].

5. The link between energy transition and climate adaptation

Romania has significant renewable energy potential (wind energy in the Dobruja region, hydropower in the Carpathian region). Increasing energy independence reduces vulnerability to climate risks [10].

Main objectives:

- Increasing the share of renewable energy
- Making energy infrastructure more resilient
- Energy efficiency programmes

Summary

Romania's climate adaptation strategy integrates several areas:

- Flood protection and water management
- Nature-based ecosystem restoration
- Agricultural adaptation
- Urban green infrastructure
- Energy transition

Extreme weather events, droughts and floods pose the greatest challenges for the country. In the future, it will be crucial to use EU funds efficiently and further integrate nature-based solutions into the national strategy.

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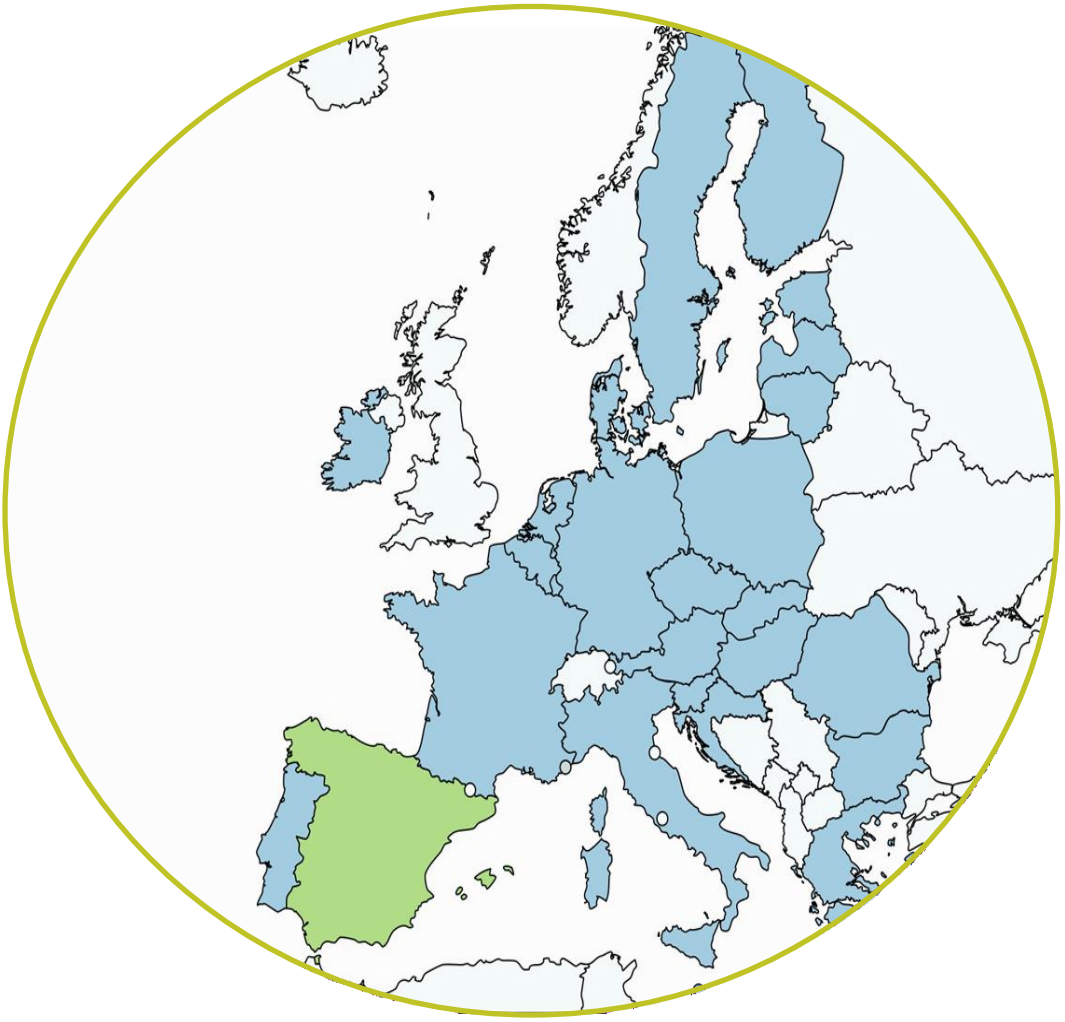

Spain

1. Introduction

Spain is one of the European Union Member States most exposed to climate change, particularly due to heat waves, droughts, water shortages and coastal erosion in the Mediterranean region [1]. According to the European Environment Agency, the effects of climate change in southern Europe are more rapid and intense than the EU average, particularly in terms of the vulnerability of water resources and ecosystems [1].

Spain's adaptation policy therefore operates within an integrated, multi-level system that includes measures at national, autonomous community and local government levels [2].

2. National strategic framework: PNACC 2021–2030

The basic document for climate adaptation in Spain is the *Plan Nacional de Adaptación al Cambio Climático 2021–2030* (PNACC), which is the country's second-generation adaptation strategy [2]. The document aims to map climate risks at a systemic level, integrate adaptation horizontally into policies and strengthen science-based decision-making. The PNACC covers 18 sectors, including water management, agriculture, health, energy, tourism, biodiversity and coastal protection.

Its implementation is supported by the AdapteCCa knowledge platform, which collects case studies, indicators and good practices [3].

3. Water management and drought adaptation

The southern and south-eastern regions of Spain are particularly vulnerable to droughts [1]. In the Murcia region, precision irrigation systems, digital monitoring and wastewater reuse are used to optimise water use [3]. The aim of these measures is to ensure the sustainability of agricultural production in the face of declining water resources [3].

4. Nature-based solutions in the built environment [4]

Nature-based solutions (NbS) are playing an increasingly important role in Spanish adaptation policy.

As part of the *myBUILDINGisGREEN LIFE* project implemented in the municipality of Solana de los Barros, green roofs, green facades and rainwater harvesting systems were installed in a school building.

According to the project results, the measures reduced the internal temperature and energy

consumption.

5. Urban climate adaptation

Barcelona's "Pla del Verd i la Biodiversitat 2020–2030" plan aims to develop green infrastructure, increase tree cover and create green corridors. Increasing urban green spaces contributes to mitigating the heat island effect and strengthening ecosystem services. [5]

Madrid's 'Madrid 360' programme is based on the development of low-emission zones, sustainable transport and the development of urban green spaces, combining mitigation and adaptation goals. [6]

6. Heatwave adaptation [7]

Seville introduced a heatwave naming system in 2022; the first such event was named "Zoe". The initiative aims to raise public awareness and improve the effectiveness of health response measures.

7. Coastal protection and ecosystem restoration [3]

Nature-based coastal protection and dune rehabilitation measures are being implemented in the Doñana area. The MASDUNAS project in the Canary Islands aims to restore the ecology of the Maspalomas dune system.

8. Forest fire prevention

Catalonia has an integrated forest fire prevention system that includes controlled burning, forest thinning and community participation [8]. The frequency and intensity of forest fires in the Mediterranean region is increasing, which justifies proactive adaptation measures [1].

9. Social innovation [9]

Following the extreme floods of 2024, Spain introduced paid leave for extreme weather events. This regulation is an innovative response to the social and labour law dimensions of climate change.

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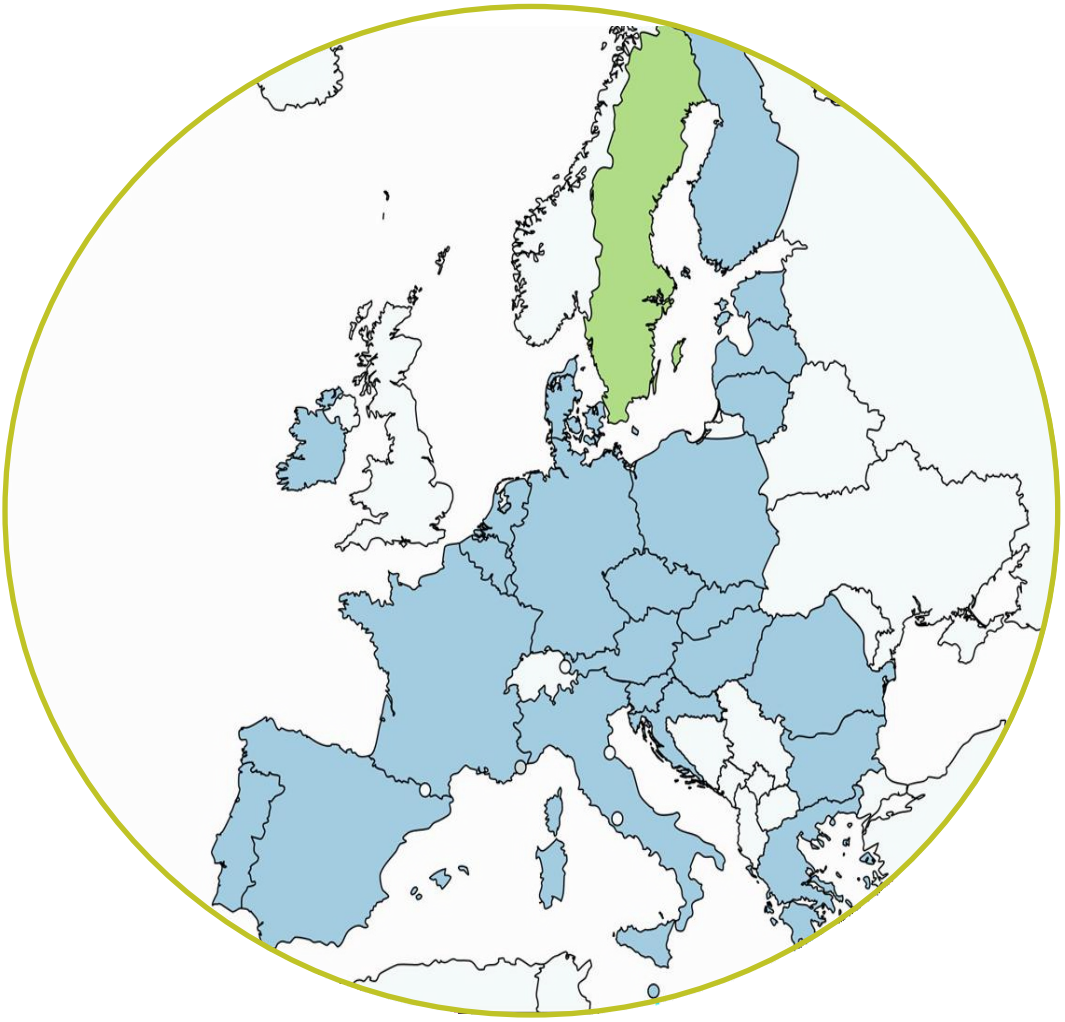

Sweden

Introduction

Climate change is posing increasingly serious challenges for countries around the world, and the northern regions are no exception. Sweden, one of Scandinavia's most developed and largest countries, is already feeling the effects of climate change: for example, periods of extreme precipitation are becoming more frequent, winters are milder, and the threat of sea level rise is increasing. Sweden has recognised that it must not only reduce its greenhouse gas emissions, but also adapt to the inevitable changes. Sweden is one of Europe's most prepared and innovative countries when it comes to adapting to climate change. The country is already feeling the effects of global warming: milder winters, more intense rainfall, more frequent flash floods, heat waves, forest fires, sea level rise and the melting of permafrost in the northern regions are all serious challenges. In response to these effects, Sweden adopted its National Climate Adaptation Strategy in 2018, which is based on scientific modelling and multi-level government cooperation [1].

A distinctive feature of the Swedish model is that adaptation is not a separate policy area, but is integrated into infrastructure development, urban planning, forestry, agriculture and energy.

1. Urban green-blue infrastructure and flood management

The city of Stockholm is actively developing green infrastructure to reduce the urban heat island effect and manage flooding from heavy rainfall. The city has installed more than 150,000 square metres of green roofs, which not only provide thermal insulation but also help to drain rainwater naturally. Rain gardens also play an important role in adapting to climate change. These gardens are specially designed green spaces that capture and filter rainwater, reducing the load on sewer systems load and moderating the flood risk. One example is the Hammarby Sjöstad district, where the coordination of water, energy and waste management as an integrated solution also plays a role in climate adaptation. Swedish cities – particularly Malmö, Gothenburg and Stockholm – are replacing traditional stormwater drainage systems with nature-based solutions. In the Augustenborg district of Malmö, for example, a 6-kilometre-long open canal system has been built to carry rainwater through green spaces, while more than 11,000 m² of green roofs help to retain water locally [2].

The new system has worked effectively even during extreme rainfall, significantly reducing flood damage. The project has demonstrated that nature-based solutions are more cost-effective and multifunctional than concrete-based infrastructure alone.

In Gothenburg, climate-adaptive streets were created as part of the Cloudburst Plan and Klimatgatan programme: water-permeable pavements, temporary flood areas, underground reservoirs and smart drainage systems were installed [3,4]. SMART systems automatically regulate drainage based on weather forecasts.

In Stockholm, more than 150,000 m² of green roofs have been created, and an integrated water-energy-waste system is in use in the Hammarby Sjöstad district [5].

The advantages of green-blue infrastructure:

- reduces flood risk,
- mitigates the urban heat island effect,
- improves air quality,
- increases biodiversity,
- improves quality of life.

2. Health preparedness for heatwaves

After the extreme heatwave of 2018, several Swedish municipalities, such as Botkyrka, introduced a three-phase heatwave protocol [6].

System components:

- Alerts based on forecasts from SMHI (Swedish Meteorological and Hydrological Institute)
- SMS-based notification system,
- designation of "cool zones" in public spaces,
- special preparation of retirement homes,
- involvement of volunteers to support vulnerable populations.

This model integrates health, meteorological and community systems and has significantly reduced the health risks associated with heat stress.

Water management adaptation to heat waves and floods

Due to climate change, sudden downpours are becoming more frequent in Sweden, which can cause serious urban flooding. The city of Malmö has responded to this challenge in an

exemplary manner by developing the 'Green Blue Malmö' strategy.

As part of the project, water-permeable pavements, artificial lakes and open channels have been created to manage rainwater naturally. The Augustenborg Eco-City project is particularly well known: here, flood management is achieved through a combination of green roofs and natural drainage systems. These solutions are not only functional, but also have aesthetic value and contribute to improving the quality of urban life. [7]

3. Nature-based coastal protection – LIFE Coast Adapt

In Skåne County, a nature-based coastal protection system was developed as part of the LIFE Coast Adapt project in response to sea level rise and coastal erosion [8].

The interventions included:

- artificial stabilisation of sand dunes (planting of Ammophila arenaria),
- planting of coastal vegetation,
- attempts to reintroduce eelgrass (Zostera marina),
- involvement of the local population in maintenance.

The project demonstrated that nature-based solutions are more flexible and cost-effective in the long term than traditional concrete barriers.

4. Agricultural water management – the Tullstorp model

Sweden's agricultural sector is also actively working on adapting to climate change. Climate-smart farming techniques include, for example, increasing the carbon content of the soil, which helps to sequester carbon dioxide and improves the soil's water retention capacity.

Modernising irrigation systems, growing drought-resistant crop varieties and promoting local varieties all serve to increase climate resilience. In addition, Sweden supports the 'Organic Sweden' movement, which promotes the spread of organic farming, contributing to the protection of natural ecosystems.

In southern Sweden, multifunctional wetland areas have been created in the Tullstorp stream catchment area [9].

The system:

- 0.5 hectares of artificial marshland per 10 hectares,

- 3,000 m³ water storage capacity,
- seasonally regulated water level,
- reduction of nitrogen and phosphorus emissions,
- irrigation reserve during droughts.

Farmers receive 30% state support for maintenance, which increases social acceptance.

5. Sustainable forest management and forest fire prevention

Approximately 70% of Sweden's territory is covered by forests. The basic principle of the forest management system is mandatory reforestation and the creation of mixed tree stands [10].

Sustainable forest management

Approximately 70% of Sweden's territory is covered by forests, which is why the country pays special attention to sustainable forest management, which is also an important part of climate adaptation.

Sweden operates one of the world's largest sustainable forestry systems. The essence of the Swedish forestry model is that for every tree that is felled, several new trees are planted – annual forest growth exceeds the rate of harvesting, which not only maintains carbon sequestration capacity but also strengthens the resilience of the ecosystem.

Strict rules must be followed during logging to ensure that the natural regeneration of forests, the protection of biodiversity and the preservation of soil quality are not compromised.

Swedish forests are not only of economic value, but also act as a climate buffer: they contribute to reducing global carbon dioxide levels and provide protection against extreme weather events such as storms and droughts.

In addition, great emphasis is placed on preserving the diversity of forest ecosystems, protecting habitats and maintaining soil quality in the long term. Sustainable forestry is one of the cornerstones of Sweden's climate strategy, as forests play a key role in combating climate change.

Climate adaptation measures include:

- mixed species composition for a more resilient ecosystem,

- drone and satellite monitoring,
- development of firefighting infrastructure,
- improving the water retention capacity of the soil.

Forests not only sequester carbon, but also play a role in stabilising ecosystems.

6. Energy and industrial innovation

Sweden has set itself the goal of establishing a fully renewable electricity system by 2040. This is also part of its climate adaptation strategy, as renewable energy sources are less exposed to global market fluctuations and result in a more flexible energy system. Wind energy production is growing steadily: in 2023, nearly 20% of electricity production came from wind energy. Decentralised energy production, such as the creation of local solar parks, also increases energy security. The 'E.ON Energy Hub Malmö' project, for example, combines solar and wind energy with battery storage to create flexible, self-sufficient systems.

The majority of Sweden's electricity production comes from hydro and nuclear energy, which provides a low-carbon system [11].

The share of wind energy is steadily increasing, while fossil-free technologies such as green hydrogen-based steel production (H2 Green Steel) have emerged in industry [12]. Decentralised energy production and energy storage increase the flexibility of the energy system, which is also an adaptation factor.

7. Digital decision support

The Klimatkarta online mapping system developed by SMHI models future climate scenarios at regional level [13].

This enables:

- preliminary climate risk assessment of land use decisions
- adaptive infrastructure planning,
- long-term strategic planning.

8. Adaptation in northern regions: changes in permafrost [14]

The effects of climate change are particularly pronounced in northern Sweden: the melting of permafrost threatens infrastructure, natural habitats and traditional ways of life, such as Sami

reindeer herding.

Within the framework of the INTERACT research network, Sweden supports cooperation between Arctic stations, the development of monitoring systems, and the involvement of local communities in the development of adaptation strategies. Innovative solutions include, for example, the thermal insulation of roads and buildings to protect frozen ground, and the introduction of early warning systems.

Summary

Sweden's climate adaptation practices are based on systemic, data-driven and nature-based solutions. Key elements of success include

- integrated urban planning,
- water retention,
- community participation,
- scientific monitoring,
- use of economic incentives.
- H2 Green Steel: fossil-free steel production plant using green hydrogen, achieving 90% less carbon dioxide emissions.
- Purchase subsidies for electric cars, especially for low-income households.
- The country has also built an electric charging network in rural areas.
- Many cities use biogas as fuel for buses.
- Carbon offsetting is mandatory for all flights taken by civil servants, which means that we must reduce our carbon emissions elsewhere by an amount equal to the emissions generated by such flights.
- It provides subsidies for insulation, heat pumps and solar panels.
- It has introduced a "repair" tax credit and reduced VAT on the repair of household appliances and bicycles.
- Sixty per cent of the country is covered by forest, which is consciously managed to fulfil its carbon sequestration function, and reforestation is also practised.

- One of the most important lessons of the Swedish model is that adaptation is not a separate project, but a fundamental principle built into all policy areas.

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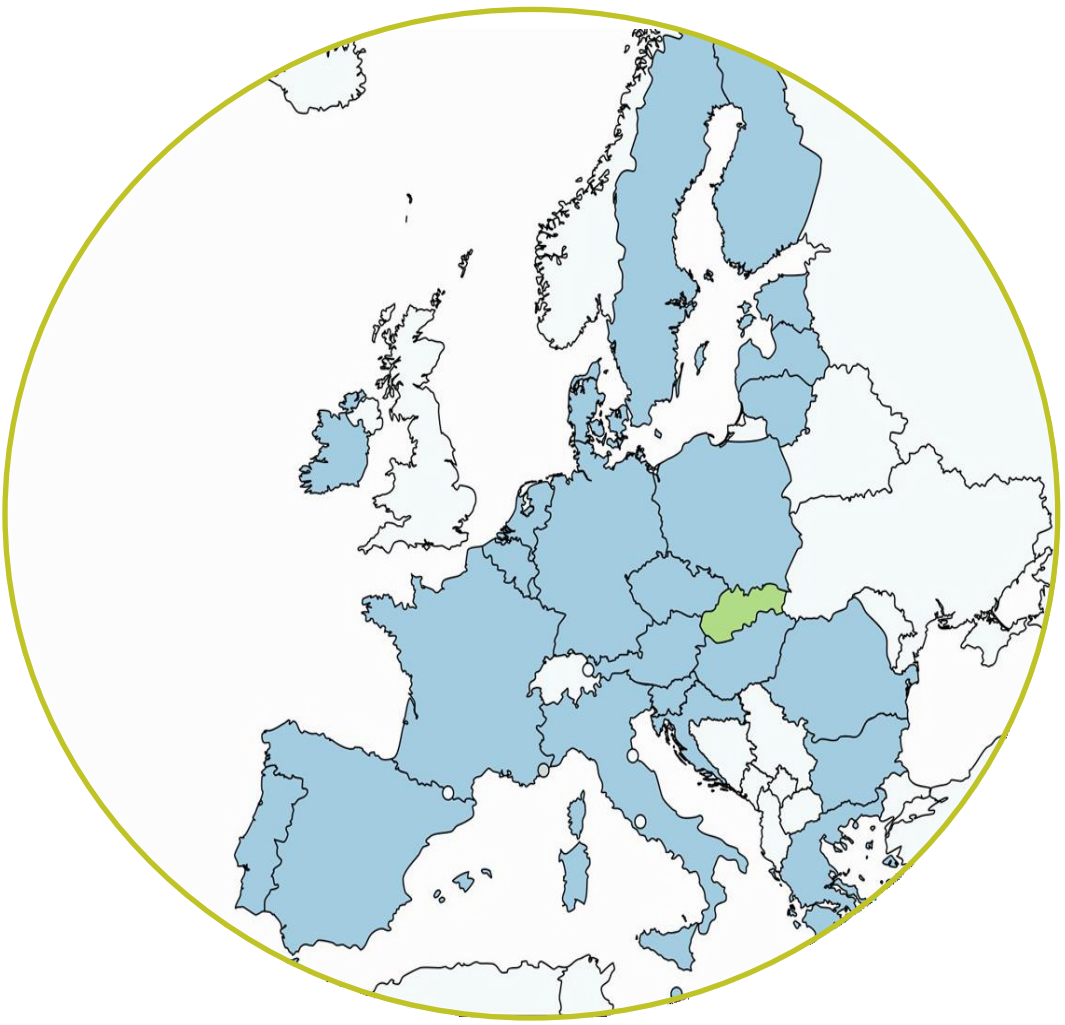

Slovakia

Introduction

Due to its geographical location – the Carpathian Mountain range and the flatlands connected to the Great Plain – Slovakia exhibits significant climatic differences. In recent decades, the country has experienced accelerated warming, more frequent heat waves and increased spatial and temporal variability in precipitation [1]. In mountainous areas, the duration of snow cover is decreasing, while in lowland regions the risk of drought is increasing.

Slovakia's climate adaptation framework is set out in the document "Stratégia adaptácie Slovenskej republiky na nepriaznivé dôsledky zmeny klímy" (Strategy of the Slovak Republic for Adaptation to the Adverse Effects of Climate Change), which was developed by the Ministry of the Environment of the Slovak Republic [2]. The strategy focuses on the following areas: water management, agriculture and forestry, urban infrastructure, and the energy and transport systems.

Agricultural and forestry adaptation

Slovakia's agriculture, especially in the southern lowlands, is highly vulnerable to drought and heat stress [3]. Yield fluctuations have increased in recent years, particularly for cereals and maize.

Adaptation measures include:

- the introduction of drought-tolerant varieties,
- development of precision irrigation systems,
- the use of soil moisture conservation cultivation techniques,
- promoting agroforestry systems.

In forest management, it is particularly important to increase the proportion of climate-resilient tree species. Spruce stands have suffered significant damage due to bark beetles and heat stress, so efforts are being made to create a mixed, more resistant tree species composition during forest restoration [4]. Forests play a key role not only economically, but also in terms of water retention and carbon sequestration.

Water management and flood protection

Slovakia's water management system is largely linked to the water system of the Danube and its tributaries. Climate change is leading to an increase in the frequency of flash floods and

intense precipitation events [5].

Several projects have been launched in the field of water retention and nature-based solutions, in particular under the coordination of the Ministerstvo životného prostredia Slovenskej republiky. Their objectives are:

- restoring floodplains to their natural state,
- revitalising small watercourses,
- to build urban rainwater retention systems,
- developing green infrastructure.

Flood protection along the Danube is of particular importance, especially in the Bratislava area, where flood defences have been modernised and mobile flood protection systems installed over the past decade [6].

Urban climate adaptation and green infrastructure

Slovak cities – especially Bratislava and Košice – are increasingly incorporating heat island mitigation and the expansion of green spaces into their climate strategies [7].

The tools used include

- creation of green roofs and green walls,
- landscaping and tree planting programmes,
- use of permeable pavements,
- development of cycling and public transport.

The Bratislava SECAP (Sustainable Energy and Climate Action Plan) document sets specific emission reduction and adaptation targets for 2030, in line with the European Union's climate policy objectives [8].

Renewable energy and energy efficiency

Hydropower and nuclear energy play a significant role in Slovakia's energy mix, while the share of renewable energy sources is gradually increasing [9].

The Gabčíkovo Waterworks on the Slovak section of the Danube is one of the country's most important hydroelectric power plants and plays a key role in low-carbon electricity generation.

Energy efficiency programmes include:

- energy modernisation of public buildings,
- support for thermal insulation of residential buildings,
- Introduction of smart energy management systems.

Linking renewable energy development and adaptation is one of the fundamental principles of national climate policy [2].

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Slovenia

Introduction

Climate change is becoming increasingly intense in Central Europe, manifesting itself in the form of more frequent heat waves, extreme precipitation events, floods and droughts. Slovenia's geographical features make it particularly vulnerable, as three different climatic influences converge on its territory: Alpine, continental and Mediterranean [1].

In the Alpine region, the length of the snow season is decreasing and the risk of floods and landslides is increasing. In continental areas, heat waves and agricultural droughts are intensifying, while the Mediterranean coast is experiencing water shortages and coastal vulnerability. Per capita economic losses related to extreme weather events are among the highest in the EU [2].

Slovenia is therefore implementing its climate adaptation policy not only through strategic documents, but also through specific projects.

LIFE4ADAPT – integrated adaptation at national level

One of Slovenia's most comprehensive initiatives is the LIFE4ADAPT project, which is being implemented with approximately €27 million in EU funding [3].

The aim of the project is to strengthen the country's resilience at a systemic level. Coordinated by the Slovenian Environment Agency (ARSO), it has established

- a national climate analysis and forecasting centre has been established,
- a modern climate control system was installed,
- dynamic, area-specific modelling tools were developed,
- and 14 pilot adaptation interventions were launched.

The significance of the project lies in the fact that it places adaptation on an institutionalised, data-driven footing. Decision-making is based on scientific evidence and links infrastructure, agriculture, water management, health and nature conservation horizontally.

Maribor's heatwave management system

Maribor, Slovenia's second largest city, has developed a heat action plan in response to increasing heat stress with the support of the Interreg Ready4Heat project [4].

The measures implemented include:

- planting thousands of trees,
- installation of shade pergolas in public spaces and institutions,
- heat mapping to identify urban 'hot spots',
- creation of climate-friendly bus stops,
- alert system focusing on vulnerable groups (elderly people, children).

The project is based on the application of nature-based solutions and is a good example of how scientific modelling can be translated into direct urban measures.

Revitalisation of the Pekre stream – nature-based flood protection

In the city of Maribor, a section of the Pekre stream that was previously prone to flooding has been transformed into a multifunctional green park [5].

During the project:

- the stream bed was redesigned,
- water retention areas were created,
- planted vegetation to regulate soil moisture,
- a recreational public space was created.

The revitalisation reduces flood risk and improves the urban microclimate.

Vipava Valley – agricultural adaptation

In the Vipava Valley, which is influenced by both continental and Mediterranean climates, the LIFE ViVaCCAdapt project responded to the problem of drought [6].

The main elements of the project are:

- real-time soil moisture monitoring,
- introduction of drip and micro-irrigation systems,
- construction of reservoirs,
- use of drought-tolerant plant varieties.

The data-driven irrigation system reduces water waste and increases crop yields. This project is an excellent example of targeted climate adaptation in rural areas.

KLIMAGRÜN and green infrastructure

The KLIMAGRÜN project focuses on the climate-adaptive transformation of green infrastructure [7]

Its objectives are:

- strengthening ecological corridors,
- using drought-tolerant plant species,
- expanding urban green spaces,
- retaining rainwater locally.

Nature-based solutions reduce the heat island effect and improve biodiversity in a cost-effective way.

HeatIslands Adapt – cross-border cooperation

The HeatIslands Adapt project, implemented as part of cross-border cooperation between Slovenia and Italy, aims to reduce the urban heat island effect [8].

The project:

- increases urban green spaces
- develops cooling infrastructure,
- supports energy-efficient urban planning.

This clearly shows that climate adaptation requires cooperation at regional level as well.

Summary

Slovenia's climate adaptation practice is integrated and multi-level. The country has:

- has institutionalised climate services (LIFE4ADAPT),
- launched urban heat stress management programmes (Maribor),
- applies nature-based flood protection (Pekre stream),
- introduced data-driven agricultural adaptation (Vipava Valley),
- is developing green infrastructure (KLIMAGRÜN).

The example of Slovenia shows that climate adaptation is effective when science-based decision-making, institutional coordination, community participation and nature-based solutions work together in an integrated manner.

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Afterword

The diversity of the good practices presented clearly shows that sustainability and adaptation to climate change do not depend on a single measure or field of expertise. Environmental protection now requires a comprehensive approach: it is reflected in legislation, local government decision-making, corporate strategies, education and small but significant steps in everyday life. Examples from individual countries and cities show that solutions based on local characteristics but thinking in terms of international cooperation can bring about real change. From deposit-refund systems and the introduction of the circular economy, through low-emission zones, the transition to renewable energy and nature conservation measures, to educational reforms and awareness-raising programmes, all the initiatives presented carry a common message: a sustainable future requires conscious planning, responsibility and long-term thinking. It is particularly noteworthy that most good practices are beneficial not only from an environmental perspective, but also from a social and economic perspective – they strengthen communities, encourage innovation and contribute to improving quality of life.

The examples also highlight that sustainability is not solely a government responsibility. Multinational companies, local communities, educational institutions and civil initiatives all play key roles. Cooperation – whether in the form of cross-border water management, joint research projects or partnerships between cities and companies – multiplies the impact of each actor. Only coordinated, systemic responses can address the challenges of the future.

The measures outlined in the document can also serve as inspiration for other countries and municipalities. Not all solutions can be transferred directly to other environments, but the basic principles – prevention, resource efficiency, social involvement and innovation – are universally applicable. The path to sustainable development is not short and not always easy, but the practices presented here prove that persistent and conscious work can bring tangible results.

Ultimately, environmental protection is not just a matter of policy, but also a matter of values. The good practices collected here encourage both decision-makers and citizens to act responsibly, keeping in mind the interests of future generations. Sustainability is not a destination, but a continuous process of learning and adaptation – a shared journey in which every step counts.