

Revision and update of the national strategy on adaptation to climate change in Slovakia

Deliverable 2.4 – Technical note on a draft Slovak NAS, NAP and roadmap - Project report

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Revision and update of the national strategy on adaptation to climate change in
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List of Abbreviations

AI	Artificial Intelligence
APVV	Slovak Research and Development Agency
AR	Assessment Report
ASPC SR	Authority for Spatial Planning and Construction of the Slovak Republic
CAP	Common Agricultural Policy
CBDRR	Community-Based Disaster Risk Reduction
CCASFP	Climate Change Adaptation Strategy Focal Point
CDDs	Cooling degree days
CER	Resilience of critical entities
CF	Common Fishery
CFP	Common Fisheries Policy
CIC	Climate Impact Chains
CRAs	Climate Risk Assessments
CRVA	Climate Risk and Vulnerability Assessment
CSRD	Corporate Sustainability Reporting Directive
CTFC	Centre for Traditional Folk Culture
DMO	Destination Management Organisation
DRM	Disaster Risk Management
DSS	Climate Risk Decision Support System
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee
EbA	Ecosystem Based Adaptation
EBFM	Ecosystem-Based Forest Management
EBRD	European Bank for Reconstruction and Development
EEA	European Environment Agency
EED	Energy Efficiency Directive
EIA	Environmental Impact Assessments
EIB	European Investment Bank
EPBD	Energy Performance of Buildings Directive
ERDF	European Regional Development Fund
ESF+	European Social Fund Plus
ESG	environmental, social and governance
ESIF	European Structural and Investment Funds
EU ETS	EU Emissions Trading System
EU	European Union
EUCRA	first European Climate Risk Assessment
EWS	Early Warning Systems
FUAs	Functional Urban Areas
GIS	Geoinformation System
GIZ	German Corporation for International Cooperation GmbH
HDDs	Heating degree days
HVAC	Heating, Ventilation, Air conditioning
ICH	Intangible Cultural Heritage
ICOMOS	International Council on Monuments and Sites
ICT	Information and Communication Technology
IoT	Internet of Things

IPCC	Intergovernmental Panel on Climate Change
KR	Key Risks
KTM	Key Type Measure
LIDAR	Light Detection and Ranging
LULUCF	Land Use, Land Use-Change and Forestry
MCA	Multi-criteria Analysis
MD SR	Ministry of Transport of the Slovak Republic
MEL	Monitoring, Evaluation, and Learning
MFF	Multiannual Financial Framework
MoA	Ministry of Agriculture
MoE	Ministry of Environment
NAP	National Adaptation Plan
NAS	National Adaptation Strategy
NBS	National Biodiversity Strategy
NbS	Nature-based Solutions
NBSAP	National Biodiversity Strategy and Action Plan
NECP	National energy and climate plans
NEHAP V	National Environment and Human Health Action Plan V
NFP	National Forestry Programme
NGOs	Non-governmental Organisations
NLP SR	National Forestry Program of the Slovak Republic
NPB	National Public Budget
NRP	Nature Restoration Plan
NRRP	National Recovery and Resilience Plan
OECD	Organisation for Economic Co-operation and Development
PAs	Protected Areas
PES	Payment for Ecosystem Services
PPP	Public-Private Partnerships
R&D	Research and Development
RCP	Representative Concentration Pathway
RED	Renewable Energy Directive
RES	Renewable Energy Sources
RIL	Reduced-impact logging
RIS3	Research and Innovation Strategy for Smart Specialization of the Slovak Republic
ROI	Return on Investment
RRF	Slovak Recovery and Resilience Facility / Resilience and Recovery Fund
RRP	Recovery and Resilience Plans
SAIDC	Slovak Agency for International Development Cooperation
SAV	Slovak Academy of Sciences
SD	Sectoral Strategic Directions
SEA	Strategic Environmental Assessment
SFDR	Sustainable Finance Disclosure Regulation
SHMÚ	Slovak Hydrometeorological Institute
SIEA	Slovak Innovation and Energy Agency
SMEs	Small and medium enterprises
SNC	State Nature Conservancy of the Slovak Republic

SO	Strategic Objectives
TCFD	Task Force on Climate-related Financial Disclosures.
TOD	Trans-Oriented Development
UBA	Umweltbundesamt (DE)
UCPM	Union Civil Protection Mechanism
UHI	Urban Heat Island
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
ÚSES	Creating the territorial system of ecological stability (plans and projects)
UWWTD	Urban Waste Water Treatment Directive
VEGA	Scientific Grant Agency
VRA	Vulnerability and Risk Assessment
WB	World Bank
WFD	Water Framework Directive
WGA	Working Group Adaptation

Executive summary

This document presents the project report under Contract REFORM/2021/OP/0006 Lot 1 - TSIC-RoC-20036 that aims to support the revision and update of the **National Adaptation Strategy (NAS)** for Slovakia (PART 1). PART 2 contains detailed Factsheets on adaptation measures for updating and further developing the **National Action Plan (NAP)**. Both are developed under the European Commission's **Technical Support Instrument**. The planned revision reflects Slovakia's commitment to proactively address the escalating impacts of climate change through a forward-looking and evidence-based national strategy, aligned with EU climate adaptation goals. This report provides the background for a NAS revision that is designed for the implementation period **2026–2040** and proposed to be structured for periodic update, ensuring continued relevance and alignment with evolving scientific knowledge, socio-economic developments, and European policies.

The introduction in this report (**Chapter 1**) outlines the rationale for the NAS revision, the policy context, and the bodies responsible for its development and implementation. It explains how a future strategy could build upon previous efforts - such as the 2014 NAS, its 2018 update, and the 2021 NAP - and how it can respond to the pressing need for more systemic, inclusive, and effective climate adaptation planning in Slovakia. The process of the development of this report was participatory, involving broad stakeholder engagement at national, regional, and local levels to ensure relevance, ownership, and feasibility.

Chapter 2 delivers the **analytical backbone** of the strategy through summarizing the comprehensive **Climate Vulnerability and Risk Assessment**¹ having been carried out under this contract, which is based on the latest science and data. It outlines how Slovakia's climate has changed over the past century and projects further changes under multiple scenarios, including increased average temperatures, more frequent heatwaves, heavy rainfall, droughts, and associated impacts on water availability, biodiversity, infrastructure, and public health. The **risk assessment** under a business-as-usual scenario highlights key vulnerabilities across sectors, underlining the urgency for immediate and coordinated adaptation efforts. This chapter also assesses progress made under the previous NAS and NAP, identifying both achievements and critical implementation gaps.

Building on this analysis, **Chapter 3** presents the potential **strategic core** of the updated NAS. It proposes phrasing of a **Vision for 2050**, centred on building a resilient Slovakia where natural ecosystems are protected, communities and businesses are empowered to adapt, and the economy remains innovative and climate smart. To realize this vision, **five strategic objectives** are defined, addressing ecosystem health, climate-resilient economic development, infrastructure adaptation, public awareness and capacity, and effective governance. Each objective is linked to **sector-specific strategic directions**, and a wide range of **adaptation measures**. The measures are proposed across 15 sectors grouped into five thematic clusters: Bioeconomy, Economy, Safety & Well-being, Built Environment and Spatial Planning, and Cross-Cutting Aspects. For each of the clusters and respective sectors, chapter 4 presents a summary of adaptation measures proposed, including a multi-criteria analysis (MCA). This is followed by a synthesis matrix on cross-sectoral MCA and recommendations for both cross-sectoral and sector-specific risk management to avoid potential unintended effects during implementation. The chapter further outlines **implementation arrangements**, including a timeline, designated responsibilities across institutions, and **financing mechanisms** that combine national, EU, and private sources. Importantly, a robust **Monitoring, Evaluation, and Learning (MEL) framework** is proposed to track progress and inform future revisions.

¹ Available online. See Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.3: Climate Risk and Vulnerability Assessment Slovakia. <https://klima-adapt.sk/dokument/f/revision-and-update-of-the-national-strategy-on-adaptation-to-climate-change-in-slovakia..pdf>.

Chapter 5 (Part 2: Factsheets) supplements the NAS report with detailed **sectoral Factsheets**, providing in-depth assessments and tailored adaptation pathways for each sector and cross-cutting aspects. Each fact sheet summarizes sector-specific risks, strategic responses, responsible actors, and links to both national and EU policy frameworks.

The **Annexes** compile supporting materials such as a comprehensive list of sectoral key risks (Annex 1), a glossary of key terms (Annex 2), financial estimates for overall implementation of the revised NAS (Annex 3), a set of indicators for MEL (Annex 4) and references (Annex 5).

This report aims to support a **coherent, integrated, and cross-sectoral approach**, aligning with best practices across Europe. It strives to **reduce vulnerabilities, enhance resilience**, and ensure a **just and inclusive adaptation transition** - anchored in science, guided by stakeholder input, and sustained by effective governance and financing.

Note to reader: throughout this report the abbreviations D1.X are used. The D abbreviates the word deliverable.

PART 1: Revision and update of the National Adaptation Strategy (NAS) for Slovakia

1. Introduction

At the end of 2023, the European Commission launched the technical support project “**Revision and update of the National Strategy on Adaptation to Climate Change in Cyprus and Slovakia**”. The consortium of international and local experts - Trinomics, AARC, alpS Consult, Fresh Thoughts and the Slovak Centre of social and psychological sciences SAS - has been commissioned to carry out this work, and the project is being implemented in close coordination and agreement with the Ministry of Environment of the Slovak Republic.

The first phase of the project analysed the state of play of the climate adaptation policies and governance framework and proposed a stakeholder engagement plan. The second phase of the project supplemented that work by providing a climate risk and vulnerability assessment (CRVA). The present report builds on the previous two phases, to create a revised Adaptation Strategy of the Slovak Republic to climate change.

1.1. Elemental information about the strategy

The “**Revision and update of the national strategy on adaptation to climate change in Slovakia**” is a revision of Slovakia’s existing National Climate Adaptation Strategy and Action Plan. Under the assumption the revised NAS will be approved by the end of 2025, the **time horizon for the revised and updated National Adaptation Strategy (NAS) with a period of validity of 2026 – 2040**. A next revision of the strategy will be based on the Monitoring, Evaluation and Learning system and respective progress reporting to be undertaken in 2039/2040. The revision should incorporate possible new climatic and socio-economic developments. Additionally, they should be in line with the revision timelines of the River Basin Management Plans and Flood Risk Management Plans, to incorporate possible lessons learned from implementation.

The strategy is structured around 15 sectors, which are organised within four sectoral clusters – bioeconomy, economy, safety and wellbeing, built environment and spatial planning, and a fifth cluster on cross-cutting aspects – urban areas, social issues, education and society, research, governance and regional/cross-border cooperation (see section 1.5 for more details). Despite this cluster structuring, there are quite some interlinkages between the sectors. Activities in one sector can lead to benefits in other sectors.

1.2. Context of the strategy / plan

Slovakia has developed and is implementing various measures to support adaptation to climate change. As an EU MS, the country has developed these within the EU legislative framework. At the same time, despite the global commitments agreed under the United Nations Framework Convention on Climate Change (UNFCCC), climate change has shown no signs of slowing down and continues to pose the most significant risk to people, economies, and nature. Therefore, it is crucial to ensure that adaptation measures remain effective and are improved/redesigned to address the escalating threats.

Slovakia has demonstrated a **commitment to develop proactively climate change adaptation measures**. In **2014**, the country adopted the **Strategy for Adaptation of the Slovak Republic to the Adverse Impacts of**

Climate Change². Building upon this foundation, in 2018, the country introduced the Strategy for Adaptation of the Slovak Republic to Climate Change – Update³. In 2021, the **National Adaptation Strategy Action Plan (NAP)** was adopted, aligning with the global climate change agenda and the EU commitments⁴.

A changing climate and extreme weather events increasingly threaten European economic security. According to the Competitiveness Compass for the EU⁵, the EU and Member States must therefore improve their resilience and step up their preparedness, regularly updating climate risk assessments and improving critical infrastructure resilience by design. Integrating climate resilience in urban planning, deploying nature-based solutions, developing nature credits and adaptation in agriculture while preserving food security, are also among the options to protect the EU economy and society from the worst of natural calamities such as floods, droughts, wildfires and storms that compromise supply chains and production sites. A **European Climate Adaptation Plan** will be presented to this end.

In line with the new EU Adaptation Strategy⁶, the adaptation planning of EU Member States should ensure that policy cycles focus on making adaptation smarter, swifter, and more systemic while bolstering international action on climate resilience. This involves a structured process including preparation, assessment of climate risks and vulnerabilities, identification and evaluation of adaptation options, implementation, and ongoing evaluation of measures to ensure their relevance and effectiveness over time. In response to this imperative, Slovakia has decided to revise its National Climate Adaptation Strategy (NAS) and Action Plan (NAP), to align it more closely with EU legislation.

Following the EU's approach to mainstream climate adaptation into sectoral policies, Slovakia has implemented relevant requirements in its national policies to enhance resilience and adapt to changing climate conditions. Besides the National Climate Adaptation Strategy (NAS)⁷ and Action Plan (NAP)⁸, there are a number of other national strategic documents important for climate resilience and adaptation to climate change⁹. A full list can be found in the Deliverable 2.2 report of this project.¹⁰

² Ministry of Environment (2014). Stratégia adaptácie Slovenskej republiky na nepriaznivé dôsledky zmeny klímy. https://climate-laws.org/documents/strategy-of-adaptation-of-the-slovak-republic-to-the-unfavorable-consequences-of-climate-change_55de?id=national-adaptation-strategy-resolution-of-the-slovak-government-no-148-2014_05e4 (Available in Slovak).

³ Ministry of Environment. (2018). Stratégia adaptácie na zmenu klímy. <https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/strategia-adaptacie-sr-zmenu-klimy-aktualizacia.pdf> <https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/strategia-adaptacie-sr-zmenu-klimy-aktualizacia.pdf> (Available in Slovak).

⁴ Ministry of Environment. (2021). Akčný plán pre implementáciu Stratégie adaptácie SR na zmenu klímy. <https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/akcny-plan-implementaciu-nas.pdf> <https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/akcny-plan-implementaciu-nas.pdf> (Available in Slovak).

⁵ https://commission.europa.eu/document/download/10017eb1-4722-4333-add2-e0ed18105a34_en

⁶ European Commission. (2021). The new EU Strategy on Adaptation to Climate Change. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN>.

⁷ Ministry of Environment. (2018). Stratégia adaptácie na zmenu klímy. <https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/strategia-adaptacie-sr-zmenu-klimy-aktualizacia.pdf> (Available in Slovak).

⁸ Ministry of Environment. (2021). Akčný plán pre implementáciu Stratégie adaptácie SR na zmenu klímy. <https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/akcny-plan-implementaciu-nas.pdf> (Available in Slovak).

⁹ These include documents such as the National Forestry Programme of the Slovak Republic 2025-2030 (available at: <https://www.mpsr.sk/aktualne/oznamenie-o-strategickom-dokumente-narodny-lesnicky-program-sr-2025-2030/19074/>), Action Plan to address the Impacts of Drought and Water Scarcity (available at: <https://www.minzp.sk/voda/koncepcne-dokumenty/h2odnota-je-voda-akcny-plan-riesenie-dosledkov-sucha-nedostatku-vody.html>), Slovakia's Recovery and Resilience Plan (available at: <https://rokovania.gov.sk/RVL/Material/28317/1>), and Water Policy Concept for 2030 with an outlook to 2050 (available at: <https://www.minzp.sk/voda/koncepcne-dokumenty/koncepcia-vodnej-politiky-roky-2021-2030-vyhľadom-do-roku-2050.html>).

¹⁰ It can also be found online. See Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.2: Report on the state of play of the climate adaptation policies and governance framework and proposal for a stakeholder engagement plan – Final Report. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf.

Additionally, a gap analysis was conducted in the context of this project to assess alignment of the Slovak policies relevant for climate adaptation with the current EU framework. Table 1 below presents this analysis in colour-coded format, where green reflects alignment, red reflects non-alignment with EU policies that have been in force for longer than one year, while yellow indicates non-alignment with policies that have been adopted recently or are yet to be implemented.

Table 1: Analysis of Slovak adaptation policies and current EU framework

EU Policy	Alignment	Policy in Slovakia
EU Climate Law		Slovakia is in the process of drafting a Climate Law aimed at legally embedding the goal of achieving climate neutrality. The updated NECP, updated and adopted in April 2025, also aims to reaffirm Slovakia's commitment to the climate-neutrality objective.
LULUCF Regulation		The NECP falls short in fully reflecting the increased ambition outlined in the LULUCF Regulation. The legislative process is currently underway for a draft Law on Landscape Planning (LP/2023/519)
Common Agricultural Policy		Slovakia's CAP Strategic Plan 2023-2027 is in place.
Forest Strategy 2030		The National Forestry Programme (NFP) of the Slovak Republic 2025-2030 (published in February 2024) establishes the national implementation. However, the EC has indicated that there are some gaps in its assessment of the draft updated National Energy and Climate Plan of Slovakia. ¹¹
Biodiversity Strategy 2030		Biodiversity protection is featured in some of the key strategic policy documents of Slovakia. However, the new National Biodiversity Strategy and Action Plan 2030 (NBSAP) is still under preparation.
Water Framework Directive (WFD)		The Concept of Water Policy of the Slovak Republic Until 2030 With a View to 2050 is in place.
Common Fisheries Policy		Implementation is still underway.
Energy Performance of Buildings Directive (EPBD)		The implementation of the EPBD in Slovakia has been robust; however, in light of recent developments, a revision has been adopted in April 2024 with a foreseen transposition by end of May 2026.
EU Emissions Trading System (EU ETS)		Slovakia participates fully in the EU ETS and has established the necessary legal and institutional framework to manage allowances, monitor emissions, and ensure compliance (Act No. 414/2012 Coll. on Trading with Emission Allowances, updated with EU ETS Phase IV (2021–2030), including provisions for auctioning allowances and monitoring emissions). The system covers key sectors such as energy and large industrial installations.
Regulation on the Governance of the Energy Union and Climate Action		Included in NECP; however, the contribution to the overall EU target of renewables falls short of the target set in the Governance Regulation.

¹¹ European Commission. (2025c). Slovakia – Final updated National Energy and Climate Plan 2021–2030. Brussels. https://commission.europa.eu/publications/slovakia-final-updated-necp-2021-2030-submitted-2025_en

EU Policy	Alignment	Policy in Slovakia
Energy Efficiency Directive (EED)		Slovakia has transposed key aspects of the EED into national law, including energy audits for large enterprises, the establishment of an energy efficiency obligation scheme, and renovation targets for public buildings (Act No. 143/2024, amending Act No. 321/2014 Coll. on Energy Efficiency, focusing on updated energy efficiency targets and measures).
Renewable Energy Directive (RED I/II/III)		Slovakia has made progress in increasing the share of renewables in its energy mix, particularly in bioenergy and hydropower. The use of biomass is increasing, but its potential is limited and needs progress with sustainability criteria. Solar and wind energy deployment has been slow due to permitting issues, grid constraints, and limited incentives. The country is now required to contribute to the EU-wide targets of 42.5% (with a 45% ambition) renewable energy share by 2030 under RED III. (Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources and High-Efficiency Cogeneration transposed the original RED (2009/28/EC) and was later updated to reflect RED II (2018/2001/EU) provisions, including guarantees of origin, access to the grid, and support schemes. Ongoing legislative amendments are expected or in process to ensure full transposition of RED III (Directive (EU) 2023/2413), which raises the EU's 2030 renewable energy target). According to updated Slovak NECP, national RES target for 2030 is 25%.
Sustainable and Smart Mobility Strategy		Multiple key initiatives in place to ensure implementation.
Corporate Sustainability Reporting Directive (CSRD)		CSRD transposition was completed in mid-2024, with amendments to the Accounting Act.
Directive on the Resilience of Critical Entities		Transposition of the into national legislation is delayed but expected in 2025.
Floods Directive		Act No. 7/2010 Coll. On flood protection addresses the assessment and management of flood risks. Flood Risk Management Plan (2022-2027) – preliminary flood risk assessment is completed.
EU Soil Strategy		Proposed EU Directive on Soil Monitoring and Resilience with implementation expected to be transposed into national legislation.

1.3. Responsible bodies

The development and implementation of National Adaptation Strategy (NAS) is coordinated by the Ministry of Environment, in collaboration with the already established Working Group on Adaptation with representatives from national and regional governance levels. While the overall responsibility for the implementation of the NAS is in the hands of the Ministry of Environment, the accompanying compilation of sectoral measures (see PART 2 Factsheets) further designate specific competent ministries and authorities as responsible for the implementation of each of the listed actions. The specific institutions that shall support the Ministry of Environment with the implementation of NAS measures within each cluster / sector are addressed in chapter 3.3 and sectoral Factsheets in chapter 4.

1.4. Target groups

This revised NAS will target the population of Slovakia and aims to guide and support a wide range of stakeholders in building a climate-resilient country. Its target audience includes:

- **Public Administrations:** Public administration from the national to the local level responsible for implementation of the NAS measures within each strategic area / sector (see chapter 3.3 and sectoral Factsheets in chapter 5).
- **Businesses and Industries:** Commercial entities ranging from small and medium enterprises (SMEs) to large corporations, involved in providing goods or services and larger private sector entities, such as manufacturing, agriculture, energy, transportation, or technology.
- **Civil Society Organizations:** Non-governmental organizations, community groups, and environmental organizations.
- **Academic Institutions:** Researchers, scientists, and educators working on climate change and adaptation.
- **The General Public:** Individuals and communities who are directly affected by climate change and who can contribute to adaptation efforts.

Engaging with these diverse groups, the strategy aims to foster collaboration, knowledge sharing, and inclusive implementation of effective adaptation measures. However, for each measure, a clear lead responsible public body has been identified to coordinate involvement and working mode with the target groups and thus, each measure is subject to individual processes and agreements.

Central to climate action is the principle of social and territorial equity. This entails recognizing and addressing the differential impacts of climate change on vulnerable populations, ensuring that adaptation and mitigation efforts are inclusive and just. Respecting human rights and intergenerational equity is crucial to building a sustainable future (see also section 3.1.).

1.5. Development of the strategy

The revision of the Slovakian NAS and work programme (based on the existing NAP) is part of a broader EU funded initiative that aims to increase the capacity of Slovak public authorities and stakeholders to implement climate adaptation actions. This includes training activities, improvements in the monitoring and evaluation framework and communication activities.

During the project, competent authorities at the national, regional and local level as well as other stakeholders (civil society representatives, research institutions, business organizations and other actors) are engaged in various ways to better understand the situation, needs, challenges, barriers and opportunities and to ensure that the final NAS adequately addresses Slovakian climate adaptation needs (see in particular Action 1 and Action 4 described below).

The development of this NAS report followed the below steps:

Action 1: Assessment of current climate adaptation policies

An assessment of progress was conducted on the implementation of the measures included in the **current NAS and its Action Plan– and the current governance framework, and identification of key stakeholders** for development and implementation of an ambitious NAS¹². The list of identified stakeholders, who were invited to participate in the different stages of the planning process and kept informed of progress made, can be found in Annex A. This work was supported with inputs from stakeholders' interviews and completed in September

¹² Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.2: Report on the state of play of the climate adaptation policies and governance framework and proposal for a stakeholder engagement plan – Final Report. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf.

2024. As a result, the 2025 NAS duly considers and integrates existing national policy documents relevant to climate adaptation from various ministries and stakeholders. The number of sectors covered by the revision has been increased compared to the original NAS. It was agreed with the MoE that the document should further serve as an umbrella document, a comprehensive framework guiding the formulation of sector-specific and local adaptation strategies.

Action 2: Analysis of climate risks and vulnerabilities

Climate risk and vulnerability assessments (CRVA) provide the basis for decision-making, highlighting the vulnerabilities and adaptive capacities of systems to effectively plan adaptation measures. Information for this action was collected through desk research, literature review, and workshops conducted in June and September 2024. The workshops aimed to (1) assess climate impacts, the different sectors' exposure and sensitivity as well as the adaptive capacity and urgency to act, and (2) risk identification and evaluation. In total, five workshop sessions were held with representatives from public administration, research institutions and civil society – stakeholders and public authorities that were identified in Action 1. The CRVA report was completed in December 2024¹³ and includes:

- A description of past and future climate developments in Slovakia and the effects of climate change on temperature, precipitation, and wind, among others.
- Relevant climate impacts observed in Slovakia and the EU for each identified sector or policy area; the climate risk assessment, where the key risks for each sector are presented, as well as the strategic directions or goals for adaptation are formulated. For each sector, climate impact chains were developed to illustrate interdependencies between the different risk drivers and climate impacts.
- Cascading and emerging risks illustrated using key risks for Slovakia.
- Existing knowledge gaps and limitations of the assessment.

Action 3: Engaging Experts and Stakeholders on key sectors

On 18 and 19 June 2024, discussions were held at the MoE, bringing together experts and stakeholders from various fields. These discussions were thematically divided into key sectors, ensuring a multidisciplinary approach to climate adaptation. These sectors served as the foundation for the adaptation strategy, allowing for a targeted assessment of risks and solutions across different areas of society and the economy. Key sectors and cross-cutting aspects are presented along five clusters, under which sectoral activities are outlined (see below Table 2 and for further details section 3.3).

Table 2: Five clusters presenting sectors and cross-cutting aspects covered by the NAS

CLUSTER	Sectors / Issues
Bioeconomy	Agriculture Biodiversity, Ecosystems and Natural Heritage Forestry Geological Environment & Soil Hydrological Regime & Water Resource Management
Economy	Economy and Industry Energy Financial and Insurance System Tourism

CLUSTER	Sectors / Issues
Safety and Well-being	Disaster risk management, Civil protection and critical infrastructure Health care Information and Communication Technology
Built environment and spatial planning	Cultural heritage Spatial planning Transport, infrastructure and buildings
Cross-cutting aspects	Urban areas Social vulnerabilities Education and society Research Governance Regional and cross-border cooperation

Action 4: Development of a draft revised National Climate Adaptation Strategy report

The revised NAS report builds upon the results of the previous actions and the ongoing collaboration and exchanges with the MoE with regard to identification of adaptation measures for each policy area (June-July 2024). It is structured and developed along the Commission Guidelines on Member States' Adaptation Strategies and Plans¹⁴.

Considering the strategic directions identified for each of the policy areas in Action 2, several potential adaptation measures that address these strategic goals were identified.

The following sources of information were used:

- measures included in the 2018 NAS and the 2021 NAP.
- national sector strategies.
- measures included in adaptation strategies of other countries with comparable risks and vulnerabilities e.g. Germany, Austria, Poland, Hungary and Czech Republic.
- measures found in the database generated by EU Mission on Adaptation to Climate Change Portal¹⁵ and on Climate-ADAPT¹⁶.
- measures suggested through stakeholders' participation in the workshops under action 2.

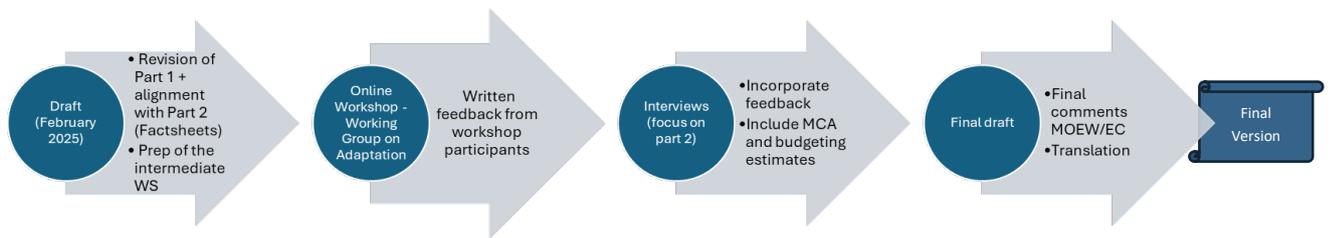
An intermediate online workshop was organised on 25 February 2025 together with selected members of the Working Group on Adaptation to collect their inputs and feedback on the draft NAS report in a participatory way and to validate the strategic framework and adaptation options. Further the draft NAS report has been subject to a **review** process in March 2025, and the feedback received has been included by end of April 2025 (see process in Figure 1).

Figure 1: Process towards finalization of the NAS report following consultation with members of the Working Group on Adaptation (February 2025 onwards)

¹⁴ <https://climate.ec.europa.eu/system/files/2023-07/Guidelines%20on%20MS%20adaptation%20strategies%20and%20plans.pdf>

¹⁵ EU Mission on Adaptation to Climate Change Portal (n.d.) available at: <https://climate-adapt.eea.europa.eu/en/mission>.

¹⁶ Climate-ADAPT (n.d.). Available at: <https://climate-adapt.eea.europa.eu/en>.



Feedback provided through the review process from members of the Working Group on Adaptation mainly related to highly valuable technical contributions for various sectors and cross-cutting aspects. More generic comments asked for more clarity in explaining the link of the climate vulnerability and risk assessment with the concrete adaptation actions proposed. The comments received were all incorporated for further advancing the draft final report. On PART 2 Factsheets the proposed adaptation actions per sector remained the same in number but received important comments for additions.

2. Climate Change - Analytical part

The following part is strongly based on the report developed in Deliverable 2.3 of the project and represents a slightly adapted version of the Executive Summary in D.2.3¹⁷.

2.1. Climate change and vulnerability assessment based on the latest science

The Slovak Republic is a landlocked country in Central Europe with a temperate climate, featuring four distinct seasons, relatively even precipitation throughout the year and the climate exhibits significant regional variations due to the country's complex landscape^{18,19,20}. With respect to climate change, it should be noted that Europe is facing accelerated and severe levels of warming, meaning that since the 1980s warming is twice as high as the global average²¹.

Looking ahead, future climate projections suggest significant warming, with mean annual temperatures rising by 2.0-3.0°C by 2050 and up to 6.0°C by 2100 under high emissions scenarios (Representative Concentration Pathway (RCP)²² 8.5)²³.

In the following chapters, more in-depth information on current and past climate, as well as potential future developments are described for various climate indicators.

2.1.1. Current and past Climate

Despite the complex climate conditions due to a multitude of influences and varied landscape topography, there has been a uniform **upward trend in annual air temperatures**²⁴ ²⁵. The data reveal an increase of approximately 2 °C in mean temperature since 1881, resulting in an average increase of approximately 0.15 °C per decade²⁶ ²⁷. In recent decades, specifically from 2001 to 2022, Slovakia has seen a notable increase in extreme maximum and minimum daily air temperatures, with a sharp rise in the frequency of heat waves. Since 1991, the number of warmer years has significantly risen, particularly highlighted by the record average annual temperature of

¹⁷ Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.3: Climate Risk and Vulnerability Assessment Slovakia. <https://klima-adapt.sk/dokument/f/revision-and-update-of-the-national-strategy-on-adaptation-to-climate-change-in-slovakia..pdf>.

¹⁸ UNFCCC (2023). Slovakia. National Communication (NC). NC 8. Biennial Reports (BR). BR 5. <https://unfccc.int/documents/626514>.

¹⁹ World Bank Group (2021). Climate Change Knowledge Portal: Country: Slovak Republic. <https://climateknowledgeportal.worldbank.org/country/slovak-republic>. Accessed 2 July 2024.

²⁰ World Bank Group (2021). Climate Change Knowledge Portal: Country: Slovak Republic. <https://climateknowledgeportal.worldbank.org/country/slovak-republic>. Accessed 2 July 2024.

²¹ Copernicus (2024): Observer: ESOTC 2023 - Europe experienced an extraordinary year of extremes with record-breaking heatwaves, wildfires, floods, and drought. <https://www.copernicus.eu/en/news/news/observer-esotc-2023-europe-experienced-extraordinary-year-extremes-record-breaking#:~:text=Since%20the%201980s%2C%20Europe%20has,fastest%2Dwarming%20region%20on%20Earth>.

²² https://en.wikipedia.org/wiki/Representative_Concentration_Pathway.

²³ IPCC (2021). Future Global Climate: Scenario-based Projections and Near-term Information. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

²⁴ Labudová, L., Faško, P., Ivaňáková, G. (2015). Changes in climate and changing climate regions in Slovakia. Moravian Geographical Reports 23 (3), 71–82.

²⁵ Labudová, L., Ivaňáková, G., Faško, P., Kajaba, P., Labuda, M. (2024). Changes in drought occurrence and intensity in the context of climate change in Slovakia. Theoretical and Applied Climatology 155 (5), 4009–4022.

²⁶ Gera, M., Damborská, I., Lapin, M., Melo, M. (2017). Climate Changes in Slovakia: Analysis of Past and Present Observations and Scenarios of Future Developments. Water Resources in Slovakia: Part II 70, 21–47.

²⁷ UNFCCC (2023). Slovakia. National Communication (NC). NC 8. Biennial Reports (BR). BR 5. <https://unfccc.int/documents/626514>.

12.4°C in Hurbanovo for the years 2018 and 2019²⁸. The rise in summer days (temperatures reaching 25°C or higher) and tropical days (temperatures of 30°C or higher) has been striking since the last decade of the 20th century²⁹. Dry periods, characterised by a lack of precipitation, have become more common, leading to more frequent and severe soil droughts due to generally warmer conditions³⁰. Seasonal differences of temperature increases are also observed, showing the largest temperature increases in January and the summer months. Between 1991–2020 and 1961–1990, January temperatures rose by more than 1.2°C, while June and July recorded increases of 1.6°C, and August over 1.8°C. With respect to past developments, research indicates that seasonal temperature changes³¹.

Unlike temperature trends, precipitation patterns in Slovakia are less pronounced due to their complex spatial and temporal distribution. The most noticeable difference in monthly precipitation totals between reference periods occur primarily in July. Extreme weather events from the Mediterranean in summer during the late 20th and early 21st centuries have resulted in substantial rainfall and flooding, notably in the years 1997, 1998, 1999, 2001, 2004, and 2005. The region's topography interacts with these weather systems, influencing precipitation trends³². However, the existing network of meteorological stations may not fully capture the spatial variability of precipitation patterns and the air masses delivering precipitation records of meteorological stations varies depending on their location and the influence of air masses delivering precipitation, which results in potentially contrasting trends within the same country. In Slovakia, the most substantial increases in precipitation were recorded at higher altitudes^{33 34 35}. This trend has intensified in recent years, with the 2024 floods, the worst in 30 years, driven by extreme rainfall, further demonstrating the increasing severity of such events³⁶.

Since the 1980s, Slovakia has experienced frequent hydrological droughts. In the 21st century, the country has encountered three significant drought events of Pan-European scale. The impact of climatic factors, particularly precipitation and potential evapotranspiration, on drought conditions has become more pronounced since 2000³⁷. Analysis of the droughts in 2003, 2012 and 2015 revealed that while these years shared similar weather conditions, the effects varied significantly across the twelve river basins assessed. The 2003 drought was moderately severe in terms of duration and precipitation deficit, while the 2012 and 2015 droughts were relatively mild in terms of return period³⁸.

The **increase in occurrence of drought** events also adversely affects groundwater, which constitutes the primarily source of drinking water in Slovakia. Since 1991, the intensity of negative changes in groundwater resources has markedly increased and reductions in groundwater reached 25% in the most affected areas and

29 Labudová, L., Faško, P., Ivaňáková, G. (2015). Changes in climate and changing climate regions in Slovakia. *Moravian Geographical Reports* 23 (3), 71–82.

30 UNFCCC (2023). Slovakia. National Communication (NC). NC 8. Biennial Reports (BR). BR 5. <https://unfccc.int/documents/626514>

31 Labudová, L., Ivaňáková, G., Faško, P., Kajaba, P., Labuda, M. (2024). Changes in drought occurrence and intensity in the context of climate change in Slovakia. *Theoretical and Applied Climatology* 155 (5), 4009–4022.

32 Labudová, L., Ivaňáková, G., Faško, P., Kajaba, P., Labuda, M. (2024). Changes in drought occurrence and intensity in the context of climate change in Slovakia. *Theoretical and Applied Climatology* 155 (5), 4009–4022.

33 Gera, M., Damborská, I., Lapin, M., Melo, M. (2017). Climate Changes in Slovakia: Analysis of Past and Present Observations and Scenarios of Future Developments. *Water Resources in Slovakia: Part II* 70, 21–47.

34 Labudová, L., Faško, P., Ivaňáková, G. (2015). Changes in climate and changing climate regions in Slovakia. *Moravian Geographical Reports* 23 (3), 71–82.

35 Lapin, M. (2021). Climate Change, Its Impacts and Possible Measures in Slovakia. *Acta Horticulture et Regiotecturae* 24 (s1), 90–96.

36 Slovakia's capital hit by biggest floods in 30 years – DW – 09/18/2024.

37 Fendeková, M. (2018b). Major Droughts in Slovakia in the Twenty-First Century. *Water Resources in Slovakia: Part II* 70, 125–144.

38 Fendeková, M. (2018). Major Droughts in Slovakia in the Twenty-First Century. *Water Resources in Slovakia: Part II* 70, 125–144.

up to 35% in local spots, resulting in an estimated total decrease of 250,000 m³/km²³⁹. In total, at least 70% of Slovakia had experienced declines in groundwater levels by 2009. However, studies reveal regional differences and indicate that the groundwater increased moderately in south-eastern Slovakia and the central Váh River Basin^{40 41}. In fact, frequent extended drought periods reduce usable water resources and highlight the vulnerability of Slovakia's water systems to climate change⁴².

2.1.2. Future Climate

Slovakia is **projected** to experience **significant changes in temperature and precipitation** in both the near and far future. Assessments for two future timeframes and scenarios were compiled, an optimistic and a pessimistic scenario for both the near (2021-2050) and far future (2071-2100), respectively. The optimistic scenario describes a future where climate mitigation efforts limit global warming (RCP4.5), whereas the pessimistic scenario describes a business-as-usual scenario without any mitigation efforts (RCP8.5). The data shows a clear trend of rising temperatures and an increase in extremely hot days across Slovakia, with more significant changes under higher emissions scenarios. Climate projections indicate that by 2050-2100 (Table 3), the annual mean temperature in Slovakia is expected to rise by approximately 1.3 to 3.2 °C compared to the reference period of 1991-2020, depending on the region and the climate change scenario (RCP4.5 or RCP8.5). Additionally, heatwaves and the frequency of days with maximum temperatures exceeding 30 °C are projected to rise by the century's end. Over the past twenty years, there has been a decline in heating degree days (HDDs) and an increase in cooling degree days (CDDs)⁴³, reflecting changing energy needs⁴⁴.

According to analysed data provided and processed by the Slovak Hydrometeorological Institute, Slovakia is expected to experience moderate increases in mean annual air temperature in °C and tropical days (maximum temperatures reaching at least 30°C) in the near future (2021-2050) and significant increases in the far future (2071-2100) under the RCP4.5 scenario. Specifically, as indicated in the data presented in the tables below, the number of tropical days is expected to rise, highlighting a concerning trend. In contrast, the RCP8.5 scenario predicts substantial increases in mean annual air temperature and tropical days for both periods. Both scenarios foresee a significant rise in the number of tropical days (days with maximum temperatures above 30°C). Figure 2 shows the mean annual air temperature for the near (2021-2050) and far future (2071-2100), compared to the reference period 1991-2020.

³⁹ Fendeková, M. (2018). Groundwater Drought Occurrence in Slovakia. *Water Resources in Slovakia: Part II* 70, 91–104.

⁴⁰ Fendeková, M. (2018). Groundwater Drought Occurrence in Slovakia. *Water Resources in Slovakia: Part II* 70, 91–104.

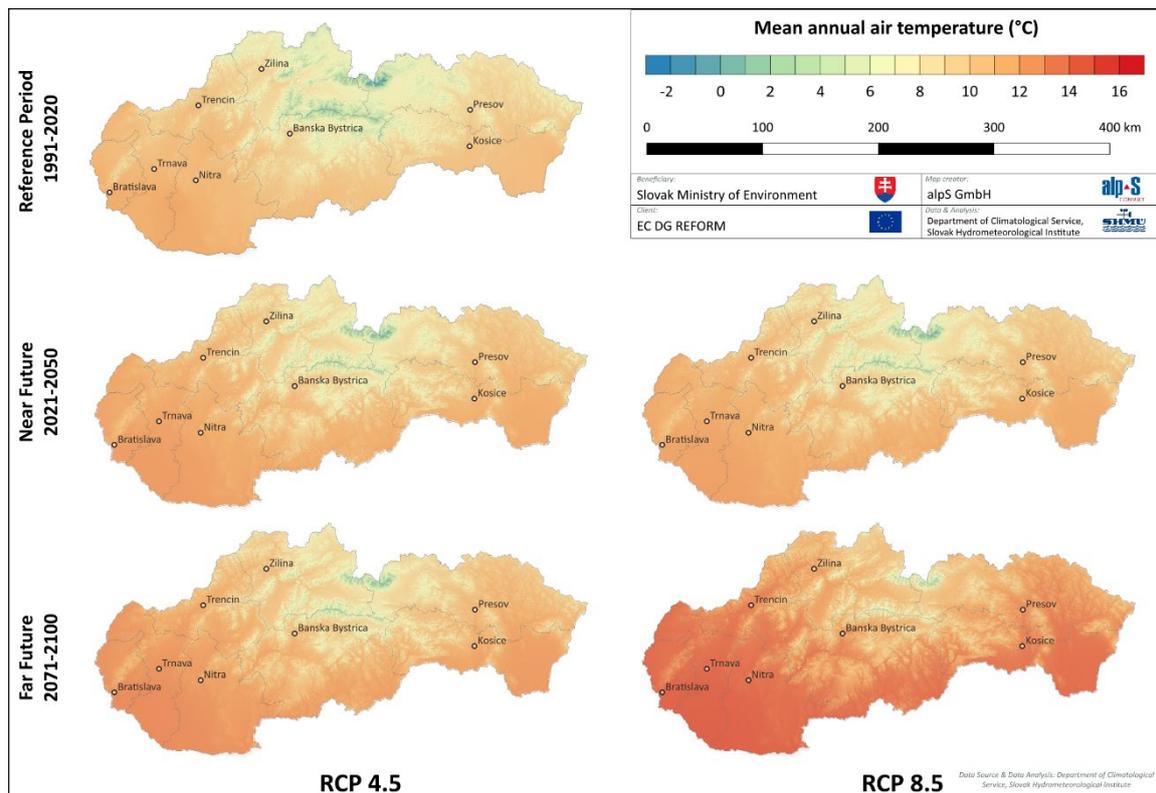
⁴¹ Zeleňáková, M., Fendeková, M. (2019). Climate Change Impacts on Water Resources. In: Negm, A.M., Zeleňáková, M. (Eds.) *Water Resources in Slovakia: Part II*, vol. 70. Springer International Publishing, Cham, pp. 3–19.

⁴² UNFCCC (2023). Slovakia. National Communication (NC). NC 8. Biennial Reports (BR). BR 5. <https://unfccc.int/documents/626514>.

⁴³ Degree days are calculated based on the assumption that outdoor temperatures around 18.3°C (65°F) indicate that heating or cooling is not needed for comfort. Degree days measure the difference between the daily mean temperature (the average of the daily high and low temperatures) and 18.3°C. If the mean temperature is above 18.3°C, the result is termed Cooling Degree Days (CDDs), obtained by subtracting 18.3°C from the mean. Conversely, if the mean temperature falls below 18.3°C, the outcome is known as Heating Degree Days (HDDs), calculated by subtracting the mean from 18.3°C (National Weather Service, n.d.).

⁴⁴ IEA (2022). Climate Resilience Policy Indicator. <https://www.iea.org/reports/climate-resilience-policy-indicator>.

Figure 2: Mean annual air temperature in °C; scenarios for the near (2021-2050) and far (2071-2100) future under RCP4.5 and RCP8.5 are shown for Slovakia, including regional boundaries and regional capitals.



Source of climate data: Department of Climatological Service, Slovak Hydrometeorological Institute.

Precipitation patterns are expected to show strong variability in the future. Climate projections suggest up to a 30 % increase in annual precipitation by 2075 compared to 1961-1990, with significant seasonal and geographical variations. However, this increase is expected to vary by season and region, with winter experiencing a more substantial rise compared to summer, and the northern regions seeing a greater increase than the southern area. These changes in precipitation may increase the country's exposure to both heavy rainfall events and droughts⁴⁵. These projections come with a high degree of uncertainty, particularly for precipitation, which is inherently more difficult to model compared to temperature⁴⁶. Rainfall patterns are anticipated to become more variable, with longer periods of dryness interspersed with more intense, short-duration rain events. By the end of the century, precipitation totals across most of Slovakia are projected to increase with potential rises of up to 10 % under RCP4.5 and up to 15 % under RCP8.5 compared to the 1981-2010 period. This corresponds to an annual increase of 50 to 70 mm for RCP4.5 and 100 to 120 mm for RCP8.5. Increases in rainfall intensities are expected to be approximately +5 to +8% for RCP2.6 from 2021-2050, +3 to +5% from 2051-2100, and up to +35% for RCP8.5 by the end of the century. Stronger storms are also anticipated, with more frequent high wind gusts and larger hail⁴⁷. Table 3 provides an overview of expected climate induced changes of heavy rain for Slovakian regions for the near (2021-2050) and far future (2071-2100).

⁴⁵ Additionally, the decrease in snow cover may lead to reduced groundwater recharge, as less snowmelt during the winter months will result in more precipitation running off rather than replenishing aquifers.

⁴⁶ IEA (2022). Climate Resilience Policy Indicator. <https://www.iea.org/reports/climate-resilience-policy-indicator>.

⁴⁷ UNFCCC (2023). Slovakia. National Communication (NC). NC 8. Biennial Reports (BR). BR 5. <https://unfccc.int/documents/626514>.

Table 3: Changes in mean annual heavy rain days (more than 40 mm precipitation) in percent for regions of Slovakia; scenarios for the near (2021-2050) and far (2071-2100) future under RCP4.5 and RCP8.5 are shown. Source of climate data: Department of Climatological Service, Slovak Hydrometeorological Institute.

Indicator	Region	Ref. Period 1991-2020	Relative changes to reference period 1991-2020 in %			
			Near Future 2021-2050		Far Future 2071-2100	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
Heavy rain [Days]	Bratislavský kraj	0.76	22	25	36	74
	Trnavský kraj	0.60	47	50	63	112
	Nitrianský kraj	0.56	59	63	77	129
	Trencianský kraj	0.76	55	67	74	111
	Banskobystrický kraj	0.85	53	68	73	105
	Zilinský kraj	0.87	83	106	108	138
	Prešovský kraj	0.93	47	63	68	97
	Košický kraj	0.81	44	56	62	98

Color coding: red = large change (> 10 days); orange = medium change (5-10 days); blue = small change (< 5 days). Source of climate data: Department of Climatological Service, Slovak Hydrometeorological Institute.

The frequency of extreme storm-related phenomena, such as wind gusts exceeding 25 m/s and hail events with hailstones measuring 2-5 cm in diameter, is projected to increase significantly; by 2100, high wind gusts could see a 20-80% rise in occurrence, while hail events with hailstones up to 5 cm could increase by 40-150%, depending on the chosen emission scenario. Additionally, during dry and windy spells, wind erosion is expected to affect exposed areas⁴⁸.

2.2. Risk assessment - Business-as-usual scenario (no adaptation efforts made)

Based on the climate impact assessment workshops, expert knowledge and scientific literature, climate impact chains were developed, reflecting the current climate impact situation and considering climate impacts of high priority, the exposed subsystems (e.g., urban ecosystems, international supply chains, freshwater systems, companies & operating sites; subsystems vary depending on the sector) and non-climatic risk drivers. These compiled impact chains served as a basis for discussions in the participatory process for deriving key risks. Key risks are characterised by their longevity, their duration of necessary time for adaptation options to fulfil their impact and their wide-ranging effects and consequences, possibly rippling through ecological, economic and societal levels^{49 50 51}.

During the climate impact assessment workshops, discussions were held in breakout groups, where the results of prior working steps have been reflected, and sector-based key risks were formulated and agreed on. The key risks reflect the exposure, sensitivity, adaptive capacity and urgency to act, presenting the current rating of climate impacts within each sector and condensing the knowledge collected in prior working steps into a current

⁴⁸ UNFCCC (2023). Slovakia. National Communication (NC). NC 8. Biennial Reports (BR). BR 5. <https://unfccc.int/documents/626514>.

⁴⁹ GIZ (2023): Climate Risk Sourcebook. With assistance of M. Zebisch, K. Renner, M. Pittore, U. Fritsch, S. R. Fruchter, S. Kienberger et al. Edited by Deutsche Gesellschaft für International Zusammenarbeit GmbH (GIZ). Bonn. https://www.adaptationcommunity.net/wp-content/uploads/2023/10/giz_2023_Climate_Risk_Sourcebook.pdf.

⁵⁰ EEA (2024): European Climate Risk Assessment. Edited by European Environment Agency (EEA). Copenhagen (EEA report, 01/2024). <https://www.eea.europa.eu/publications/european-climate-risk-assessment>.

⁵¹ IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of working group 2 to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, New York.

risk landscape. Hence, the current risk assessment was derived for each key risk. These assessments were further linked with climate data under two scenarios: **optimistic (RCP4.5)** and **pessimistic (RCP8.5)**, spanning the near future (2021–2050) and distant future (2071–2100). In addition, the temporal dynamics (e. g. acute or slow onset events) as well as potential spatial variabilities (e. g. some regions might be affected more than others; hence local, regional or national occurrence are differentiated) are also considered.

The risk assessment represents a business-as-usual scenario, i.e. consequences to be expected if no adaptation measures are implemented. The current and future risk landscape of Slovakia shows that severe adverse impacts have to be expected if no or only insufficient action is taken as the levels of nearly every identified key risk reach high to very high levels in the far future at the latest. In the near future, apart from two exceptions in the tourism sector, key risks reach medium to high levels. As such, the assessment highlights the urgent need for both extensive mitigation and adaptation efforts to prepare for the challenges in the far future, emphasising that the time to act is now to avoid escalating costs, irreversible damage, and lost opportunities to build resilience and reduce risks effectively. With regard to potential financial burdens, it should be noted that risk of costs of inaction due to insufficient mitigation and adaptation to climate change (KR-FI-3) is already rated as high. A comprehensive list of all identified risks can be found in ANNEXES Annex 1: List of sectoral key risks. Each key risk has a code to link it to the respective sector and supports its quick identification.

2.2.1. Key sectoral risks under Business-as-usual conditions

In eight of the 15 sectors assessed, the key risks identified have already a *high* risk level and are expected to become more severe in the coming decades⁵². These key risks are related to malfunctioning water management systems in agriculture (KR-A-3), loss of biodiversity and habitats (KR-B-1), damage to and loss of people, livelihoods and (critical) infrastructure, in particular due to extreme events such as heat, drought and floods (KR-DRM-1, KR-DRM-2, KR-WM-1, K-SP-1, KR-TIB-2), loss of ecosystem service provision provided by forests (KR-FO-1) and adverse effects due to inadequate forest management (KR-FO-2).

Most importantly, the key risk of rising costs of inaction in terms of adaptation and mitigation (KR-FI-3; currently and in the near future rated as *high* and *very high* in the far future) draws attention to the fact that urgent action is needed to tackle (severe) climate change induced impacts. This becomes even more important as there is an increasing risk of rising insurance costs and potentially insurable climate impacts (KR-FI-1; currently and in the near future rated as *high* and *very high* in the far future).

Apart from some exceptions, all key risks reach *high* or *very high* levels in the far future (2071-2100) either only under a pessimistic or under both an optimistic and pessimistic scenario. Extreme events such as heat waves, droughts, pluvial and fluvial flooding as well as forest- and wildfires play an essential role in shaping the Slovak risk landscape. With respect to heat, in particular urban areas face major risks due to the urban heat island effect, resulting in heat stress for inhabitants and increased energy demands for cooling of buildings and transport infrastructure (KR-SP-1, KR-H-1, KR-TIB-2). Associated heat waves and droughts pose major threats to biodiversity and terrestrial and aquatic ecosystems (KR-FO-1; currently and in the near future rated as *high* and *very high* in the far future), potentially leading to a *very high* risk of decreased food security and lack of food (KR-A-4) in the far future under a pessimistic scenario. Likewise, extreme events such as floods and wildfires do not only adversely affect people and lead to major destructions of infrastructure and buildings, but might also result in a risk to cultural heritage, i.e. historical, archaeological, cultural and natural heritage sites and landscapes might get damaged (KR-CH-1; currently and in the near future *medium* risk, *high* risk in the far future) and are one factor affecting soil erosion (KR-GES-1; currently rated as *medium*, *high* in the near future and *very high* in

⁵² For the full assessment see Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.3: Climate Risk and Vulnerability Assessment Slovakia. <https://klima-adapt.sk/dokument/f/revision-and-update-of-the-national-strategy-on-adaptation-to-climate-change-in-slovakia..pdf>

the far future under a pessimistic scenario). Adverse consequences must also be expected for the Tourism sector as impacts of such events can lead to limited accessibility of attractions (KR-T-3; currently and in the near future *medium* risk, *high* risk in the far future). In addition, there is an increasing risk of insufficient water supply, malfunctioning wastewater and sewage systems (KR-WM-2, KR-WM-3; currently rated as *medium*, *high* in the near future and *very high* in the far future under a pessimistic scenario) as well as decreasing groundwater availability and quality (KR-GES-2; currently and in the near future rated as *medium* and *very high* in the far future under a pessimistic scenario). With regard to spatial planning, a risk of long-lasting maladaptation and lock-ins is expected if no respective measures are taken, meaning that the risk is rated as *medium* for the near future and *high* in the far future under both scenarios (KR-SP-2).

2.2.2. Transboundary, cascading and emerging risks

In addition to sectoral key risks (chapter 2.2.1), transboundary, cascading as well as newly and emerging risks have to be considered, underlining the complex interconnectedness going beyond the Slovak Republic.

Transboundary risks, that can lead to both positive and negative effects, can be defined as those risks induced by climate change that cross national borders, moving from one country to its immediate neighbour as well as leaping across entire regions and continents, transmitting risks to countries and people thousands of kilometres away from the initial point of impact⁵³. Potential transboundary risks affecting Slovakia can be associated with the energy supply and trade as well as the water resources and river basin management. Regarding the latter, disputes over water management and allocation among countries sharing these resources have to be expected as climate change affects precipitation patterns and leads to an increased frequency of droughts, potentially resulting in adverse effects on water availability and quality.

Cascading risk emerges from the interconnectedness of systems and their elements, when interactions of individual risks result in cascades of failures⁵⁴. Examples of relevant cascading risks for Slovakia are related to water stress/scarcity and urban heat islands. Urban heat, amplified by a heightened frequency of heat waves, can lead to increased energy demands for cooling, straining the power grid, potentially resulting in power outages, and adversely affecting inhabitants. Water stress and water scarcity are related to multiple aspects such as irrigation needs, decreasing crop yields and productivity, negative impacts on livelihoods of farmers, higher food prices and reduced food security and adverse effects on public health due to waterborne diseases, all of which are connected in a complex interplay of potential domino effects.

Emerging risks from climate change encompass a broad range of threats that are increasingly recognised as critical to understand and manage the global climate crisis and our responses to it. They may be new or familiar risks that become apparent in emerging circumstances and may not be fully understood or assessed but nevertheless pose a threat to human security^{55 56}. Emerging risks often arise from feedback processes between climatic changes, human mitigation and adaptation interventions, and processes in natural systems which can

⁵³ Anisimov, A., Magnan, A.K. (Eds.) (2023). The global transboundary climate risk report.

⁵⁴ UNDRR, UNU-EHS, 2022. Understanding and managing cascading and systemic risks: lessons from COVID-19, Bonn, Geneva. <https://www.undrr.org/media/79311/download?startDownload=20240702>.

⁵⁵ International Risk Governance Council (IRGC), 2010. The Emergence of Risks: Contributing Factors.

<https://infoscience.epfl.ch/record/228055/files/The%20Emergence%20of%20Risks%20Contributing%20Factors.pdf>.

⁵⁶ IPCC (2014). Emergent Risks and Key Vulnerabilities. In: IPCC (Ed.) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp. 1039–1099.

threaten human security, leading to unexpected, severe consequences⁵⁷. Slovakia is exposed to several emerging risks, ranging from an increased frequency of extreme weather events, impacts on human health and critical infrastructure, limited water availability to shifting energy consumption patterns, economic impacts e.g. affecting agriculture and tourism and loss of biodiversity.

Knowledge gaps and uncertainties further add to the complexity of the Slovak risk landscape. For instance, tipping effects dynamics of the Earth climate system might result in unprecedented severe impacts, calling for an even stronger and faster implementation of mitigation and adaptation measures⁵⁸. In addition, data and knowledge gaps as well as limitations have been identified in course of the project (e.g. a lack of investigation and monitoring of underground water quality, lack of data concerning effects of the extension of the vegetation period, weak crisis management in the ICT sector), based on the expertise of involved stakeholders, highlighting the need for further investigations and actions to address these limitations.

In addition, social vulnerabilities and inequalities in the context of climate change are other aspects of major concern and should be addressed in both adaptation and mitigation, ensuring, among other things, a socially just adaptation^{59 60}.

2.2.3. Urgent Need for Action

This risk assessment underscores the escalating consequences of inaction with key risks expected to intensify significantly under a business-as-usual trajectory. Without adaptation (along with mitigation efforts), the risks of irreversible damage, soaring costs, and missed opportunities for resilience will rise. Extreme weather, biodiversity loss, resource scarcity, and economic strain collectively emphasise the need for immediate measures to address these challenges. The following box (Figure 3) summarises key messages derived from the Climate Risk and Vulnerability Assessment.

⁵⁷ IPCC (2014). Emergent Risks and Key Vulnerabilities. In: IPCC (Ed.) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp. 1039–1099.

⁵⁸ Lenton, T.M., Armstrong McKay, D.I., Loriani, S., Abrams, J.F., Lade, S.J., Donges, J.F., Milkoreit, M., Powell, T., Smith, S.R., Zimm, C., Buxton, J.E., Bailey, E., Laybourn, L., Ghadiali, A., Dyke, J.G. (Eds.) (2023). The Global Tipping Points Report 2023. University of Exeter, Exeter.

⁵⁹ Breil, M., Downing, C., Kazmierczak, A., Mäkinen, K., Romanovska, L., 2018. Social vulnerability to climate change in European cities – state of play in policy and practice. Technical Paper ETC/CCA 2018/1. <https://ora.ox.ac.uk/objects/uuid:73ed1b8d-3a0f-44d6-a841-e98879ba7d8a/files/s7m01bm91h><https://ora.ox.ac.uk/objects/uuid:73ed1b8d-3a0f-44d6-a841-e98879ba7d8a/files/s7m01bm91h>.

⁶⁰ IPCC (2023). Summary for Policymakers. In: Intergovernmental Panel on Climate Change (Ed.) Synthesis Report of the IPCC Sixth Assessment Report (AR6). https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf.

Figure 3: Key messages derived from the Climate Risk and Vulnerability Assessment

Key messages

- 1** In eight of the 15 sectors assessed, at least one key risk identified already has a *high* risk level.
- 2** All key risks reach *medium* or *high* levels in the near future (2021-2050), with one exception in the Tourism sector.
- 3** With only some exceptions, all key risks reach *high* or *very high* levels in the far future (2071-2100), either under a pessimistic scenario only or under both an optimistic (RCP4.5) and pessimistic scenario (RCP8.5).
- 4** Extreme events such as heat waves, droughts, pluvial and fluvial flooding as well as forest- and wildfires play an essential role in shaping the risk landscape of Slovakia.
- 5** Rising costs of inaction (mitigation and adaptation) and insurance costs (including potentially insurable climate impacts) have to be expected.
- 6** There are no substantial opportunities from a business-as-usual approach, i.e. if no further adaptation measures are implemented.
- 7** Climate change and its impacts are strongly intertwined with security issues.
- 8** Climate change adaptation and mitigation should acknowledge the complex interplay of social, economic, environmental and cultural dimensions and processes within and across regions and countries. This requires a cross-sectoral, holistic and forward-looking way of thinking and acting.

2.3. Adaptation progress assessment

2.3.1. Evolving adaptation policy making

Slovakia has considered climate change adaptation (measures) in its policy making. The first *Strategy for Adaptation of the Slovak Republic to the Adverse Impacts of Climate Change* was adopted in 2014. It aimed to address the effects of climate change on various sectors, including natural systems, human health, urban environments, agriculture, forestry, transportation, energy, industry, and tourism, and it also included a set of adaptation measures for each sector. Monitoring and evaluating the effectiveness of adaptation measures were integral components of the 2014 Strategy. At the time, a standardised methodology for this purpose was lacking, posing challenges. While there were efforts to develop a specific set of indicators and methodology, the monitoring focus remained on tracking the costs of adaptation measures implemented.

It was recommended to update the Strategy every 5-10 years. Accordingly, in 2017, the MoE started the process of updating the Strategy which led to the *Climate Change Adaptation Strategy of the Slovak Republic* adopted in 2018 (hereinafter, “2018 NAS”). To ensure the fulfilment of the strategy’s main objective, the 2018 NAS established six sub-objectives accompanied by framework measures.⁶¹

Building on the 2018 NAS, the Slovakian government adopted the *Action Plan for the implementation of the Slovak Climate Change Adaptation Strategy (NAP)* in 2021. It delineates five overarching cross-cutting measures. These measures aim to bolster the implementation framework, advance scientific inquiry and research in climate change adaptation, establish an efficient crisis management system to address extreme events like floods and fires, promote green infrastructure, and foster education and awareness. In order to meet the main objective and strategic priorities, and also to provide a framework for the implementation of the seven specific focus areas⁶², 5 cross-cutting actions will be supported through 18 implementing tasks. In total, 45 specific measures and 169 associated tasks have been identified for the duration of the NAP’s validity until 2027. It is important to note that, within the context of the NAP, measures provide the overall direction while the implementation tasks are the specific actions required to implement those measures successfully. Implementation tasks (specific tasks, actions) are implemented and reported in the short-term (2021 – 2023) and mid-term (2024 – 2027) time horizon.

2.3.2. Analysis of the implementation of adaptation measures

A comprehensive analysis of the NAP was carried out in the context of this project, focusing on the adaptation measures and implementation tasks outlined in the first NAP. The assessment carried out was based on the evaluation files provided by the MoE in March 2024, incorporating only the information available up to that time.

Since the MoE differentiates between short-term, mid-term, and long-term measures, progress has been documented for 10 of the total 18 cross-cutting measures. However, the absence of information in the evaluation files does not imply that these measures are either not implemented or being implemented, as they will be the focus of the next evaluation cycle.

With regard to the analysis of the sectoral adaptation measures that focused on the 169 NAP implementation tasks, a traffic light assessment was conducted based on three main aspects:

⁶¹ Please see the 2 State of Play (DLV2) report for more details. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf

⁶² These are the following: water protection, management, and utilization; sustainable agriculture; adaptive forestry; preservation of the natural environment and biodiversity; ensuring health and well-being of populations; enhancing the resilience of the built environment; and implementing technical, economic, and social measures.

- **relevance** within national policies, considering the priority given in the NAP to adaptation measures within each sector, availability of complementary sectorial plans and coverage of different types of adaptation measures,
- **effectiveness**, considering the diversity of stakeholders involved within each sector and the capacity for implementation monitoring, and
- **coherence**, exploring the extent to which sectorial adaptation measures contribute to broader climate change mitigation efforts.

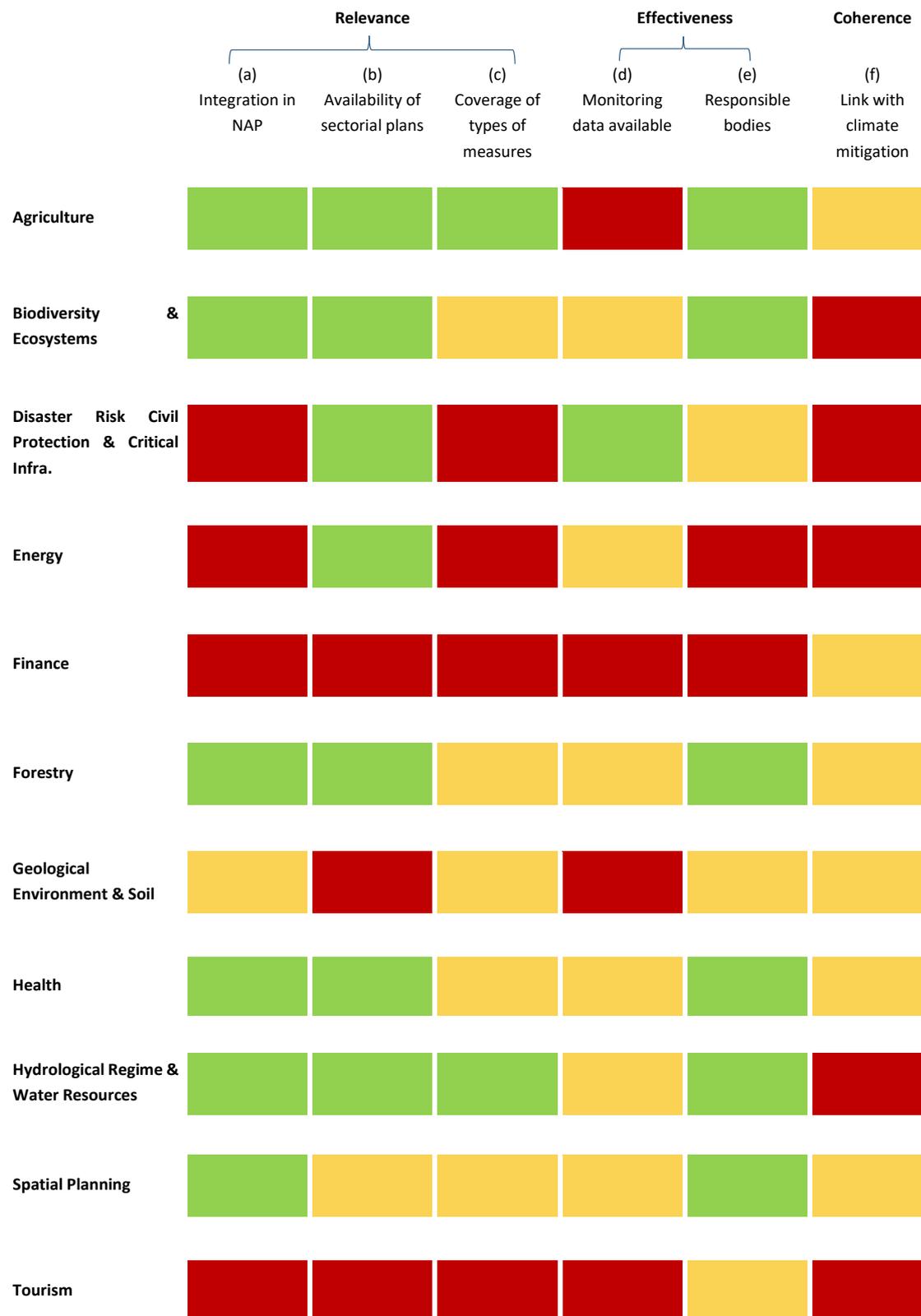
All 169 implementation tasks outlined in the NAP were assessed against the established criteria⁶³. For evaluating the interconnectedness with climate mitigation, a light assessment was conducted for each implementation task, and only those with clear mitigation benefits were identified as such. For a full overview of the assessment methodology and limitations, please refer to the State of Play (D2.2) report of this project⁶⁴. Table 4 below shows the results of the assessment for the implementation tasks included in the NAP⁶⁵.

⁶³ The list of sectors corresponds to the finalised selection agreed upon during the inception phase of the project. The sectors of Cultural Heritage and Information & Communication Technology were excluded from the analysis as none of the implementation tasks were found to be primarily relevant to these sectors.

⁶⁴ Available online. See Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.2: Report on the state of play of the climate adaptation policies and governance framework and proposal for a stakeholder engagement plan – Final Report. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf.

⁶⁵ For precise colour-coding please see explanatory note below the assessment table or refer to the State of Play (DLV2.2) report. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf

Table 4: Assessment of climate adaptation implementation tasks NAP



SOURCE: Own elaboration based on information from the NAP for the 169 implementation tasks. a) Integration in NAP: Sectors are categorised into green (>20 implementation tasks), yellow (between 10 and 20 tasks), and red (<5 tasks). b) Availability of Sectorial Plans: Sectors are categorised into green (complementary Sectorial plans available), yellow (crosscutting sector), and red (no Sectorial plans available). c) Responsible Bodies: Sectors are categorised into green (>6 different responsible bodies), yellow (between 5 and 3), and red (below 2). d) Coverage of Types of Measures: Sectors are categorised into green (>8 different sub KTMs), yellow (between 4 and 7 tasks),

and red (<3 different sub KTMs). e) Monitoring Data Available: Indicator is the share of implementation tasks with data on implementation status available. Green indicates >80% of implementation tasks with implementation information available, yellow indicates between 30 and 80%, and red indicates less than 30%. f) Link with Climate Mitigation: Green indicates most of the measures have a clear link with adaptation measures, yellow indicates only partly, and red indicates very few measures have a clear link with climate mitigation.

Overall, the assessment shows that:

- The sectors **Forestry, Hydrological Regime & Water Resources Management, Spatial Planning, Health, Biodiversity and Ecosystems, and Agriculture have a higher number of implementation tasks included in the NAP**. Conversely, sectors like Disaster Risk Management, Civil Protection & Critical Infrastructure, Energy, Finance, and Tourism have fewer tasks associated, which might indicate relatively lower priority on adaptation efforts in these sectors. There is a notable absence of complementary sectorial plans outlining adaptation measures for the Tourism and Finance sectors.
- **Efforts aimed at formulating or updating policy instruments are extensively covered across various sectors**, with particular attention drawn to sectors like Biodiversity and Ecosystems, Spatial Planning, and Hydrological Regime & Water Resources Management. Conversely, sectors such as Tourism and Disaster Risk Management, Civil Protection & Critical Infrastructure, lack specific actions pertaining to this Governance and Institutional dimension. However, there is a noticeable absence of policies for coordination, cooperation and networks which might imply a potential oversight in establishing effective mechanisms for inter-ministerial collaboration and engagement with key stakeholders.
- **There is limited inclusion of actions with a focus on Economics and Finance** across sectors. The Forestry sector stands out with more actions concerning financing and incentive instruments while the Hydrological Regime & Water Resources Management sector shows a notable gap in this regard. Moreover, there is a noticeable lack of actions on insurance and risk-sharing instruments across sectors, with only two actions among the 169 identified (both within the Disaster Risk Management, Civil Protection & Critical Infrastructure sector).
- Across sectors, there is a **clear prioritisation of technological options, such as early warning systems, over grey options, which typically involve the creation of new physical infrastructure. Also, there is a notable prioritisation of Nature-Based Solutions and Ecosystem-Based Approaches**. The Forestry and Agriculture sectors are the ones with more actions in this dimension, indicating a specific emphasis on nature-based and ecosystem-centred strategies within these sectors.
- The **implementation of actions for knowledge and behavioural change varies significantly**, with certain sectors prioritising it highly. Notably, the Hydrological Regime & Water Resources Management sector leads with 10 measures dedicated to this aspect. Furthermore, the Transport Infrastructure sector stands out for its focus on capacity building, knowledge transfer, and empowering stakeholders.

The assessment also revealed that monitoring data availability is generally poor across sectors. However, a diverse array of stakeholders is engaged in implementing adaptation measures, with varying levels of involvement depending on the sector. When it comes to connections with climate change mitigation, the assessment indicated varying levels of integration. In general, the link with climate mitigation benefits was found to be weak across all sectors.

2.3.3. Evaluating effectiveness in reducing vulnerabilities and strengthening resilience

Assessing the effectiveness of the 2018 NAS and National Adaptation Plan (NAP) in reducing vulnerabilities and strengthening resilience presents several challenges. These difficulties stem from a combination of data limitations, governance complexities, and the evolving nature of climate risks⁶⁶.

Uncertainty of Climate Change Impacts

Climate change projections contain inherent uncertainties and present a broadband of possible future scenarios, making it difficult to predict specific vulnerabilities and the effectiveness of adaptation measures. According to the **IPCC Sixth Assessment Report (AR6)**⁶⁷, **non-linear climate impacts** - such as feedback loops in ecosystems, tipping points in hydrological cycles, and the compounding effects of multiple hazards - can make long-term vulnerability assessments even more challenging. For instance, prolonged drought conditions can lead to soil degradation, reducing agricultural productivity, while simultaneous heat stress exacerbates risks to public health and infrastructure⁶⁸. These cascading effects mean that adaptation policies **must be flexible and regularly adjusted** to remain effective.

Moreover, vulnerability is shaped not only by environmental changes but also by **socio-economic factors**, including land-use patterns, demographic trends, and economic transitions. For example, urbanization and infrastructure development can either mitigate or amplify climate risks depending on how they are planned and implemented. In Slovakia, the increasing demand for water resources, coupled with shifting agricultural practices and population aging, alters the landscape of climate vulnerability over time⁶⁹. Without **continuous monitoring, improved climate modelling, and adaptive governance frameworks**, adaptation measures may become outdated or insufficient in addressing new and emerging risks.

As the IPCC AR6 highlights, **effective adaptation requires iterative risk management**, where policies are continuously revised based on the latest climate science, observed impacts, and socio-economic developments⁷⁰. This underscores the importance of **enhancing climate data collection, strengthening interdisciplinary research, and integrating dynamic adaptation planning** into Slovakia's NAS and NAP to ensure they remain responsive to both short-term and long-term climate vulnerabilities.

Data Availability and Quality

One of the primary challenges in evaluating 2018 NAS and NAP is the availability and reliability of climate adaptation data. While Slovakia has made progress in conducting climate impact assessments, gaps remain in sector-specific and regional climate vulnerability analyses.

A major issue is the **inconsistency and fragmentation of data sources** across different sectors and administrative levels. Many sectoral adaptation measures depend on localized climate data, yet regional and municipal governments often lack the necessary resources and technical capacity to collect and maintain high-quality

⁶⁶ European Environment Agency (EEA). (2024). *European Climate Risk Assessment*. EEA Report No 01/2024. ISBN: 978-92-9480-627-7. Retrieved from <https://www.eea.europa.eu/en/analysis/publications/european-climate-risk-assessment>.

⁶⁷ IPCC (2021): *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. <https://www.ipcc.ch/report/ar6/wg1/>.

⁶⁸ IPCC (2022): *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/>.

⁶⁹ European Environment Agency (EEA) (2021): *Adaptation in Europe: Addressing risks and opportunities*. EEA Report No 1/2021. <https://www.eea.europa.eu/publications/adaptation-in-europe>.

⁷⁰ IPCC (2022): *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/>.

datasets. This results in discrepancies between national and local adaptation assessments, making it difficult to accurately measure vulnerabilities and track progress.

Furthermore, **data continuity and long-term monitoring remain insufficient**. Adaptation actions require consistent, long-term tracking to assess their effectiveness, yet many existing datasets are limited in scope or are collected intermittently. This hinders the ability to analyse long-term resilience trends and evaluate whether adaptation measures are truly reducing vulnerabilities over time.

Addressing these data challenges will require **greater coordination between national, regional, and sectoral administrative bodies**, investment in **robust data collection systems**, and the development of **standardized metrics for adaptation evaluation**. Expanding access to high-quality climate data will be essential for accurately measuring progress in reducing vulnerabilities and strengthening resilience.

Monitoring and Evaluation Frameworks

Although Slovakia has integrated adaptation into national policies, the mechanisms for monitoring and evaluating the actual impact of these policies remain underdeveloped. The **lack of standardized indicators and methodologies** for evaluating adaptation progress hinders a clear understanding of how well NAS and NAP are reducing vulnerabilities. This also affects the ability to adjust strategies based on lessons learned.

Without clear benchmarks for assessing climate resilience, comparing adaptation efforts across sectors or regions becomes difficult. Additionally, qualitative data on community resilience, governance effectiveness, and social adaptation measures are often underreported or missing entirely, further limiting a comprehensive evaluation of NAS and NAP effectiveness.

Governance Framework

The Slovak government has set up a governance framework on climate adaptation that aids in continuously mainstreaming climate adaptation into other policy areas. This is done through a single coordination body – the Working Group on Adaptation – which involves many relevant institutions and organisations⁷¹. The Working Group is also tasked at the expert level to serve for ongoing coordination in the implementation of the NAP and its adaptation measures across all governance levels. Based on findings of the *D2.2: Report on the state of play of the climate adaptation policies and governance framework and proposal for a stakeholder engagement plan*⁷², regional and local governments however do not have roles or responsibilities prescribed by the national government when it comes to adaptation and thus lack capacity for implementation but also monitoring and evaluation. This lack of engagement presents a bottleneck towards comprehensive implementation of the NAP (and NAS) and its thorough evaluation in terms of effectiveness of measures. Furthermore, it has been noted by stakeholders that national, sectoral, regional and local adaptation plans are being prepared in isolation from each other thus a comprehensive picture cannot be retrieved.

In conclusion, the challenges outlined above - uncertainty in climate change impacts, data availability and quality issues, gaps in monitoring and evaluation frameworks, and bottlenecks with responsibilities for implementation across sectors and governance levels have significantly hindered a thorough assessment of the 2018 NAS in reducing vulnerabilities and strengthening resilience. The inherent unpredictability of climate change, coupled with socio-economic and environmental dynamics, makes it difficult to establish clear cause-and-effect

⁷¹ European Commission (2023) [Assessment of progress on climate adaptation in the individual Member States according to the European Climate Law](#).

⁷² Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.2: Report on the state of play of the climate adaptation policies and governance framework and proposal for a stakeholder engagement plan – Final Report. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf.

relationships between the implementation of single adaptation measures and resilience outcomes. Moreover, the lack of comprehensive, high-quality, and standardized data limits the ability to track long-term trends and measure the overall effectiveness of adaptation actions. Owing to the current role of the Working Group on Adaptation as a coordination mechanism rather than an expert body, a mechanism is missing that links the national, sectoral, regional and local adaptation activities hindering the ability to assess effectiveness of adaptation measures on a larger scale.

To enable a more thorough evaluation of adaptation effectiveness, Slovakia shall strengthen data collection and systematic integration across sectors, invest in long-term climate monitoring, and foster stakeholder coordination and respective governance mechanisms and develop a more dynamic and iterative adaptation monitoring, evaluation and learning framework (see chapter 3.6).

3. Strategic part

3.1. Guiding principles behind the strategy and its implementation

To ensure a just and effective response to climate change, some key principles are needed that guide the strategy's development and its implementation. These guiding principles serve as a framework to ensure coherence, adaptability, and alignment with overarching objectives. By adhering to these principles, the strategy can achieve consistency, remain resilient in the face of dynamic realities of implementation, and foster a collaborative approach across all stakeholders involved. These principles are:

- **A Just and Equitable Transition:** Central to climate action is the principle of social and territorial equity. This entails recognising and addressing the differential impacts of climate change on vulnerable groups, ensuring that adaptation and mitigation efforts are inclusive and just. Respecting human rights and intergenerational equity is crucial to building a sustainable future.
- **Science-Informed Decision-Making:** Climate change adaptation must be informed by robust and state of the art scientific knowledge. Integrating insights from various disciplines, such as climate science, ecology, and social sciences, is essential for developing effective strategies. The precautionary principle should guide decision-making, especially in the face of uncertainty. Contingency planning is vital to respond to unforeseen challenges and adapt to changing circumstances.
- **Integrating Climate Change into all Policies:** Climate change adaptation must be mainstreamed across all sectors of government. This requires integrating adaptation considerations into sectoral policies and plans, ensuring coherence between adaptation and mitigation efforts. An ecosystem approach, which recognises the interconnectedness of natural systems, can guide sustainable development and climate resilience.
- **Avoiding Maladaptation:** It is crucial to avoid maladaptation, which refers to actions that may exacerbate climate risks or create new vulnerabilities. Careful assessment and planning are essential to ensure that adaptation measures are effective and do not have unintended consequences.
- **Effective Governance and Coordination:** Effective climate action requires strong institutional cooperation and coordination. Clear roles and responsibilities must be defined, and collaboration between different government agencies and stakeholders is essential. Transparency and accountability are key to building trust and ensuring public participation in decision-making.

3.2. Vision, objectives and strategic directions

3.2.1. Developing a strategic framework

As part of Slovakia's efforts to strengthen its climate resilience, a structured approach was adopted to develop a **strategic framework** for the revision of the NAS. Based on previous actions to develop the strategy report (see chapter 1.5) this process aimed to elaborate a vision, related strategic objectives and define sector-specific strategic directions.

The strategic framework for revising the NAS was designed with a three-tiered approach, incorporating a long-term vision, mid-term strategic objectives, and sectoral strategic directions:

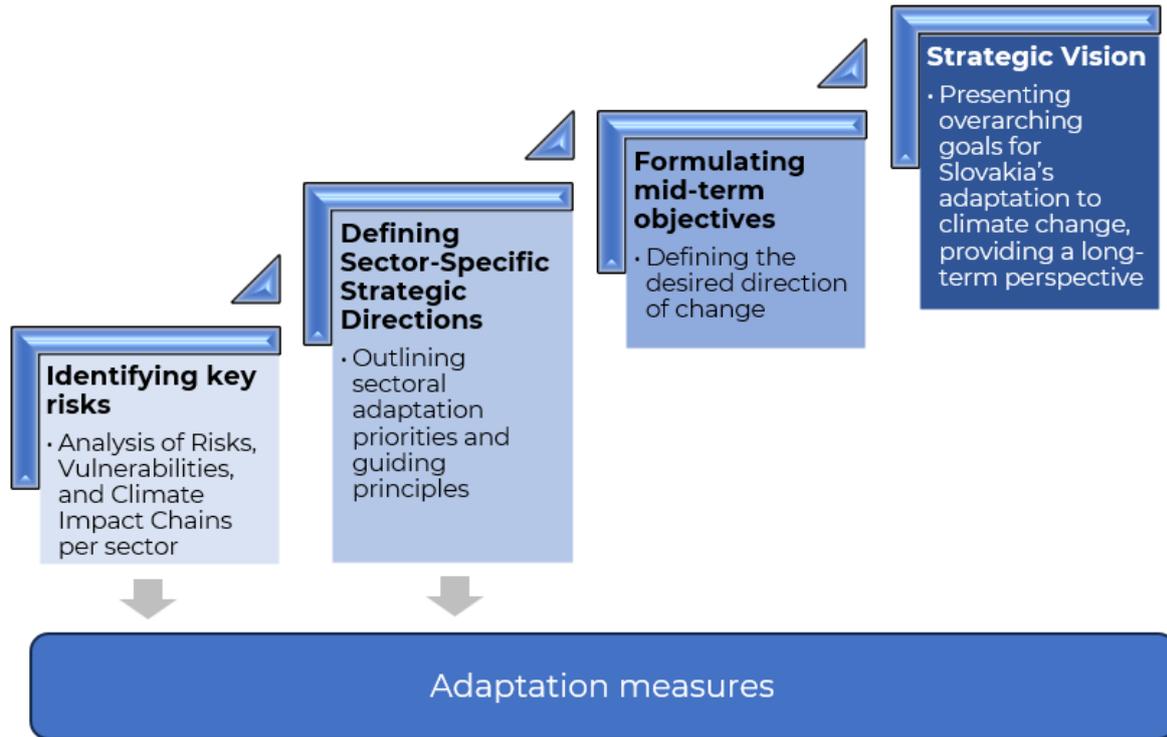
- The **strategic vision 2050** sets overarching goals for Slovakia's adaptation to climate change, providing a long-term perspective on resilience and sustainability.
- The **strategic objectives**, formulated for the medium term (i.e., up to 2040), define the desired direction of change towards the strategic vision aligning with sectoral priorities, based on the assessment of

current climate adaptation policies⁷³ and ensuring the 2025 NAS duly considers and integrates existing national policy documents relevant to climate adaptation from various ministries and stakeholders.

- The **strategic directions** serve as guidance to ensure a structured approach to achieving these objectives. While the strategic directions were assigned to strategic objectives for organizational purposes, many of them are cross-cutting and address multiple risks across different sectors.

This conceptual framework guided the selection of adaptation measures to address the key risks (Figure 4).

Figure 4: Conceptual framework for the development of the vision, strategic objectives and strategic directions for the Slovak National Adaptation Strategy



SOURCE: authors' own elaboration.

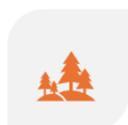
3.2.2. Vision, strategic objectives and sectoral strategic directions

The below Figure 5 illustrates the formulation of a Vision 2050 and five strategic objectives to be followed.

Figure 5: Vision 2050 and strategic objectives

⁷³ Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.2: Report on the state of play of the climate adaptation policies and governance framework and proposal for a stakeholder engagement plan – Final Report. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf.

VISION 2050
 Improve Slovakia's resilience towards the adverse consequences of climate change, where communities, businesses and people are empowered to adapt, natural ecosystems are protected, and an innovative economy is stimulated.



STRATEGIC OBJECTIVE 1

Healthy Ecosystems: Conserve, restore, and sustainably manage ecosystems, including forests, wetlands, mountains, river and freshwater ecosystems, and agricultural landscapes, ensuring they provide essential ecosystem services, support biodiversity, and strengthen climate resilience.



STRATEGIC OBJECTIVE 2

A Climate-Smart Economy: Stimulate a diversified economy that is resilient to climate risks and actively drives climate mitigation and adaptation efforts through innovative, low-carbon, and sustainable practices.



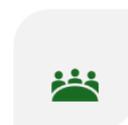
STRATEGIC OBJECTIVE 3

Resilient Infrastructure: Ensure the development of a robust infrastructure network for transportation, energy grids, and water management systems capable of withstanding slow onset climatic changes and extreme weather events, such as floods, droughts, and heatwaves.



STRATEGIC OBJECTIVE 4

Informed and Empowered Society: Establish a society that is well-informed about climate change risks and equipped with the necessary knowledge and skills to effectively adapt.



STRATEGIC OBJECTIVE 5

Effective Governance and Policy: Build strong governance and policy frameworks that prioritise climate change adaptation, ensuring integration across all relevant sectors through effective coordination, clear responsibilities, and adequate funding.

Vision 2050

The main vision for 2050 of the updated Adaptation Strategy of the Slovak Republic to climate change is to improve Slovakia's resilience to the adverse consequences of climate change, where communities, businesses and people are empowered to adapt, natural ecosystems are protected, and an innovative economy is stimulated.

Strategic objectives (SO)

For achieving the vision, five specific strategic objectives have been formulated:

- **Strategic objective 1 (SO 1): Healthy Ecosystems:**
 Conserve, restore, and sustainably manage ecosystems, including forests, wetlands, mountains, river and freshwater ecosystems, and agricultural landscapes, ensuring they provide essential ecosystem services, support biodiversity, and strengthen climate resilience.
- **Strategic objective 2 (SO 2): A Climate-Smart Economy:**
 Stimulate a diversified economy that is resilient to climate risks and actively drives climate mitigation and adaptation efforts through innovative, low-carbon, and sustainable practices.
- **Strategic objective 3 (SO 3): Resilient Infrastructure:**
 Ensure the development of a robust infrastructure network for transportation, energy grids, and water management systems capable of withstanding slow onset climatic changes and extreme weather events, such as floods, droughts, and heatwaves.
- **Strategic objective 4 (SO 4): Informed and Empowered Society:**
 Establish a society that is well-informed about climate change risks and equipped with the necessary knowledge and skills to effectively adapt.
- **Strategic objective 5 (SO 5): Effective Governance and Policy:**
 Build strong governance and policy frameworks that prioritise climate change adaptation, ensuring

integration across all relevant sectors through effective coordination, clear responsibilities, and adequate funding.

Sectoral strategic directions (SD)

Based on the risk and vulnerability assessment (see summary of the full assessment in chapter 2.2), strategic directions were developed for each sector. In course of the participatory development of strategic directions, for each of the sectors the overall "climate impact and risk landscape" has been considered as baseline to formulate the strategic directions ensuring all identified vulnerabilities and risks are addressed (please see full assessment⁷⁴ for the methodological approach applied). In addition, specific objectives of the current NAP were also considered. The identified climate impacts and related risks for each sector were discussed in workshops with relevant stakeholders to evaluate exposure and sensitivity, climate impacts of high priority, adaptive capacity and urgency to act. This step was crucial in establishing a clear roadmap for adaptation efforts and setting the stage for targeted measures. Measures are defined with the focus on identified key risks that are already at high risk levels across all sectors. However, also for the long term identified risk levels (beyond the validity of the revised NAS) it is imperative for suitable measures to be implemented as adaptation takes time, resources and foresight to become fully effective. Risks and related impacts of climate change develop gradually but can reach irreversible tipping points. By the time the most severe consequences arrive, it may be too late to implement effective solutions. Thus, early adaptation reduces long-term costs, protects vulnerable ecosystems and communities, and strengthens resilience. Delaying action only increases future risks and limits our options to respond effectively.

The following sector-specific strategic directions were proposed and validated with stakeholders in a workshop held in September 2024. The directions outline the key adaptation priorities and guiding principles necessary to enhance climate resilience contributing to achieve the defined strategic objectives. If there are objectives in the current NAP that refer to a specific strategic direction, the number of the objective is given in brackets.

⁷⁴ Available online. See Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.3: Climate Risk and Vulnerability Assessment Slovakia. <https://klima-adapt.sk/dokument/f/revision-and-update-of-the-national-strategy-on-adaptation-to-climate-change-in-slovakia..pdf>.

SO 1: Healthy Ecosystems

Related sectoral strategic directions:

SD-A-1: Agricultural land in Slovakia including soils and its biodiversity is valued and protected. Related practices are adapted to EU-level and national governance frameworks and policies are implemented to prevent degradation (e.g. soil erosion). (NAP 2.1, 2.2, 2.3, 2.6)

SD-B-1: The value of a rich biodiversity of ecosystems, species, genes and soils is recognised as an important parameter to foster resilience against climate change. Effective and targeted legislative frameworks support the preservation and protection of sensitive ecosystems, with special consideration of sustainable use of agricultural land and forests. (NAP: 4.2, 4.3, 4.4, 4.5)

SD-B-3 : The connectivity of terrestrial ecosystems is ensured, and ecologically relevant areas are mapped and protected.

SD-FO-1: Sufficient and effective measures are implemented to ensure climate-resilient forests and their associated ecosystem services, including monitoring, restoration and protection. (NAP: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.3, 4.5, 4.7)

SD-FO-2: Provisioning Forest ecosystem services (including sustainable timber production) are appropriately supported as a tool to mitigate climate change.

SD-GES-1: The ecosystem service provision of soils is secured through sustainable management practices, especially considering agriculture, forest soils and urban soils, to protect water retention capacity and limit excess surface runoff, reduce evapotranspiration and thus improve the overall soil water balance. (NAP 2.1, 2.2, 7.1)

SD-WM-2: Nature-based water retention measures support infrastructural flood protection (e.g. sponge city approaches) and are themselves supported by healthy and resilient ecosystems and soils. (NAP: 1.1, 1.4, 1.7)

SD-WM-4: Sufficient and effective measures are implemented to ensure climate-resilient water management, including reuse, allocation and monitoring of water resources.

SD-SP-1 Ecologically relevant areas, land and soil reserves are used to ensure long-term sustainability and preservation and lower the vulnerability of the respective area. Relevant areas are connected to ensure suitable bio-corridors for species.

SO 2: A Climate-Smart Economy

Related sectoral strategic directions:

SD-EI-1 : Existing regulations and frameworks enforcing protective measures in companies against extreme events like floods and droughts and businesses are continuously adapted to changing climate risks and altered empirical values.

SD-EI-2: Industries are aware of relevant climate impacts that affect them and have the capabilities to manage them effectively, including enhanced resilience of supply chains. Further support to businesses such as additional financial resources or relevant information to assess their individual risk due to climate change is provided. (NAP: 7.3)

SD-EI-3: Innovative concepts and niche business developments supporting climate change adaptation objectives are supported financially and through enabling policies. (NAP: 7.3)

SD-CH-1: Tangible cultural goods like buildings, museums, archives, etc. are protected and preserved through regular, preventive maintenance and climate-adapted servicing ensuring a sufficient level of resilience.

SD-A-2: Agricultural crop production and livestock farming practices are sustainable and adapted to changing climatic conditions (i.e. climate-smart) and nutrient runoff is reduced by increased fertilisers efficiency. Investments are made to ensure climate-resilient irrigation and water-retention systems. Farmers and other agriculture-related businesses are aware of climate-related risks and hazards and have sufficient know-how to mitigate and react to them, including nature-based solutions. (NAP 2.1, 2.4, 2.5)

SD-T-1: Tourism offers are diversified to meet emerging markets and demands and to ensure competitiveness of destinations. (NAP 7.4)

SD-T-2: Tourism is effectively managed based on partnership and data to support sustainability by key resources, including measures in visitor management, adaptation to changing climatic conditions (e. g. cool attractions for extreme heat) and implementation of preventive measures against natural hazards.

SD-T-3: Tourism is sustainable, adapted to climate change and contributes to high quality, climate-friendly life in destinations and supports resilience in changing conditions.

SO 3: Resilient Infrastructure:

Related sectoral strategic directions:

SD-TIB-1: Effective governance frameworks are implemented, and sufficient funds are made available to ensure a climate-resilient adaptation of transport, infrastructure and buildings to climate change

SD-TIB-2: Transport, infrastructure and buildings are adapted to climatic conditions such as increased heat and natural disasters such as floods, land- or mudslides (e. g. through used materials and technology). (NAP: 7.2)

SD-E-1: Security of supply from an optimally structured energy and electricity system is ensured, including an expansion of PV-, solar-, wind- and water-based sources, and considering the role of energy supply at the interface of climate mitigation and adaptation.

SD-E-2: Energy and electricity infrastructure (from production to distribution to the end-user) is adapted to changing climatic conditions, e.g. increased risk of grid failure.

SD-E-3: The capacity of the energy and electricity system is sufficient to meet potentially changing demands (e. g. increased cooling requirements). Technical innovations ensure that these demands are covered as efficient as possible.

SD-DRM-1: Critical infrastructure, civil protection and disaster risk management are in place, reflecting relevant laws of the European Union and account for climate change impacts and associated risks to ensure a resilient Slovak Republic.

SD-H-1: Slovakian healthcare infrastructure is adapted to changing demands and climate risks resulting from heat waves and diseases. Sufficient capacities are available, i.e. training, infrastructure, energy, human and financial resources, complemented by available information for the general public and sufficient accessibility to healthcare infrastructure, both specifically for vulnerable groups and including mental health. Protection through state and emergency mechanisms are ensured. (NAP: 5.1, 5.2, 5.3, 5.4, 5.6, 7.5)

SD-H-3: The sanitation system is adapted to changing water availability and demand and increasing climate risks such as extreme events.

SD-H-4 Safe water supply is ensured, and water networks are further expanded.

SD-WM-3: Water and wastewater infrastructure is fixed, maintained and adapted to changing climatic conditions (e.g. heat, aridity, floods) to secure a reliable supply of safe water.

SD-ICT-2: ICT infrastructure is adapted to climate-related impacts, taking into account the need for a green transformation.

SD-SP-2: Technical specifications and building regulations in urban planning for urban flooding, drought and urban heat island effect are proactively climate-adapted to limit heat stress on people and heat load on infrastructure. (NAP: 6.1, 6.2, 6.3, 6.4, 7.2)

SD-SP-3: Decision-making systems take changes in empirical values regarding climate hazards and extreme events into account to secure reliable and accessible infrastructure. (NAP: 6.2, 6.3, 6.4, 7.2)

SO 4: Informed and Empowered Society

Related sectoral strategic directions:

SD-B-2: Management practices in agriculture, fishery, forestry and other related fields are adapted with the objective of ensuring the optimal provision of ecosystem services from terrestrial and aquatic ecosystems. Relevant information and awareness-raising initiatives support practitioners in adapting their activities and increasing their sustainability. (NAP: 4.1, 4.6, 4.7)

SD-CH-2: Intangible cultural heritage and associated practices and traditions are secured and well promoted to support local identity.

SD-CH-3: Tangible natural heritage are mapped, linked to landscape management and sufficiently protected, considering climate-change related, destructive impacts.

SD-E-4 : Awareness raising of the Slovak society with respect to the supply with and demand of energy in the context of climate change ensures energy sufficiency as crucial pillar next to efficiency.

SD-FI-1: Sufficient funding of adaptation and mitigation measures ensures a climate-resilient Slovak society. Climate adaptation-related financial needs in other government sectors/ministries are known and funding is allocated appropriately. The governmental body is aware of the resulting effects like reduced availability of funds in other fields of action. Funding opportunities from competitive EU programmes available to support climate change adaptation efforts at all levels are additionally used.

SD-FI-2: Public finances allocation is prudent and under transparent public scrutiny. In their operations, public and financial institutions take into account climate change related risks such as the potential lack of risk transfer (uninsurable climate impacts), have sufficient knowledge concerning climate change related impacts on the financial sector and act accordingly. EU-level obligations, e.g. the EU Taxonomy, are implemented.

SD-DRM-2: Effective preventive and emergency measures are implemented at all levels of governance to ensure resilience of communities, settlements and critical infrastructure against natural disasters. Current emergency response systems are evaluated and adapted where necessary to ensure readiness in extreme events even under altered conditions, including ensuring sufficient funding and provision of technical sources.

SD-GES-2: Areas at risk for landslides and mudslides are mapped, considering future climate developments and their relevance for hazard and risk maps.

SD-H-2: The resilience of the population (especially disadvantaged groups) is strongly supported. People are aware of health risks, including mental health, due to heat and risks resulting from air-, food-, water- or vector-borne diseases.

SD-WM-1: Health and life of people, properties and animals are protected from pluvial and fluvial flood events. (NAP: 1.2, 1.4)

SD-ICT-3: Sufficient and effective awareness raising measures are implemented with respect to climate-related impacts on the ICT sector, in particular on IT infrastructure.

SO 5: Effective Governance and Policy

Related sectoral strategic directions:

SD-A-3: People in Slovakia have access to sufficient regional, high-quality food and agricultural products, the production of which is supported through governance and funding, valuing the historical role of agriculture, while at the same time protecting the livelihoods of farmers and the cultural landscape itself.

SD-CH-4: Effective governance frameworks, aligned with propositions/policies by the European Union and international organisations like UNESCO, are implemented.

SD-EI-1: Existing regulations and frameworks enforcing protective measures in companies against extreme events like floods and droughts and businesses are continuously adapted to changing climate risks and altered empirical values.

SD-EI-3: Innovative concepts and niche business developments supporting climate change adaptation objectives are supported financially and through enabling policies. (NAP: 7.3)

SD-FI-3: Schemes and obligations for technical and property insurance are enforced and adapted to climate change and potentially unprecedented climate-related impacts.

SD-ICT-1: Sufficient governance frameworks are implemented on a national scale to ensure state-wide effective crisis management, i. e. ICT infrastructure breakdowns, including regulations for privately owned ICT infrastructure.

SD-SP-4: Spatial development plans and management instruments are in place that shape and regulate the use of land in coherence with and support of climate mitigation and adaptation objectives. Maladaptation and lock-in effects are avoided, securing future availability of adaptation options (NAP: 6.1, 6.2, 6.3, 6.4, 7.2).

3.3. Summary and multi-criteria analysis of adaptation measures within each sector and for cross-cutting aspects

The following section provides a **summary of the adaptation measures proposed for the timeframe of 2026 to 2040 along five clusters**, under which various sector activities are covered. Please note that there are quite some interlinkages between these sectors. For example, activities in one sector (e.g. water) can lead to benefits in other sectors (e.g. biodiversity). Details for measures proposed per sector within the five clusters are provided in PART 2 Factsheets.

The five clusters correspond to the five strategic objectives identified and cover a total of 15 sectors and additional cross-cutting aspects. The following table presents this correlation between the clusters and the strategic objectives.

Table 5: Overview of correlation between the five clusters and NAS objectives

CLUSTER	Sectors	Respective strategic objective(s) to target
Bioeconomy	Agriculture	Strategic objective 1: Healthy Ecosystems

CLUSTER	Sectors	Respective strategic objective(s) to target
	Biodiversity, Ecosystems and Natural Heritage Forestry Geological Environment & Soil Hydrological Regime & Water Resource Management	Strategic objective 5: Effective Governance and Policy
Economy	Economy and Industry Energy Financial and Insurance System Tourism	Strategic objective 2: A Climate-Smart Economy Strategic objective 3: Resilient Infrastructure Strategic objective 5: Effective Governance and Policy
Safety and well-being	Disaster risk management, Civil protection and critical infrastructure Health care Information and Communication Technology	Strategic objective 4: Informed and Empowered Society Strategic objective 5: Effective Governance and Policy
Built environment and spatial planning	Cultural heritage Spatial planning Transport, infrastructure and buildings	Strategic objective 3: Resilient Infrastructure Strategic objective 5: Effective Governance and Policy
Cross-cutting aspects	Urban areas Social vulnerabilities Education and society Research Governance Regional and cross-border cooperation	Strategic objective 3: Resilient Infrastructure Strategic objective 4: Informed and Empowered Society Strategic objective 5: Effective Governance and Policy

To systematically evaluate the effectiveness of all adaptation measures across the five clusters, a **Multi-Criteria Analysis (MCA)** was applied. This approach assessed each sector and cross-cutting aspects using five key criteria: **economic costs and benefits**, **ecosystem impacts**, **social outcomes**, **climate risk management capacity** (under various climate scenarios, including RCP 8.5), and **potential unintended spillover effects**. Each criterion was qualitatively scored using a consistent scale (moderate to very strong impact, or manageable risk), enabling both **sector-specific insights** and **cross-sectoral comparison** (see also chapter 3.3.6).

The **adaptation actions assessed** were selected through a comprehensive review of relevant sources to ensure both national relevance and alignment with EU and international best practice. These sources included:

- **Stakeholder inputs from participatory workshops** conducted under deliverable D2.2 as well as through consultation with the Working Group on Adaptation (WGA), ensuring that national, regional and local knowledge, practitioner experience and perspectives were fully integrated. **Measures from the 2018 National Adaptation Strategy (NAS)** and the **2021 National Action Plan (NAP)**, reflecting Slovakia’s prior policy commitments and baseline adaptation planning.
- **National sectoral strategies and policy documents**, which helped identify adaptation priorities and ongoing initiatives across all key sectors.
- **Adaptation Strategies of countries facing similar climate risks and vulnerabilities**, including Germany, Austria, Poland, Hungary, and the Czech Republic, providing comparative insights and transferability of proven measures.
- **EU-level resources**, such as the **database of the EU Mission on Adaptation to Climate Change Portal** and the **Climate-ADAPT platform**, which offered access to a broad range of tested, evidence-based adaptation measures.
- And finally, **expert judgment**, applied to refine, validate, and contextualize measures in light of scientific knowledge, feasibility, and national priorities.

This structured and inclusive approach ensures that the MCA supports adaptation planning that is **strategic, evidence-based, and grounded in both policy and practice**.

Results of the MCA are presented for each sector in the following sub-chapters. Chapter 3.3.6 presents a **Cross-Sector Synthesis Matrix** that provides a high-level comparison of how each sector performs across the five MCA criteria - **economic costs and benefits, ecosystem impacts, social outcomes, climate risk management, and unintended spillover effects**. This matrix intends to function as a visual tool to summarize and contrast sectoral strengths, challenges, and synergies, highlighting where co-benefits and trade-offs may exist. It shows that **high-impact sectors** - such as water management, education, health, and urban areas - offer broad resilience benefits across criteria. Conversely, it also helps to flag **sectors that may require additional safeguards**, such as those with higher risks of unintended consequences or where implementation capacity may vary. The matrix supports **strategic decision-making and resource prioritization** by making complex, multi-dimensional information more accessible and actionable. It also ensures that adaptation planning maintains a balanced focus on **cost-effectiveness, equity, ecological integrity, and systemic resilience**.

3.3.1. Cluster Bioeconomy

Agriculture

The **Agriculture** sector encompasses the cultivation of crops (cereal, fruit, citrus, vegetables, olives, wine, etc.) and the production of animal products, such as dairy, meat and others. It includes issues of food security and safety for humans as well as animal health and welfare. Spatially, it covers all agriculturally used land, greenhouses, pastures and spaces for animal husbandry and livestock farming⁷⁵.

Summary

Slovakia’s agricultural land, including its fertile and diverse soils, is a vital national asset. To safeguard this resource, robust policies and practices must be implemented to prevent soil degradation, such as erosion and risk from reduced water availability and quality. By aligning with the (next) Common Agricultural Policy (CAP), Slovakia can take a step towards better supporting sustainable and climate-resilient agricultural practices and

⁷⁵ FAO (2021). The State of Food and Agriculture 2021. Making agrifood systems more resilient to shocks and stresses. FAO, Rome.

addressing risks from changing growing conditions and extreme weather events in line with the EU Farm to fork Strategy.

Adapting crop production and livestock farming to changing climatic conditions, such as increased temperatures and altered precipitation patterns, includes revising the regionalisation and structure of cultivated crop types, preparing new genetic material, revising crop protection concepts, using new soil processing technologies, adjusting the soil water regime, and implementing fertilization measures to preserve soil fertility. These actions also contribute to mitigating the negative consequences of climate change on the soil and consequently on its production function. They allow cultivated crops to better cope with increasing air temperatures and changing precipitation patterns.

Additionally, reducing nutrient runoff through improved fertilizer efficiency is crucial for protecting water quality and mitigating greenhouse gas emissions.

Investing in climate-resilient irrigation and water retention systems where relevant and without compromising future ground water reserves is essential for ensuring a reliable water supply for agriculture, especially during periods of drought. By implementing efficient irrigation technologies and restoring natural water retention features in the landscape, such as wetlands and riparian zones, Slovakia can enhance agricultural resilience to climate variability. In this context, removing existing procedural barriers and investments in building of the green and blue infrastructure will enhance the ecosystem services provision on the farm level and increase the resilience in the agricultural landscapes.

Bio farming, especially the use of new agricultural techniques, such as no-till farming and use of different crops with draught resilient root systems is a more sustainable way of farming and limits drying and nutrients loss from the soil. Therefore, increasing funding or establishing new funding mechanisms would be a strong incentive for such practices. New carbon offsetting schemes⁷⁶, whether state operated or under state regulation, could be able to provide sufficient financial motivation for farmers to engage in more sustainable but less profitable agricultural techniques. The offsetting scheme could be based not only on the amount of carbon retained in the soil, but also on the amount of water compared to usual agricultural practices. Meanwhile, countries are encouraged to adopt their own voluntary or mandatory carbon removal schemes, which is promoted by European legislation (Carbon Removal Certification Framework⁷⁷).

Regarding animal production, cooling methods, housing systems, and the selection of breeds, suitable for higher temperatures (use of traditional, resistant breeds), must be addressed. The voluntary and forced relocation of animals in response to climate change to safeguard genetic diversity for future needs must be discussed and supported. Animal nutrition and feeding techniques will have to be adjusted.

Increasing threats are posed by the decline of pollinators, which has significant impacts on crop production. The synergies between wild pollinators and honeybees are vital for the productivity of many agricultural sectors in Slovakia.

In addition to the risks to food security, this decline also threatens small and medium-sized enterprises involved in honey production and honey-based products.

⁷⁶ Carbon offsets fund specific projects that either lower CO2 emissions, or “sequester” CO2, meaning they take some CO2 out of the atmosphere and store it.

⁷⁷ https://climate.ec.europa.eu/eu-action/carbon-removals-and-carbon-farming_en

Additionally, climate adaptation in the agricultural sector needs to address the increasing volatility in food prices driven by climate impacts on food production. This challenge is especially important at the national level, where climate-induced disruptions in global food supply chains can exacerbate food insecurity. Although Slovakia's share of locally processed and consumed food is relatively low, and the country largely relies on food imports⁷⁸, it remains crucial to strengthen domestic agricultural resilience. This includes improving local food production, diversifying crops, and fostering sustainable farming practices to mitigate the impact of climate change. Efforts to enhance food security should also focus on building robust food supply systems and strengthening the agricultural sector's capacity to adapt to unpredictable climate events, thereby reducing dependence on global markets.

Slovakia's rich agricultural heritage and diverse food traditions are valuable assets that should be preserved and promoted. By supporting local food production and promoting short food supply chains, Slovakia can enhance food security, reduce environmental impacts, and strengthen rural economies. This could lead to multiplication effects for increased ecosystem services provision and support of other sectors such as tourism, especially in the mountainous regions of Slovakia. Furthermore, Slovakia can ensure that farming communities continue to thrive and contribute to the country's unique identity by recognising the cultural and historical significance of agriculture.

To effectively address climate-related risks and hazards, farmers and other agriculture-related businesses must be equipped with the necessary knowledge and skills. This includes raising awareness of climate change impacts, providing training on climate-smart practices, and supporting the adoption of nature-based solutions, such as agroforestry and conservation agriculture. Special focus should be given to small farms and support of pasturing in overgrown and abandoned grasslands in mountainous rural areas which will become more relevant for farming with redistribution of precipitation. Establishing demonstration farms, integrating soil protection modules into agricultural curricula, and providing continuous professional development for extension workers and researchers will further strengthen capacity building and ensure long-term adoption of sustainable practices.

Multi criteria analysis

Key Action: Climate-Resilient Agriculture

Table 6: MCA Agriculture

Criteria	Aspect	Assessment	Rating ⁷⁹
Economic Costs and Benefits	Costs	Medium to high initial investment (e.g., irrigation systems, precision agriculture tools, conservation infrastructure).	☑☑ (Strong, with upfront costs)
	Benefits	Long-term savings through efficient input use (fertilizers, water); higher and more stable yields; supports green jobs in agro-tech and advisory services.	

⁷⁸ https://www.pks.sk/tlacove_spravy2/pks-podiel-slovenskych-vyrobkov-na-pultoch-obchodov-sa-vratil-k-negativnemu-trendu/.

⁷⁹ ☑ = Moderate
 ☑☑ = Strong
 ☑☑☑ = Very Strong
 △ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ⁷⁹
	Funding Sources	CAP Strategic Plan, EU funds, national subsidies.	
Ecosystem Impacts	Benefits	Enhanced soil health, improved water infiltration, reduced erosion, nutrient runoff reduction, carbon sequestration, and increased agrobiodiversity.	✓✓✓ (Very strong)
	Risks	Over-irrigation may cause soil salinization if poorly managed; inappropriate implementation of new practices could harm microbial diversity.	
Social Outcomes	Benefits	Builds farmer resilience and awareness; supports rural livelihoods; promotes traditional and ecological knowledge sharing.	✓✓ (Strong, needs equity safeguards)
	Risks	Risk of inequality: smaller farms may lack access to funding, training, or technology. Need for targeted inclusion policies.	
Climate Risk Management (Across Scenarios)	Effectiveness	Strong across multiple climate risks: drought, heatwaves, soil degradation, water stress. Measures are aligned with RCP 4.5 and RCP 8.5 scenarios.	✓✓✓ (Very strong with high relevance & flexibility)
	Flexibility	High adaptability due to nature-based solutions, climate-smart farming, and diversified cropping systems.	
Unintended Spillover Effects (Positive & Negative)	Positive	Strengthens climate literacy in the farming community; potential to scale sustainable land management to other sectors.	⚠ (Manageable if guided properly)
	Negative	Risk of misapplication of new methods without proper training; may deepen urban-rural tech divide if digital tools dominate adaptation.	

Biodiversity circumscribes “the variability among living organisms from all sources including, among other things, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems”⁸⁰. This encompasses three levels of biodiversity as defined by the Convention on Biological Diversity: species, ecosystems and genetic diversity.

Ecosystems are defined as “a functional unit consisting of living organisms, their non-living environment and the interactions within and between them.”⁸¹.

Natural Heritage refers to natural features, geological and physiographical formations and delineated areas that constitute the habitat of threatened species of animals and plants and natural sites of value from the point of view of science, conservation or natural beauty. It includes private and public areas, zoos, aquaria. and botanical gardens, natural habitats, marine ecosystems, sanctuaries, reservoirs etc⁸².

Summary

Slovakia has a rich and diverse biodiversity, encompassing diverse ecosystems, species, genes, soils and protected areas⁸³. Biodiversity is essential for the resilience of our planet and also for Slovakia’s economy⁸⁴. To recognising the critical role of biodiversity in mitigating and adaptation to climate change and supporting human well-being and economic activities it is imperative to implement effective legislative frameworks to protect and preserve species, habitats, and ecological processes, particularly in sensitive environments like mountain regions and aquatic ecosystems for safeguarding crucial ecosystem services they provide. This also requires adaptive management practices in key economic sectors such as water management, forestry and agriculture.

This aligns with the EU Biodiversity strategy to 2030 and the new EU Nature Restoration Law and aims to enhance the management of the Natura 2000 network by strengthening the protection, increasing connectivity and promoting flexibility to allow for well-connected systems that better withstand climate stressors. Well managed and resilient protected areas (PAs) are also an important barrier to land transformation and help retain greenhouse gases from converted areas during deforestation and drainage. Slovak PAs also play a crucial role in the tourist and recreation sectors in Slovakia and add to economic and social benefits of the society.

Slovakia is preparing the revision of the National Biodiversity Strategy (NBS)⁸⁵ which will encompass global and European goals and targets, and translate them for implementation at the national level, including climate adaptation related measures. Coordination of the implementation between NAS, the National Restoration Plan (NRP) and NBS is crucial for achieving positive impacts on the ground.

Maintaining the connectivity of terrestrial and aquatic ecosystems is essential for species movement, seed dispersal, and genetic material flows, but also for flood and drought protection. Mapping and protecting ecologically relevant areas support safeguarding and management of critical habitats and biodiversity hotspots. In this regard, the EU Nature Restoration Law will be transposed in Slovakia by developing a National Restoration Plan (NRP) by 2026. As such, key strategies for enhancing ecosystem connectivity include:

⁸⁰ IPCC (2021). Annex VII: Glossary. In: IPCC (Ed.) Climate Change 2021 – The Physical Science Basis. Cambridge University Press, pp. 2215–2256.

⁸¹ IPCC (2021). Annex VII: Glossary. In: IPCC (Ed.) Climate Change 2021 – The Physical Science Basis. Cambridge University Press, pp. 2215–2256.

⁸² <https://uis.unesco.org/en/glossary-term/natural-heritage>

⁸³ <https://www.cbd.int/countries/profile?country=sk>.

⁸⁴ https://www.oecd-ilibrary.org/environment/oecd-environmental-performance-reviews-slovak-republic-2024_9f6b0a83-en.

⁸⁵ <https://www.cbd.int/doc/world/sk/sk-nbsap-v3-en.pdf>.

- **Establishing ecological corridors:** Creating corridors of natural habitats connecting isolated areas, allowing species to move between them.
- **Minimising fragmentation:** Reducing land fragmentation by avoiding infrastructure development in sensitive areas.
- **Restoring and revitalisation of degraded ecosystems:** Restoring degraded habitats, such as peatlands, wetlands and forests, to enhance ecosystem connectivity, function and provision of ecosystem services. Restoration of degraded habitats plays a crucial role in adaptation of rural areas and its re-connection with the wider landscapes.

In its future National Restoration Plan, Slovakia must focus on the co-benefits for climate adaptation of restoring degraded ecosystem and their functions to achieve additional synergies for both biodiversity and society. Implementation of measures foreseen in the NAS will support these efforts through coordinated action on restoration and adaptation in various related sectors including spatial planning, water management, agriculture and forestry.

Beyond the implementation of the EU Nature Restoration Law, prioritising Ecosystem-Based Adaptation (EbA) presents a sustainable and cost-effective approach that harnesses nature-based solutions and ecosystem services to help people and economies thrive in the face of a changing climate. Tailored to specific contexts, it enhances biodiversity while addressing societal challenges, such as reducing vulnerability to extreme weather, securing water resources, and protecting livelihoods. Unlike traditional engineered solutions, EbA is adaptable and can evolve with changing conditions, making it more resilient in the face of uncertainty.

Invasion and spread of non-native species may result in biome shifts, with consequent changes for biodiversity and the spectrum of ecosystem services provided. Hence, improved, non-native species management will need to be applied across relevant sectors with dedicated measures for prevention, early detection, and control management, including rapid response, rehabilitation and restoration.

To optimise the provision of ecosystem services from terrestrial and aquatic ecosystems, it is crucial to adopt sustainable and climate resilient management practices in agriculture, forestry, and other related fields such as water management and urban planning and to reduce non-climatic impacts, such as pollution and overexploitation of resources. Such an approach is also valuable in protecting soil health. With the Carpathians covering a large portion of the country, adaptation measures in mountain areas particularly aim to safeguard fresh water sources, introduce climate resilient forest management, ensure a sustainable and adapted development of Tourism, address problems caused by rock weathering processes, and deal with morphological changes in the landscape. They aim to prevent the formation or activation of slope deformations (slides) or other potentially harmful geodynamic phenomena.

To support practitioners in their efforts to adopt sustainable practices, it is essential to provide relevant information and raise awareness about the importance of biodiversity conservation and ecosystem services. By sharing knowledge and best practices, individuals and organizations can be empowered to make informed decisions that benefit both people and nature.

It is also necessary to support and maintain Slovakia's cultural landscapes as part of the country's cultural heritage and diversity, including historical agricultural (landscape) structures, as well as landscape and garden architecture elements, such as composed landscape units, historical parks, regional landscape types. This can be achieved through Climate-Resilient Landscape Management considering the interconnectedness of agriculture,

forests, water, biodiversity, and energy. It involves collaboration among farmers, land managers, policymakers, civil society organizations, and businesses to address common challenges at a local scale⁸⁶.

Multi criteria analysis

Key actions:

- Build a robust legislative framework to enhance ecosystem preservation and strengthen enforcement mechanisms
- Foster Adaptive Management Practices for Ecosystem Services Sustainability in key sectors
- Establish and Expand Ecological Corridors and enhance their connectivity

Table 7: MCA Biodiversity, Ecosystems and Natural Heritage

Criteria	Aspect	Assessment	Rating
Economic Costs and Benefits	Costs	Moderate to high. Includes legal reform, corridor infrastructure (e.g. wildlife overpasses), training programs, enforcement mechanisms, and ecological restoration.	✓✓ (Strong with high long-term ROI, medium upfront costs)
	Benefits	High long-term value: avoids costly ecosystem degradation, supports green tourism, water filtration, flood mitigation, and soil stability. Measures like ecosystem service valuation, PES, and agrobiodiversity preservation create cost-effective resilience.	
	Funding Sources	Opens access to EU funds (e.g., LIFE, CAP, Nature Restoration Law) and biodiversity credits; National Recovery and Resilience Plan (NRRP)	
Ecosystem Impacts	Benefits	Protects native habitats, restores degraded ecosystems, strengthens ecological networks, boosts carbon sinks, enhances species and genetic diversity.	✓✓✓ (Very strong, systemic benefit across habitats)
	Risks	Poor implementation or lack of invasive species control in corridors can result in unintended ecological imbalances. Requires site-specific planning.	
Social Outcomes	Benefits	High social value: promotes inclusive land stewardship, builds rural-urban cooperation, strengthens public awareness of biodiversity. Provides jobs in restoration, conservation, and monitoring.	✓✓✓ (Very strong through inclusiveness)
	Risks	Possible stakeholder conflict (e.g., farmers, developers) without compensation or consultation. Urban residents may undervalue rural ecosystem functions unless well communicated.	

⁸⁶ https://gca.org/wp-content/uploads/2020/12/Achieving_Climate_Change_Adaptation_Through_Integrated_Landscape_Management_-_Feb_2020_0.pdf.

Criteria	Aspect	Assessment	Rating
Climate Risk Management (Under Climate Scenarios)	Effectiveness	Very strong: all measures support nature-based adaptation. Enhances resilience to extreme weather, temperature shifts, drought, and species migration pressure (esp. under RCP 8.5).	✓✓✓ (Very strong, core to resilience under RCP 4.5 & 8.5)
	Flexibility	High flexibility and synergy with climate-informed spatial planning, conservation finance, and ecosystem monitoring tools.	
Unintended Spillover Effects (Positive & Negative)	Positive	Improves quality of life via nature access; promotes green business opportunities; strengthens local cultural identity tied to landscapes and species.	⚠ (Moderate risk - needs integrated planning and safeguards)
	Negative	Misaligned land-use policies or underfunded implementation could backfire. Risk of symbolic or fragmented corridors ("greenwashing") without real ecological value.	

Forestry

The **Forestry** sector encompasses ecosystems mainly covered by tree species, but also by non-forest woodland and associated ecosystem elements such as other species and soils. The sector also includes forest products such as wood and processed wood by-products. Within the sector, the human role is to manage forests and woodlands as well as to economically evaluate forests and their products and services⁸⁷.

Summary

Slovak forests are important for soil protection and water management, but also for protecting human settlements and infrastructure from landslides and avalanches. Forests also have an important economic function in terms of timber production, and provide vital ecosystem services, such as carbon storage with great importance for Slovakia's carbon neutrality targets.

The vision of the National Forestry Program of the Slovak Republic (NLP SR)⁸⁸ and its Action Plan⁸⁹ for the period 2025-2030 'Forests for Society' is to manage forests and forestry based on timely and accurate information, an interdisciplinary approach and the participation of stakeholders at all levels, ensuring the preservation of biodiversity, sustainable development and the quality of life of Slovakia's population. In the context of this vision, the following three global NLP SR targets have been defined for the period 2025-2030:

1. Forestry as the basis of a modern bioeconomy
2. Diversified forests better withstand climate change and mitigate its impacts
3. A thriving society using all the functions of forests in a non-conflicting way

The Slovak NLP SR strategic goals are translated in the Action plan measures focusing on increasing the resilience of forests to climate change through adaptation measures such as converting unsuitable forest stands into mixed

⁸⁷ European Commission (2021c). New EU Forest Strategy for 2030.

⁸⁸ <https://www.enviroportal.sk/dokument/narodny-lesnický-program-slovenskej-republiky-pre-obdobie-rokov-2025-2030>.

⁸⁹ <https://rokovania.gov.sk/RVL/Material/30253/1>.

forests, introducing close-to-nature management in forest to at least 25% of the area and protecting the gene pool of native tree species.

The proposed adaptation actions aim to support the achievement of these targets by conducting **comprehensive Forest Health Monitoring**, which allows monitoring of forest health, biodiversity, and carbon stocks to track the impacts of climate change and make informed management decisions. This should include the application of remote sensing technologies, field surveys, and citizen science initiatives.

Targeted Restoration Efforts will prioritise the restoration of degraded forests. Restoration activities should focus on planting native tree species, improving soil health, and promoting natural regeneration. This will also be in line with the requirements for managing Natura 2000 sites, the EU Nature Restoration Law and water management activities under the Water Framework Directive. These activities will also contribute to absorbing and storing carbon dioxide from the atmosphere, thus contributing to the 2030 EU targets based on EU's climate commitments for carbon removals under the Land Use, Land Use Change and Forestry Regulation (LULUCF).

In order to ensure the economic function of forests while preserving environmental sustainability, **Sustainable Timber Production** will be promoted. Sustainable forest management practices support the production of timber and other forest products while maintaining the long-term health and resilience of forests. This includes implementing certification schemes, promoting responsible harvesting practices, and investing in forest regeneration. Incentives for this transition in forestry practices could be linked to carbon offsetting schemes - whether state operated, under state regulation or under EU regulation- to ensure that forest owners / managers are compensated for forest management practices that preserve / increase forest ecosystem services, by providing sufficient financial motivation to engage in more expensive and less profitable close to nature forestry (eventually not to engage in any forestry operation) and to increase the forests' carbon sink. Another reinforcement for sustainable forest management refers to improving verification mechanism and imposing a strong and effective enforcement of the use of sustainability criteria for biomass for energy purposes in the EU ETS system.

Multi criteria analysis

Key Actions:

- Enhance Forest Health Monitoring and Early Warning Systems
- Forest Restoration and Protection through adaptive silviculture
- Promote and transition to Sustainable Forest Management Practices

Table 8: MCA Forestry

Criteria	Aspect	Assessment	Rating ⁹⁰
Economic Costs and Benefits	Costs	Moderate to high. Investments in technology (e.g., sensors, LiDAR, drones), restoration planting, training, and forest management transition.	☑☑ (Strong economic case, esp. long-term)
	Benefits	Significantly protects timber supply, reduces pest and fire losses, supports bioeconomy, enables carbon	

⁹⁰ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

△ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ⁹⁰
		credit participation, and reduces long-term maintenance and disaster recovery costs.	
	Funding Sources	CAP Strategic Plan, LIFE, Horizon Europe, carbon offset schemes, National Forest Plan, National Recovery and Resilience Plan (NRRP)	
Ecosystem Impacts	Benefits	Increased biodiversity through mixed-species stands, restoration of degraded lands, carbon sequestration, soil stabilization, improved water retention.	✓✓✓ (Very strong, crucial for biodiversity, soil, and water)
	Risks	If species selection is inappropriate, or deer/herbivore populations are not controlled, regeneration may fail. Over-reliance on monoculture replacements can reduce diversity gains.	
Social Outcomes	Benefits	Strengthens local engagement in forest stewardship, supports traditional forest knowledge, promotes eco-tourism and green jobs.	✓✓ (Strong, needs inclusive outreach)
	Risks	Technological complexity might exclude smaller forest owners; inequity in benefit access unless inclusive support is ensured.	
Climate Risk Management (Across Climate Scenarios)	Effectiveness	High resilience against drought, pest outbreaks, storms, and wildfires. Forest monitoring enables early response and adaptive planning.	✓✓✓ (Very strong. key role in adaptation and mitigation)
	Flexibility	Adaptive silviculture and nature-based restoration support a wide range of climate futures (RCP 4.5 to 8.5).	
Unintended Spillover Effects (Positive & Negative)	Positive	Strengthens climate literacy, links forestry with carbon markets, enhances multifunctional land uses (e.g., recreation + timber + biodiversity).	⚠ (Moderate, mitigation needed for tech barriers and ecological trade-offs)
	Negative	Risk of surveillance overreach (privacy concerns); overengineering could replace low-tech solutions; unequal digital access among forest owners.	

The **Geological Environment and Soil sector** focuses on the study, protection, and sustainable management of geological formations and soil resources. It encompasses soil composition, erosion, contamination, land stability, and resource extraction, playing a crucial role in environmental protection, agriculture, construction, and climate change mitigation⁹¹. This sector integrates geology, hydrogeology, geotechnical engineering, and soil science to assess environmental risks and promote sustainable land-use practices⁹² (European Environment Agency, 2020).

Summary

The **geological environment and soil sector in Slovakia** is increasingly affected by climate change, with rising temperatures, extreme weather events, and shifting precipitation patterns intensifying soil degradation, erosion, and geohazards. More frequent and intense droughts reduce soil moisture and fertility, negatively impacting agriculture and increasing the risk of desertification, particularly in southern regions. Conversely, heavy rainfall and extreme storms accelerate soil erosion, landslides, and flooding, particularly in mountainous and hilly areas. Changes in temperature and precipitation also affect groundwater recharge, leading to water shortages in some regions and increased contamination risks in others. Additionally, permafrost degradation in high-altitude areas may contribute to increased rockfalls and slope instability. Urban expansion, combined with climate pressures, exacerbates soil sealing and reduces the land's natural ability to absorb water, increasing flood risks.

To enhance resilience, a comprehensive approach is needed, integrating soil conservation, geohazard risk management, pollution prevention, water retention strategies, climate-resilient planning, and improved monitoring.

A key priority is **soil conservation and erosion control**, which can be achieved by promoting agroforestry, conservation tillage, and sustainable land management in agriculture and forestry. Establishing vegetative buffer zones along rivers and slopes will help prevent soil loss, while nature-based solutions can enhance overall soil stability. Closely linked to this is the need for **landslide and geohazard risk management**, particularly in Slovakia's mountainous regions. Early warning systems, improved land-use planning, and slope stabilization through bioengineering and geotechnical reinforcement are crucial to reducing landslide risks.

At the same time, **soil quality and contamination prevention** must be strengthened by monitoring and remediating contaminated soils, particularly in industrial and mining areas. Sustainable waste management practices should be reinforced to limit hazardous pollutants, while regulations should be introduced to prevent excessive soil sealing due to urban expansion. Protecting Slovakia's groundwater resources is equally important,

⁹¹ European Commission (2021). *EU Soil Strategy for 2030*. Available at: https://environment.ec.europa.eu/topics/soil-and-land/soil-strategy_en.

⁹² European Commission: Joint Research Centre, AKCA, E., ALDRIAN, U., ALEWELL, C., ANZALONE, E., ARCIDIACONO, A., ARIAS NAVARRO, C., AUCLERC, A., AYDINSAKIR, K., BALLABIO, C., BALOG, K., BARAGAÑO, D., BARITZ, R., BELTRANDI, D., BERNATEK-JAKIEL, A., BØE, F., BORRELLI, P., BREURE, T., BRIONES, M., BROOHTHAERTS, N., BURTON, V., BUTTAFUOCO, G., CAGNARINI, C., CHERLINKA, V., CHEVALLIER, T., DE LA TORRE, A., DE MEDICI, D., DE ROSA, D., DI LONARDO, S., DMYTRUK, Y., DRAGOVIC, S., ERPUL, G., EVRARD, O., FRANK, S., GARCÍA FRANCO, N., GASCUEL, C., GEZGIN, S., HACKENBERGER, D.K., HAVENGA, C., HINSINGER, P., JONES, A., KAYA, F., KÖNINGER, J., LABOYRIE, M., LAMANDÉ, M., LIAKOS, L., LUGATO, E., MADENOGLU, S., MARTIN JIMENEZ, J., MASON, E., MATTHEWS, F., MAURISCHAT, P., MELPOMENI, Z., MIMMO, T., MONOKROUSOS, N., MORENO JIMENEZ, E., MUNAFÒ, M., ORGIAZZI, A., ORTAS, I., OZCAN, H., OZTAS, T., PANAGOS, P., PEIRO, A., PICCINI, C., POCH, R.M., POEPLAU, C., POESEN, J., POLAT, A., REIFF, T., RIENKS, F., ROMANOVA, S., RONCHI, S., ROS, G., OZTURK SABRI, H., SAGGAU, P., SALATA, S., SANDÉN, T., SANZ, F., SCAMMACCA, O., SCARPA, S., SCHILLACI, C., SERPA, D., SILVA, V., SONMEZ, B., SPALEVIC, V., VAN DER HEIJDEN, M., VAN EYNDE, E., VAN LIEDEKERKE, M., VANMAERCKE, M., VIDOJEVIĆ, D., VIEIRA, D., VIRTO, I., WOJDA, P., YUNTA MEZQUITA, F., ZDRULI, P., ZHANG, C. and ZUPANC, V., *The state of soils in Europe*, ARIAS NAVARRO, C., BARITZ, R. and JONES, A. editor(s), Publications Office of the European Union, Luxembourg (2024). Available at: <https://data.europa.eu/doi/10.2760/5897030>, JRC137600.

requiring measures to enhance **water retention and groundwater protection**. Sustainable irrigation techniques, organic matter enrichment, and wetland restoration will improve groundwater recharge while reducing flood risks. Additionally, strict regulations must be enforced to prevent groundwater contamination from industrial and agricultural activities.

Building **climate-resilient infrastructure and integrating land-use planning** are also essential. Updating construction codes to consider soil stability and geological risks under changing climate conditions will enhance safety, while nature-based solutions such as green infrastructure can mitigate urban heat islands and soil compaction. Land-use policies must be adapted to integrate climate risks into regional and municipal planning, ensuring long-term sustainability.

Finally, **monitoring, research, and public awareness** should be expanded to strengthen Slovakia’s response to climate change impacts on soil and the geological environment. Enhancing national monitoring systems will help track changes and predict risks, while increased research efforts will support the development of innovative adaptation solutions. Engaging the public and key stakeholders in soil conservation and sustainable land management will further reinforce these efforts.

Multi criteria analysis

Key Actions:

- Foster sustainable soil and water balance management practices
- Advance risk mapping to account for increasing climate-related geohazards

Table 9: MCA Geological Environment & Soil

Criteria	Aspect	Assessment	Rating ⁹³
Economic Costs and Benefits	Costs	Moderate: includes mapping (e.g., LiDAR, remote sensing), erosion control infrastructure, incentives for sustainable agriculture/forestry, and green urban infrastructure.	☑☑ (Strong, long-term return, moderate initial costs)
	Benefits	High return through avoided damage (floods, landslides, erosion), better land productivity, and reduced infrastructure repair. Also supports green jobs in soil restoration and risk management.	
	Funding Sources	EU Green Deal, CAP Strategic Plan, national budgets, Horizon Europe (for mapping technology).	
Ecosystem Impacts	Benefits	Healthy soils support biodiversity, water retention, nutrient cycling, carbon sequestration, and erosion control across landscapes. Mapping contributes to identifying critical areas for conservation and thus indirectly can prevent loss of valuable land and habitats.	☑☑☑ (Very strong, core to land resilience, biodiversity, water systems)
	Risks	Improper implementation (e.g., compacted soils from machinery, poor no-till practices) can harm soil function.	

⁹³ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ⁹³
		Urban green solutions require regular maintenance to retain effectiveness.	
Social Outcomes	Benefits	Protects communities from landslide and erosion risks, enhances local resilience, supports farmer knowledge, and improves public spaces in urban zones.	☑☑ (Strong, protective, inclusive if well-communicated)
	Risks	Uneven application across municipalities or lack of stakeholder engagement could reduce social buy-in. Farmers may resist new land-use rules without sufficient support or incentives.	
Climate Management (Across Climate Scenarios)	Risk Effectiveness	High: erosion control, water retention, and geohazard mapping are crucial under both wetter and drier climate futures (especially RCP 8.5).	☑☑☑ (Very strong, foundational to flood, drought, and erosion response)
	Flexibility	High: approaches (e.g., contour farming, green roofs, hazard zoning) can be adjusted regionally and scaled over time.	
Unintended Spillover Effects (Positive & Negative)	Positive	Boosts intersectoral resilience (agriculture, water, infrastructure); supports public education and urban greening.	⚠ (Moderate risk - needs maintenance and cross-sector alignment)
	Negative	If over-engineered or poorly maintained, green infrastructure may fail. Risk of regulatory burden if risk maps are not aligned with local planning capacities.	

Hydrological Regime & Water Resource Management

The **Hydrological Regime & Water Resource Management** sector addresses freshwater systems and their management including drinking water, irrigation water and wastewater. Water resources are directly linked to climate change as the hydrological cycle is highly dependent on climatic factors. Changes in rainfall patterns and temperature have implications on the availability of surface and subsurface water, as volume and timing of precipitation, as well as evaporation are driving factors of the water balance⁹⁴.

Summary

In order to adapt the water sector to climate change and to make the hydrological regime more resilient, there is a need to promote **nature-based water retention measures**, such as wetland restoration, afforestation, and sustainable land management practices. This approach also supports the implementation of the Water Framework Directive (WFD), Flood Directive (FD), the Nature Restoration Law (NRL) as well as the EU Habitats

⁹⁴ World Bank Group (2022). Water Resource Management. <https://www.worldbank.org/en/topic/waterresourcesmanagement#2>. Accessed 10 October 2024.

and Birds Directives and Common Agricultural Policy (CAP). These measures can help to reduce flood risks while improving biodiversity, water quality, and soil health.

Concerning **water and wastewater infrastructure**, there is a need to invest in the enlargement, modernisation, maintenance, and adaptation of water and wastewater infrastructure as well as the application of alternative technologies (e.g. root zone wastewater treatment plants) to ensure its resilience to changing climatic conditions. Existing legislation in the sector needs to be fully implemented (e.g. new Urban Waste Water Directive). Regarding new infrastructure projects, green structural approaches and non-structural adaptation concepts will be prioritised over grey infrastructure elements. Therefore, it is important to preserve areas for a wider application of so-called "green" measures in watersheds, where one of the main goals should be to increase the adaptability of the landscape by restoring and increasing the country's ecosystem functions and services.

This also includes implementing comprehensive climate-proofed **flood protection measures** to mitigate risks from both pluvial (rain-induced) and fluvial (river-related) flooding, improving mapping, modelling and managing flood risks, halting construction in future flood prone areas, restoring natural flood plains and upgrading early warning systems (see also section on [Disaster risk management, Civil Protection and Critical Infrastructure](#)).

Furthermore, as identified earlier – that adaptation policies should focus more on physical infrastructure – it is necessary to invest more into water and wastewater infrastructure to remedy the big investment gap and find new sources and new approaches to funding this infrastructure in the future. Wherever possible, another objective is to support the integration of nature-based solutions with traditional infrastructure to create more resilient and sustainable water management systems. For example, green roofs, rain gardens, and permeable pavements can help capture and infiltrate rainwater, reducing the burden on stormwater infrastructure.

Provision of reliable water supply is essential for addressing key economic risks in agriculture, energy production, tourist industry and transport. Risks to freshwater, if not addressed, will cascade to agriculture due to temporary water shortages and increase irrigation demand and eventually food security. It is crucial to prevent disrupted power supply to power plants, both hydro and nuclear. Both types are the backbone of the Slovak energy system and are vulnerable to unreliable water supply. Production of renewable energy from water can negatively influence climate change mitigation targets.

Similarly, water retention measures on agricultural land including new agricultural techniques could contribute to adapt water regime to climate change in countryside.

In order to ensure the secure and sufficient **provision of drinking water** to Slovak Citizens and the economy under a changing climate it needs to be ensured that the provision of safe and reliable drinking water supplies and effective wastewater treatment to protect public health and environmental quality is secured.

Multi criteria analysis

Key Actions:

- Climate-Integrated Hydrological Planning and Monitoring
- Assess, climate proof, improve and maintain water and waste water infrastructure

Table 10: MCA Hydrological Regime & Water Resource Management

Criteria	Aspect	Assessment	Rating ⁹⁵
Economic Costs and Benefits	Costs	High initial investments (e.g., flood defences, infrastructure upgrades, restoration of floodplains). Includes mapping, data systems, and green infrastructure installation.	☑☑☑ (Very strong, high return on resilience investment)
	Benefits	Major long-term savings: reduced flood damage, fewer disruptions to supply, improved drinking water quality, and health outcomes. Enhanced cost-efficiency from better water recycling and reduced loss.	
	Funding Sources	EU Cohesion Fund, LIFE Programme, EIB adaptation loans, CAP eco-schemes, national budgets, e.g. through National Recovery and Resilience Plan (NRRP)	
Ecosystem impacts	Benefits	Reestablishes natural floodplains and wetlands, restores groundwater balance, improves water quality, and supports aquatic biodiversity.	☑☑☑ (Very strong, critical for natural hydrology, biodiversity)
	Risks	Risk of ecological harm if solutions overly favour grey infrastructure (e.g., dams) over nature-based options. Potential unintended hydrological effects if not properly modelled.	
Social Outcomes	Benefits	Strong social resilience: protects vulnerable populations, reduces water-borne disease risks, supports equitable water access, enhances green space in cities.	☑☑ (Strong, if equitably implemented)
	Risks	Potential land-use conflicts or community resistance if water retention measures affect agricultural or urban zones without consultation or compensation.	
Climate Risk Management (Across Climate Scenarios)	Effectiveness	Actions address both ends of the hydrological spectrum - drought and flood - under all future climate scenarios (especially RCP 8.5).	☑☑☑ (Very strong, essential across all climate futures)
	Adaptability	Highly flexible: solutions range from traditional infrastructure to nature-based and decentralized systems (e.g., rain gardens, water reuse).	
Unintended Spillover Effects (Positive & Negative)	Positive	Green infrastructure co-benefits: cooler cities, biodiversity support, aesthetic value, recreational space.	⚠ (Moderate risk - needs systemic coordination & eco-integration)

⁹⁵ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ⁹⁵
	Negative	Risk of overbuilt grey infrastructure without green integration; poor coordination may lead to data fragmentation or regional inequities in adaptation progress.	

3.3.2. Cluster Economy

Economy and Industry

Following the sectorial definition used by the International Energy Agency, the **Economy & Industry** sector encompasses heavy industries such as steel, aluminium, paper, chemicals, and cement, as well as light industry⁹⁶. In this context, the light industry includes a diverse range of sub-sectors including food processing, textiles, and the manufacturing of consumer goods, vehicles, and machinery⁹⁷. In this summary, the Economy & Industry sector excludes agricultural (including aquacultural) activities, tourism, and services related to the Information and Communication Technology (ICT) industry, as these are covered by other specific sectors detailed in other chapters.

Summary

Industry and specially manufacturing industry are a key economic sector for Slovakia, accounting for one-fifth of GDP and providing one quarter of all jobs in the economy⁹⁸. The industrial base is today largely based on heavy, metallurgical and automotive industries. Business entities are often exposed (directly or indirectly) to the consequences of climate change, especially through the lack of natural resources causing an interruption of production or logistics activities, which ultimately leads to financial or economic problems/losses. Also, an increase in drought and flooding events might lead to interruption of production due to a lack or too much water.

A weakness of the non-state sector is the relatively low level of awareness of the possible risks posed by the adverse consequences of climate change and the need to mitigate them. This is related to insufficient information and insufficient transfer of research results into operational practice. To ensure the resilience of businesses and industries in the face of increasing climate risks, it is essential to continuously adapt existing regulations and frameworks. By incorporating the latest scientific knowledge and empirical data, effective measures to protect businesses from extreme events such as floods and droughts can be taken. This may involve mandatory or voluntary risk assessments for companies, updating building codes, industry-specific drought prevention measures (e.g. water efficiency and water recycling measures), flood protection measures, strengthening infrastructure standards to cope with extreme events, and implementing early warning systems.

Industries must also be equipped with knowledge and tools to assess and manage climate-related risks. This includes understanding the potential impacts of climate change on supply chains, operations, markets and further investments. Indirect risk is imposed through increasing costs of production. To support businesses in their efforts to build resilience, the provision of additional financial resources should be investigated, such as subsidies or low-interest loans, and in a longer run tax reform addressing positive and negative externalities. Also, technical assistance and access to relevant information via the Slovakian climate change portal⁹⁹ as well as trainings for business managers should be provided. Also, more efforts to awareness activities in the sector

⁹⁶ IEA (2023a). Industry - Energy System. <https://www.iea.org/energy-system/industry>.

⁹⁷ IEA (2023b). Light industry. <https://www.iea.org/energy-system/industry/light-industry>.

⁹⁸ Retrieved from: <https://www.cedefop.europa.eu/en/countries/slovakia>. (Accessed 3 March 2025).

⁹⁹ <http://www.klima-adapt.sk>

should be made. In parallel, localized production, development of climate-resilient industrial clusters, decentralized storage hubs, and the adoption of circular economy practices will help reduce exposure to international supply chain risks. Strengthening SME participation through financial support, preferential procurement, and business-to-business collaboration platforms can further enhance regional value chains and industrial resilience.

Innovative concepts and niche business developments that contribute to climate change adaptation can play a crucial role in driving sustainable economic growth. By fostering a supportive environment for climate-innovative businesses and investigating in research, Slovakia can position itself as a leader in the global green economy. Equally important is the development of human capital: retraining and upskilling programmes in climate-relevant professions, support for R&D in adaptation technologies, and training on EU Taxonomy requirements to ensure that businesses and institutions have the expertise needed to meet adaptation challenges. Financial incentives targeted at green skills and adaptation innovation will further strengthen the workforce's capacity to drive a sustainable industrial transition.

In the context of the objectives of the National Energy and Climate Plan adopted in 2019, decarbonisation combined with the principles of the circular economy should be more prioritized. Slovakia needs a clear plan for a sustainable transformation of its industry which could be supported by financial instruments at EU level (e.g. Modernisation Fund, Innovation Fund).

Development opportunities should be supported in high and low tech. Slovakia has potential in advancement of information technologies for monitoring and resource management. The market for renewable energy production technologies, space cooling and related technologies, such as passive cooling (e.g., solar shading, natural ventilation) and efficient water use technologies for agriculture, industry, settlements, and households may provide space for expanding. Potential of small and medium enterprises should be supported in green and blue infrastructure, landscape protection and management, flood protection and irrigation.

Slovakia should shift towards more resilient business model based on local energy production, circular economy principles, shorter supply chains and more local production and consumption of resources and products. Effective implementation of the sustainable finance criteria and ESG (environmental, social and corporate governance framework) with combination of more targeted financial instruments (with bigger focus on adaptation) will drive this transformation.

Multi criteria analysis

Key Actions:

- Reinforcing existing flood protection measures
- Establish industry-specific drought prevention measures
- Strengthening regional value chains within Slovakia
- Continue to support human capital and business development initiatives

Table 11: MCA Economy and Industry

Criteria	Aspect	Assessment	Rating ¹⁰⁰
Economic Costs and Benefits	Costs	Medium to high: infrastructure upgrades, energy efficiency retrofits, climate-proofing industrial zones, decarbonisation investments.	✓✓ (Strong in the long-term, especially with decarbonisation incentives)
	Benefits	High resilience ROI: avoids business disruptions, supply chain failures, damage to assets. Enhances competitiveness via energy savings, green certifications, and innovation funding access.	
	Funding Sources	EU Just Transition Fund, Horizon Europe, EU Modernisation Fund, EU Innovation Fund, National Recovery and Resilience Plan (NRRP), EIB green industrial loans.	
Ecosystem Impacts	Benefits	Indirect: reducing emissions and pollutants supports air and water quality. Transitioning to low-impact materials and local sourcing reduces global environmental footprints.	✓ (Moderate - mostly indirect, needs safeguards)
	Risks	Industrial expansion or mismanaged waste could worsen local pollution if safeguards are not in place. Greenwashing risk without solid ESG standards.	
Social Outcomes	Benefits	Protects jobs and facilities from flood or heatwave impacts. Prepares workforce for green economy via training and upskilling. Enhances energy security.	✓✓ (Strong if managed equitably and with training support)
	Risks	Risk of job loss in fossil-intensive sectors without adequate retraining programs. Socioeconomic divide may widen without targeted support for vulnerable workers/regions.	
Climate Risk Management (Across Climate Scenarios)	Effectiveness	Industrial zones are highly vulnerable to flooding, supply disruption, and energy volatility - all worsened under high-emission scenarios (RCP 8.5). Measures support climate-proofing of critical economic infrastructure.	✓✓✓ (Very strong, essential for asset protection and operational continuity)
	Flexibility	Many industries can adopt flexible resilience measures, but success depends on regulatory clarity and financial accessibility.	

¹⁰⁰ ✓ = Moderate

✓✓ = Strong

✓✓✓ = Very Strong

△ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁰⁰
Unintended Spillover Effects (Positive & Negative)	Positive	Sparks innovation, supports green tech startups, shortens supply chains for resilience. New economic opportunities in renewable energy, circular manufacturing, and environmental services.	⚠ (Needs policy alignment and social protection measures)
	Negative	Risk of overregulation stifling small businesses; decarbonisation pathways might create temporary economic shocks if too abrupt or poorly managed.	

Energy

The **Energy** sector is responsible for providing many of our basic needs, such as electricity for lighting, heating that keeps homes warm and the fuel that powers transportation. Generally, the Energy sector is involved in the extraction, production, refining and distribution of primary energy sources. The Energy sector comprises major energy demand sub-sectors, including industry, residential, commercial, transport and agriculture, and the energy supply sub-sectors, including resource extraction, conversion and delivery of energy products¹⁰¹.

Summary

Climate change impacts will affect weather patterns and water levels, bringing challenges such as water availability for hydropower and cooling water available for nuclear power plants. More global warming will reduce the efficiency of thermal power plants and electricity transmission¹⁰². Additionally, more extreme weather events will increase infrastructure vulnerability, which needs to be addressed via adaptation measures. This also requires diversification of energy supply, including nuclear fuel diversification, exploration of small modular reactor (SMR) technologies with climate-resilient siting standards, and building and maintaining interconnectors with neighbouring countries (e.g., Hungary, Ukraine, Poland) designed to withstand extreme climate events. At the same time, new transmission and distribution lines should be constructed, and outdated 220 kV systems phased out in favour of more resilient 400 kV lines, while substations are upgraded to remote-control mode to ensure redundancy and resilience against extreme weather. Expanding interconnection capacity (such as the SK-HU 400 kV line) will further secure supply during climate-related disruptions. Overall, the country should focus on building a modern, secure and resilient energy system. This would be characterised by the systematic inclusion of climate change adaptation into the planning processes at all levels, including infrastructure development and maintenance, as well as developing smart grids, demand-side management and efficiency. Resilient district heating systems integrating renewable sources and waste heat, alongside promotion of renewable and low-carbon hydrogen with climate-sensitive site planning, will further support this transformation. In addition, the gas distribution system must be modernised by replacing outdated boilers with efficient, low-emission, climate-resilient alternatives, while deploying smart metering, optimising compressors and network pressure to increase flexibility during climate disruptions. Increasing the use of renewable energy (driven mainly by climate mitigation policies) in Slovakia will help the country adapt to climate change. By using more diverse energy sources, Slovakia won't rely as much on centralized electricity production, which depends heavily on vulnerable transmission and distribution networks. This also increases energy security in the case of extreme events. At the same time, it is important to note that energy infrastructure with an increased RES share

¹⁰¹ European Climate Risk Assessment. Edited by European Environment Agency (EEA). Copenhagen (EEA report, 01/2024). Available online at <https://www.eea.europa.eu/publications/european-climate-risk-assessment>, checked on 3/11/2024.

¹⁰² <https://www.sciencedirect.com/science/article/abs/pii/S0140988316303334>.

will pose different challenges such as more flexible transmission and distribution network infrastructure. This in the long term increases the resilience to climate change but is very capital intensive. To reduce exposure to extreme events, small-scale electricity and heat installations (such as rooftop PV or building-level heat generation) must be designed with resilience to hail, high temperatures and flooding in mind. Energy communities and self-consumers should be encouraged to combine RES with storage systems tested for reliable performance under heatwaves, droughts and storms. The energy and electricity infrastructure, encompassing production, distribution, and end-user systems, must be adapted to withstand the impacts of climate change and in particular extreme events. It also needs to cope with a shift towards renewable energy supply. This includes measures to mitigate the increased risk of grid failures caused by extreme weather events, such as storms and heat waves. By investing in robust infrastructure, implementing advanced grid management technologies, and developing contingency plans, Slovakia can ensure a reliable and resilient energy supply. Expansion of energy storage capacity (batteries, hydrogen electrolysis, pumped hydro) should follow resilience standards ensuring safe operation under climate extremes, while hydropower and pumped-storage plants should incorporate projections for precipitation change, drought risks and biodiversity impacts. The process needs to involve re-evaluation of technical norms and standards to reflect the changing climate conditions during the long lifetime of energy infrastructure. This includes embedding climate projections into energy planning and permitting processes and fully transposing and enforcing Directive 2022/2557 on the resilience of critical entities (CER Directive)¹⁰³, ensuring that energy infrastructure planning, operation and maintenance explicitly integrate climate-related risks. Planning for energy production and consumption will have to encompass changing seasonal patterns with increasing demand for cooling, prolonged droughts affecting electricity supply and heatwaves affecting peak electricity demands. Climate change will impact electricity demand curves as the needs of end consumers evolve. The potential development of electricity demand, influenced by climate change and the emergence of modern more sustainable technologies (e.g., electromobility, smart grids, etc.), needs to be sufficiently analysed and addressed.

As climate change alters weather patterns and consumer behaviour, energy demand may fluctuate. To meet these changing demands, it is necessary to assess future energy needs and invest in the necessary infrastructure and technologies. By embracing technical innovations, such as energy storage solutions and demand-side management strategies, Slovakia can optimise its energy consumption and reduce its reliance on traditional power plants and on traditional energy systems, i.e. centralized energy production and distribution which increase vulnerability and dependence on one system of production and distribution. Therefore, supporting electricity sharing, energy communities and smart grids is increasing flexibility and resilience of energy systems. Technical conditions which should follow the legislative framework to enable such decentralisation are either still being developed or the incentives from government and key stakeholders are not sufficient. Establishing a stable legislative framework with sufficient incentives for decentralised and climate-resilient energy systems will therefore be essential.

Therefore, raising public awareness about energy supply and demand is crucial for ensuring energy sufficiency and promoting energy efficiency. By educating the public about the challenges and opportunities associated with climate change, Slovakia can encourage responsible energy consumption and support the transition to a sustainable energy future. Through targeted public awareness campaigns, energy efficiency programs, and community engagement initiatives, Slovakia can foster a culture of energy conservation and empower individuals to make informed choices that contribute to a more sustainable energy system.

¹⁰³ Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the resilience of critical entities and repealing Council Directive 2008/114/EC, published in Official Journal L 333, 27 December 2022, pages 164–198
<https://eur-lex.europa.eu/eli/dir/2022/2557/oj>

Changing patterns of energy production and consumption already affect vulnerable social groups and Slovakia needs to involve into the planning concepts of fair access to energy resources and measures to address energy poverty.

Multi criteria analysis

Key Actions:

- Security of energy supply
- Climate proofing energy and electricity infrastructure
- Inform the general public about individual measures to be taken with regards to both supply and demand of energy

Table 12: MCA Energy

Criteria	Aspect	Assessment	Rating ¹⁰⁴
Economic Costs and Benefits	Costs	High upfront investment in infrastructure (interconnectors, small modular reactors (SMRs), RES systems, storage). Long timeframes for SMR and grid modernization.	☑☑☑ (Very strong, high strategic return with initial cost)
	Benefits	Strong long-term returns: greater energy security, lower operational costs, job creation, reduced imports. Boosts competitiveness and green innovation.	
	Funding Sources	National & EU funds (National Recovery and Resilience Plan (NRRP), EU Modernisation Fund, NECP), green finance, Public-Private Partnerships (PPPs).	
Ecosystem Impacts	Benefits	Decarbonisation and reduced pollution from fossil fuel reduction; potential biodiversity co-benefits from low-impact siting of renewables.	☑☑ (Strong if sited sustainably)
	Risks	Siting of RES (especially hydropower and wind) can disrupt habitats; large-scale hydrogen or battery production may stress water and mineral resources.	
Social Outcomes	Benefits	Energy self-sufficiency through energy communities and RES self-consumers; lower long-term energy bills; improved public awareness and engagement.	☑☑ (Strong, equitable access and community models needed)
	Risks	Risk of inequity: affluent communities may benefit more from subsidies/incentives unless inclusivity is ensured. Energy poverty may persist without targeted support.	

¹⁰⁴ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁰⁴
Climate Risk Management (Across Climate Scenarios)	Effectiveness	Very high: directly addresses key risks - heatwaves, floods, seasonal hydropower variability, grid strain under RCP 8.5 scenarios.	☑☑☑ (Very strong, central to resilience across RCPs)
	Flexibility	High: supports grid decentralization, diversification of sources, and flexible infrastructure resilient under changing climate conditions.	
Unintended Spillover Effects (Positive & Negative)	Positive	Empowers local governance (energy communities); strengthens EU energy market integration; enables circular energy models (waste heat reuse, cogeneration).	⚠ (Manageable with careful planning and inclusion)
	Negative	Technological lock-in risk (e.g., over-reliance on imported nuclear fuel or SMRs); underutilization of new infrastructure; risk of social exclusion in innovation hubs.	

Financial and Insurance System

The **financial sector** is part of the economy, including firms and institutions that provide financial services to commercial and retail customers. This sector comprises a broad range of industries such as banks, investment companies, insurance companies, and real estate firms¹⁰⁵. The public sector institutions, such as central banks and financial regulators, oversee the financial system to ensure stability and prevent crises.

The financial system channels funds from those who are net savers (i.e. who spend less than their income) to those who are net spenders (who spend more than their income)¹⁰⁶.

The **insurance sector** involves companies offering risk management utilising insurance contracts. The basic concept of insurance is that one party, the insurer, guarantees payment for an uncertain future event. Meanwhile, another party, the insured or the policyholder, pays a smaller premium to the insurer in exchange for protection on the uncertain future occurrence¹⁰⁷.

Summary

Climate change represents substantial macroeconomic, fiscal and financial risk and it may have severe and adverse impacts on public finances and financial markets. Climate change will increasingly represent risks for financial markets, and property and insurance markets. In this complex environment, climate related extreme events may trigger financial crisis with broad political and fiscal implications. Stress tests should be explored as a supporting tool to prepare better for future risks from climate change. Updating actuarial and risk assessment models with climate projections and extreme weather data will be essential to ensure insurance regulation and pricing adequately reflect future risks. Slovakia needs to adopt a pro-active approach, where investments today may generate significant savings later.

¹⁰⁵ Kenton, W. (2021). Financial Sector: Definition, Examples, Importance to Economy. https://www.investopedia.com/terms/f/financial_sector.asp. Accessed 6 June 2024.

¹⁰⁶ European Central Bank (n.d.). Managing climate-related risks. https://www.ecb.europa.eu/ecb/climate/managing_mitigating_climate_risk/html/index.en.html. Accessed 6 June 2024.

¹⁰⁷ <https://uis.unesco.org/en/glossary-term/natural-heritage>.

To ensure a climate-resilient future, Slovakia must prioritise securing sufficient funding for adaptation and mitigation measures in all policies (mainstreaming adaptation). This requires a clear understanding of the financial needs across various government sectors and the allocation of adequate resources. Government bodies must be mindful of potential trade-offs, such as reduced funding for other sectors, and actively seek additional funding opportunities from EU programs. In parallel, targeted financial incentives, such as subsidies or tax breaks for property owners and businesses investing in climate-resilient infrastructure, will support wider insurance coverage and adaptation.

The EU's Solidarity and Emergency Aid Reserve was fully exhausted during the 2021–2023 period due to a series of climate-related extreme events across Europe. This highlights the urgent need to play an active role in EU negotiations on the future of solidarity mechanisms and to recognise that climate change adaptation will become an increasingly demanding aspect of budgeting, requiring significant allocation of domestic resources. Development of publicly backed risk pools and reinsurance mechanisms will also be needed to manage systemic climate risks.

Public finances must be managed prudently and transparently, strongly focusing on climate-related risks. Public and financial institutions should assess the potential impact of climate change on their operations, including the insurability of climate-related risks. Compliance with EU-level regulations, such as the EU Taxonomy and the Corporate Sustainability Reporting Directive (CSRD), is essential to ensure sustainable and climate-friendly investments. Awareness campaigns for property owners and businesses, alongside training for local governments and insurers on integrating climate adaptation into risk management strategies, can strengthen understanding and uptake of insurance solutions.

Insurance will never be able to cover all impending risks, and there will still be certain limits, despite efforts to maximise the market's insurance capacity. Nevertheless, it remains a suitable form of providing cover for potential climate-change-related risks, for example, in the case of agriculture, where the prevention possibilities against extreme weather events are very limited, and insurance, therefore, serves as a necessary financial aid for future periods. To protect individuals and property from the increasing risks associated with climate change, it is crucial for the state administration to lead strategic dialogue with the insurance providers, adjust legislative framework and strengthen insurance schemes and adapt them to emerging challenges. This involves updating and further developing national and EU insurance policies to cover a wider range of climate-related risks, such as extreme weather events and natural disasters. By ensuring adequate insurance coverage, Slovakia can mitigate the financial burden of climate change impacts on individuals and businesses.

Slovakia needs to map and assess social risks affiliated with changing insurance policies of the main providers and risks of insurance coverage in high-risk regions or localities. It may decrease risks for vulnerable groups in the population and create pressures on public finance to cover the gaps and impacts of climate related extreme events.

Multi criteria analysis

Key Actions:

- Mainstream adaptation into public administration budgets
- Strengthen the insurance scheme

Table 13: MCA Financial and Insurance System

Criteria	Aspect	Assessment	Rating ¹⁰⁸
Economic Costs and Benefits	Costs	Moderate to high for system-wide risk modelling upgrades, staff training, and integration of climate data. Costs also associated with incentives for climate-resilient investments and reforms in public budgeting.	☑☑☑ (Very strong, System-wide resilience & green finance potential)
	Benefits	Very high long-term returns: reduced fiscal shocks, improved financial stability, lower uninsured losses, growth in sustainable finance markets (e.g., green bonds, insurance-linked securities).	
	Funding Sources	EU Adaptation Funds, Modernisation Fund, private capital markets, public budgets, Public-Private Partnerships (PPPs).	
Ecosystem Impacts	Benefits	Indirect but significant: promotes investment in nature-based solutions, green infrastructure, and ecosystem services via insurance-linked incentives.	☑☑ (Strong if linked with NbS and resilient infrastructure)
	Risks	Minimal, but if misaligned incentives are used (e.g., subsidizing unsustainable infrastructure), they may unintentionally support ecological degradation.	
Social Outcomes	Benefits	Improves risk awareness, enhances personal and business resilience, and ensures more equitable access to climate-resilient insurance options. Especially beneficial if policies support low-income or vulnerable populations.	☑☑ (Strong, but equity must be prioritized)
	Risks	Climate-adjusted premiums may become unaffordable; without strong equity safeguards, financial protections could exclude at-risk groups.	
Climate Risk Management (Across Climate Scenarios)	Effectiveness	Addresses both slow-onset and acute financial risks (e.g., climate shocks, rising adaptation costs, systemic banking exposure). Enables future-proof fiscal and insurance systems.	☑☑☑ (Very strong, foundational for economy-wide adaptation)

¹⁰⁸ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁰⁸
	Flexibility	High: financial institutions and regulatory bodies can integrate new data and adapt models across RCP scenarios (especially relevant for RCP 8.5).	
Unintended Spillover Effects (Positive & Negative)	Positive	Promotes market innovation (e.g., parametric insurance, resilience bonds), strengthens public-private collaboration, and builds investor confidence.	⚠ (Moderate - requires pricing and access safeguards)
	Negative	Mispricing of risks could cause under-insurance or overregulation; transition mismanagement may destabilize vulnerable insurers or exclude high-risk customers.	

Tourism

Tourism includes all activities of incoming travellers who visit a place for less than one year for leisure, business or other personal purposes. This includes tourism behaviour and patterns, tourist activities and the use of local infrastructure (e. g. recreational areas and parks, beaches, etc.) by daily visitors and overnight guests. Furthermore, it encompasses the recreation activities of local inhabitants. The sector is highly interconnected with and dependent on the development of many other fields of action and the state of natural areas.

Summary

Slovakia's tourist industry is particularly vulnerable to the climate change. Snow tourism is already negatively affected by insufficient snow in winter and at the same time, there is increasing impact of artificial snow production (water, energy). Lakes face eutrophication due to increasing temperatures and the process might endanger summer tourism. Slovak regional and local economies are heavily dependent on tourism and sensitive to climatic changes.

In planning, incorporation of EU methodological recommendations (EU Agenda for Tourism 2030, EU Tourism Transition Pathway (2022)) and other non-legislative frameworks for assessment of investment risks linked to negative consequences of climate change¹⁰⁹ into processes at the level of strategic and environmental assessment (SEA and EIA) may provide important impetus for increasing resilience of the tourist industry and tourist infrastructure.

To remain competitive in the ever-evolving tourism market and exploit changes in the tourism market due to southern European tourism destinations becoming hotter, it is essential to **diversify tourism offers**. This diversification should be accompanied by incorporating green and blue measures into program documents and territorial strategies in the tourism sector (e.g. Tourism Development Strategy and others).

From the perspective of sector competitiveness, it is crucial to consider the anticipated adverse effects of climate change in investment planning. These may include a reduction in the number of days with snow cover in certain regions and altitudes, limited water availability during prolonged droughts, and similar challenges. Additionally, there is a need to support a shift in service orientation toward alternative forms of tourism, such as wellness, eco-tourism, agro-tourism, gastro-tourism, and geo-tourism.

¹⁰⁹ <https://www.klima-adapt.sk/metodicke-umernenia>.

This diversification should be accompanied by **investing in digital technologies** to enhance the tourist experience, improve marketing, facilitate online bookings and **strengthen partnerships with local communities** to develop authentic and culturally sensitive tourism experiences.

Effective tourism management is crucial for ensuring the sustainability of tourism destinations. By adopting a partnership-based approach and leveraging data-driven insights, it is possible to implement measures that support the conservation of key resources and mitigate the negative impacts of tourism. Key strategies for effective tourism management include:

- **Protecting biodiversity:** Conserving biodiversity through sustainable land use practices, wildlife conservation, and habitat restoration.
- **Visitor management:** Implementing strategies to manage visitor flows, reduce overcrowding, and protect sensitive areas.
- **Natural hazard preparedness:** Implementing preventive measures to mitigate the risks associated with natural hazards, such as wildfires, floods, and landslides. Inter-connect early warning systems, agro-meteorological information systems or create an information system on weather conditions and warnings, flood or fire risks in tourism facilities and national park administrations.
- **Monitoring and evaluation:** Regularly monitoring the impacts on tourism and evaluating the effectiveness of management strategies.
- **Develop and implement schemes for financial incentives and/or flexible tax system** that would respond to the needs of businesses implementing measures to mitigate or prevent the adverse effects of climate change (e.g. development of ecological and nature tourism, development of sustainable forms of transport in tourism, etc.).

Sustainable tourism plays a vital role in promoting high-quality, climate friendly tourism. By adopting sustainable practices, the tourism industry can preserve natural and cultural heritage, support local economies, and enhance the overall quality of life. This should be done by approaches that minimise the carbon footprint of tourism activities such as the use of renewable energy, energy-efficient technologies, and sustainable transportation options.

Multi criteria analysis

Key Actions:

- Update the national tourism strategy, including
 - Diversifying tourism offerings (e.g., from winter sports to year-round options)
 - Sustainable visitor and resource management
 - Building climate resilience in tourism infrastructure and services
 - Supporting cultural heritage, community involvement, and awareness

Table 14: MCA Tourism

Criteria	Aspect	Assessment	Rating ¹¹⁰
Economic Costs and Benefits	Costs	Moderate: development of new tourism infrastructure, training programs, digital solutions, and marketing campaigns. Higher in mountain regions adapting to loss of snow.	☑☑ (Strong with good growth potential if diversified)
	Benefits	Increases sector resilience, supports off-season tourism, fosters green jobs (ecotourism, wellness), and stabilizes rural economies.	
	Funding Sources	European Regional Development Fund (ERDF) through the Operational Programme Slovakia 2021–2027, EU cohesion fund, LIFE Programme, European Social Fund Plus (ESF+), Slovak Recovery and Resilience Facility (RRF).	
Ecosystem Impacts	Benefits	High when linked with sustainable transport, protected area management, and resource efficiency (water, energy). Promotes conservation-aligned tourism (e.g., spa, wellness, cultural tourism).	☑☑ (Strong if aligned with sustainability goals)
	Risks	Mismanaged tourism growth may lead to overdevelopment, habitat degradation, and biodiversity loss - especially if visitor pressure is not monitored in protected areas.	
Social Outcomes	Benefits	Strengthens rural-urban ties, fosters local identity and cultural awareness, engages local actors in tourism planning. Diversifies income for communities.	☑☑ (Strong if communities are centred)
	Risks	Tourism gentrification or poor stakeholder inclusion may cause cultural insensitivity or loss of authenticity; benefits may skew toward large operators.	
Climate Risk Management (Across Scenarios)	Effectiveness	Helps mitigate risks such as heatwaves, wildfire, water shortages, and snow loss. Increases flexibility of sector to shifting seasonal patterns under both RCP 4.5 and 8.5.	☑☑☑ (Very strong across RCP scenarios)
	Flexibility	High: actions like diversified offers, all-season tourism, and wellness/spa development are flexible, low-regret investments.	
Unintended Spillover Effects (Positive & Negative)	Positive	Encourages sustainable practices in travel and hospitality; creates resilience co-benefits for health, transport, and education sectors.	⚠ (Manageable with safeguards and zoning)

¹¹⁰ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹¹⁰
	Negative	Risk of maladaptation: e.g., water scarcity from overuse in spas, increased pressure on infrastructure during hot seasons, or over-commercialization of cultural heritage.	

3.3.3. Cluster Safety and Well-being

Disaster risk management, Civil Protection and Critical Infrastructure

Disaster Risk Management (DRM) is defined as “processes for designing, implementing and evaluating strategies, policies and measures to improve the understanding of current and future disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, prevention and protection, response and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life and sustainable development”¹¹¹.

While there is no official definition of **Civil Protection**, it can be understood as the protection of people, the environment and properties against natural and man-made disasters. This involves planning, preparation and response activities, such as deploying forces and equipment as appropriate.

In Europe, **Critical Infrastructure** is defined by the European Union legislation¹¹² as “an asset, a facility, equipment, a network or a system, or a part of an asset, a facility, equipment, a network or a system, which is necessary for the provision of an essential service”.

Summary

To safeguard Slovakia's critical infrastructure and ensure its citizens' safety, it is essential to implement effective prevention and emergency measures at all governance levels. By assessing and mapping potential hazards and vulnerabilities, identifying risks, and taking proactive steps to mitigate these risks, Slovakia can significantly prevent and reduce losses and damages of natural disasters. This also means continuously improving and streamlining procedures and putting effective measures in place to prevent, mitigate and eliminate emergencies.

Furthermore, it is imperative to implement a robust disaster risk management (DRM) system accounting for increasing risks posed by climate change.

Development and implementation of a DRM system will include:

- Conducting climate risk and vulnerability analyses for all critical infrastructure sectors (energy, transportation, water, telecommunications), developing hazard maps and elaborating climate-proofing guidelines for infrastructure planning.
- Integrating climate resilience criteria into the design and construction of new and retrofitting of existing infrastructure, following EU standards and best practices.
- Considering identified risks and using hazard maps in spatial planning processes and applying nature-based solutions for preventive action to minimise exposure to natural hazards and promote climate robust development.
- Creating a dedicated climate resilience fund to finance infrastructure adaptation and disaster preparedness, leveraging EU funding mechanisms and fostering public-private partnerships (PPPs) for innovation.
- Strengthening emergency response capabilities through adequate training, equipment, and resources for effective disaster response. Effective early warning systems can alert the public about impending natural disasters, allowing them to take necessary precautions.
- Educating the public about disaster risks and promoting preparedness measures, such as creating emergency plans and stocking essential supplies, can enhance community resilience.

¹¹¹ IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

¹¹² European Commission (2024b). EU Policy for cultural heritage. <https://culture.ec.europa.eu/cultural-heritage/eu-policy-for-cultural-heritage> <https://culture.ec.europa.eu/cultural-heritage/eu-policy-for-cultural-heritage>. Accessed 15 April 2024.

- Developing effective post-disaster recovery and reconstruction plans to minimize economic and social disruption, enabling communities to rebuild and recover from natural disasters.

Multi criteria analysis

Key Actions:

- Strengthening Climate-Resilient Critical Infrastructure and Disaster Preparedness
- Development of a Comprehensive Multi-Level Emergency Preparedness and Response Program

Table 15: MCA Disaster Risk Management, Civil Protection and Critical Infrastructure

Criteria	Aspect	Assessment	Rating ¹¹³
Economic Costs and Benefits	Costs	Medium to high: upgrades to infrastructure, emergency systems, training, and maintenance. Costs increase with delays in implementation.	✓✓✓ (Very strong, high savings through risk prevention and readiness)
	Benefits	High long-term savings: reduced disaster recovery costs, fewer infrastructure failures, and improved business continuity.	
	Funding Sources	Regional Development Fund (ERDF) through the Operational Programme Slovakia 2021–2027, EU cohesion fund, LIFE Programme, European Social Fund Plus (ESF+), Slovak Recovery and Resilience Facility (RRF), Union Civil Protection Mechanism (UCPM) – rescEU, EIB Technical assistance.	
Ecosystem Impacts	Benefits	High when integrating nature-based solutions: flood buffers, reforestation, and slope stabilization reduce exposure while enhancing ecosystems.	✓✓ (Strong when green infrastructure is prioritized)
	Risks	Over-reliance on grey infrastructure (e.g., concrete flood barriers) may lead to ecological fragmentation or downstream impacts.	
Social Outcomes	Benefits	Enhances community safety and resilience, especially for vulnerable groups. Builds local capacity and trust in institutions through inclusive planning and awareness.	✓✓✓ (Very strong, protects lives and enables community resilience)
	Risks	If communication and training are uneven, some communities may remain underprepared. Risk of public disengagement if warnings are not localized or understandable.	

¹¹³ ✓ = Moderate

✓✓ = Strong

✓✓✓ = Very Strong

△ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹¹³
Climate Risk Management (Across Scenarios)	Effectiveness	Directly targets impacts from floods, landslides, heatwaves, and wildfires. Adaptation is explicitly designed for pessimistic RCP 8.5 scenarios.	✓✓✓ (Very strong, core strategy for extreme climate futures)
	Flexibility	High: approaches are scalable, modular (across local/regional levels), and tied to updated climate projections and hazard maps.	
Unintended Spillover Effects (Positive & Negative)	Positive	Fosters cross-sector coordination, accelerates innovation in risk monitoring (AI, drones), and catalyses green infrastructure and civil preparedness culture.	⚠ (Manageable with inclusive, updated planning)
	Negative	Without inclusive spatial planning, may result in bottlenecks (in over-concentrated "safe" zones), or maladaptation (e.g., reliance on outdated hazard maps or missing vulnerable populations).	

Health is defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” by the World Health Organization¹¹⁴. Thus, the three components of ‘health’ evaluated to assess climate risks and vulnerabilities are physical health, mental health and general well-being. Key predictors of well-being used by the IPCC include annual income, access to food and water, a healthy environment and access to green spaces¹¹⁵. Although usually assessed separately, physical health, mental health and well-being are inter-connected – any type of health problem can reduce overall well-being and vice versa.

Summary

To address the challenges posed by climate change, Slovakia's healthcare system and infrastructure must be adapted to changing demands and emerging health risks. This involves increasing the capacity and preparedness of the health sector and increasing the resilience of critical health infrastructure. Sufficient capacity in terms of training, infrastructure, energy, human resources, and financial resources, needs to be ensured. Additionally, it is essential to provide accessible healthcare services to all, particularly vulnerable groups, including those with mental health conditions.

To protect public health, robust emergency mechanisms must be in place to respond effectively to health crises. This includes the development and implement a National Heat-Resilient Healthcare Infrastructure Program, ensuring that healthcare services remain effective, accessible, and well-prepared.

Enhancing the energy efficiency and security of buildings and providing an appropriate microclimate on the premises of health facilities is essential. Although the funding possibilities for renovation of public buildings is increasing on year-to-year basis, investments into renovation of hospitals will not be available from 2026 (currently there is no substitution for expiring Recovery and Resilience Plans (RRP) investments into hospitals). Hospitals are one of the public buildings which are the least prepared for future climate change crisis and one of the least energy efficient public buildings. Therefore, new funding possibilities must be found also from an adaptation point of view. Beyond that, it is crucial to expand doctors’ knowledge about the risks of high temperatures and the existing warning, social and rescue systems. By investing in early warning systems, emergency preparedness plans, critical entities relate to health and surge capacity, Slovakia will mitigate the impacts of climate-related health risks.

Promoting public health and well-being requires a concerted effort to raise awareness in the general public about climate-related health risks, including heat stress, air pollution, foodborne illnesses, waterborne diseases, and vector-borne diseases. By providing accurate and timely information, individuals will be empowered to take preventive measures and protect their health e.g. during heatwaves or floods.

Addressing climate risks to human health involves individual access to energy and protective measures, including availability and pricing of cooling options. On the level of dwellings, it means adapted urban design and measures preventing exposure to water borne diseases affiliated with floods, or city planning decreasing outside temperature.

¹¹⁴ IPCC, 2022d. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

¹¹⁵ IPCC (2022). Chapter 6: Cities, Settlements and Key Infrastructure. In: IPCC (Ed.) Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of working group 2 to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, New York.

Particular attention will be paid to vulnerable groups, such as the elderly, children, and individuals with underlying health conditions. By providing targeted health education and support services, health disparities can be reduced and the population's overall health improved.

A reliable and resilient water supply and sanitation system is essential for public health and environmental protection. To address the challenges posed by climate change, the water supply sanitation infrastructure should be adapted to changing water availability and demand, as well as the increasing risks of extreme weather events (see also chapter 3.3.1 on Hydrological Regime & Water Resource Management). Key activities include increasing the share of municipalities connected to public sewerage in lagging regions, expanding sewer networks and wastewater treatment plants in smaller agglomerations (especially in protected water management areas), and upgrading hydraulic capacity in larger agglomerations to withstand extreme events. New wastewater infrastructure must comply with the requirements of the recast Urban Waste Water Directive, incorporating adaptive treatment practices for hazardous substances and emerging contaminants. Enhanced monitoring and effluent control mechanisms will ensure system resilience during heavy rainfall or flooding.

Promoting energy-efficient and low-carbon wastewater treatment technologies will reduce emissions and strengthen resilience, while ecosystem-based adaptation measures - such as wetlands, natural retention areas, and protection of water resources - will preserve ecosystem services and secure high-quality drinking water. Governance frameworks, legislative support, and financial incentives must be developed to enable municipalities and private actors to invest in climate-resilient wastewater infrastructure. This also requires social inclusion, ensuring that vulnerable communities benefit from improved access to safe water and sanitation. Looking ahead, Slovakia should also consider the development of water protection areas to meet future demands.

Finally, Slovakia should prepare its health and water systems for the geographic expansion and increased transmission of infectious diseases. This includes boosting vaccination coverage and availability, design and run targeted public information campaigns, conducting financial analyses of new disease burdens, and modelling future vaccination needs.

Multi criteria analysis

Key Actions:

- Develop and implement a National Heat-Resilient Healthcare Infrastructure Program
- Inform the general public about individual measures to be taken in environmental emergencies
- Specific Healthcare Measures for Minority Groups
- Improve water management practices accounting for climate risks
- Safeguarding climate-resilient drinking water supply

Table 16: MCA Health care

Criteria	Aspect	Assessment	Rating ¹¹⁶
Economic Costs and Benefits	Costs	Moderate to high: upgrading facilities, deploying mobile teams, outreach campaigns, wastewater upgrades.	✓✓✓ (Very strong, high cost-efficiency and long-term return)
	Benefits	Very high: reduced healthcare system overload, lower emergency care costs, protection of labour productivity during heatwaves, long-term savings on hospitalizations.	
	Funding Sources	Slovak Recovery and Resilience Facility (RRF), NEHAP V, European Social Fund Plus (ESF+), EU4Health Programme, ERDF, Cohesion Fund, LIFE Programme.	
Ecosystem Impacts	Benefits	Indirect benefits via green hospital design, water conservation, and pollutant reduction in wastewater systems.	✓✓ (Strong, indirect but important when paired with green design)
	Risks	Minimal, unless wastewater expansion or new infrastructure is poorly managed in sensitive ecosystems.	
Social Outcomes	Benefits	Protects vulnerable groups (e.g., Roma communities, elderly, children), promotes equitable access to healthcare, improves mental health resilience.	✓✓✓ (Very strong, equity-focused, community-protective)
	Risks	If not culturally adapted or inclusive, campaigns may miss target audiences. Infrastructure gaps in rural areas could exacerbate inequalities.	
Climate Risk Management (Across Scenarios)	Effectiveness	Very high: directly addresses rising heat risks, disease vector expansion, and water safety issues, all of which worsen under RCP 8.5.	✓✓✓ (Very strong, critical under worsening heat and disease scenarios)

¹¹⁶ ✓ = Moderate

✓✓ = Strong

✓✓✓ = Very Strong

△ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹¹⁶
	Flexibility	High: mobile health units, green infrastructure, and public awareness are flexible and scalable responses.	
Unintended Spillover Effects (Positive & Negative)	Positive	Promotes trust in institutions, enhances emergency planning, drives green innovation in the health sector.	⚠ (Manageable with systemic integration and rural outreach)
	Negative	Over-reliance on short-term interventions (e.g., temporary cooling centres) without system integration risks long-term inefficiencies. Overcentralisation may leave rural zones under-supported.	

Information and Communication Technology

An **information and communication technology (ICT)** system comprises integrated networks, systems and components that enable the transmission, receipt, capture, storage and manipulation of information by users on and across electronic devices¹¹⁷.

Summary

ICT is crucial for developing and maintaining resilient, smart and energy efficient infrastructure on which the whole economy and state are dependent, such as smart and resilient energy infrastructure both on supply and demand side, smarter and circular use of resources and more efficient transportation of goods and people.

Enhanced resilience of Slovakia to climate change requires integrating climate change adaptation into planning, prioritising ICT development and leveraging technological innovations. A well-structured governance framework is essential to ensure effective crisis management in the face of ICT infrastructure breakdowns. This framework will encompass both public and private sector entities, establishing clear roles and responsibilities, and outlining procedures for coordinated response and recovery efforts. This framework will contain i) Robust emergency response plans, ii) Effective communication channels, iii) Regular stress tests to check the effectiveness of crisis management plans and identify areas for improvement and iv) Regulations for private ICT infrastructure.

Climate change poses significant risks to ICT infrastructure, including damage from extreme weather events or power outages. To mitigate these risks, it is essential to adapt ICT infrastructure to the changing climate. This applies to private (e.g. data centres) and public ICT infrastructure.

Raising awareness of climate-related risks to the ICT sector is essential for fostering a culture of preparedness and resilience. Educating stakeholders - such as policymakers, industry professionals, and the general public - is essential to promote proactive actions to mitigate risks to the ICT.

Multi criteria analysis

Key Actions:

- Implement Commission Delegated Regulation (EU) 2024/1774 supplementing Regulation (EU) 2022/2554 of the European Parliament and of the Council with regard to regulatory technical standards

¹¹⁷ Fu, G., Horrocks, L., Winne, S. (2016). Exploring impacts of climate change on UK's ICT infrastructure. Infrastructure Asset Management 3 (1), 42–52.

specifying ICT risk management tools, methods, processes, and policies and the simplified ICT risk management framework

- Develop and Implement a Green ICT Resilience and Awareness Program

Table 17: MCA Information and Communication Technology

Criteria	Aspect	Assessment	Rating ¹¹⁸
Economic Costs and Benefits	Costs	High: due to ICT infrastructure upgrades (e.g., green data centres, edge computing), regulatory implementation (EU 2024/1774), and public education campaigns.	☑☑☑ (Very strong, long-term cost savings, innovation, digital resilience)
	Benefits	Includes avoided economic losses from service disruption, reduced energy use, green tech innovation, and improved business continuity.	
	Funding Sources	National and EU digital & environmental funds, private ICT sector contributions, Public-Private Partnerships (PPPs).	
Ecosystem Impacts	Benefits	Strong indirect benefits: reduced emissions via energy-efficient infrastructure, integration of climate data in environmental monitoring.	☑☑ (Strong with lifecycle-aware ICT practices)
	Risks	High energy demand or materials use from ICT expansion could offset sustainability if not managed holistically. “Greenwashing” risk exists if lifecycle emissions are ignored.	
Social Outcomes	Benefits	Improves service continuity during crises (e.g., floods, wildfires), supports access to information, promotes digital literacy for resilience.	☑☑ (Strong, inclusive digital resilience must be ensured)
	Risks	Uneven access to ICT upgrades could widen digital divides; public education efforts may miss vulnerable or rural populations without targeted outreach.	
Climate Risk Management (Across Scenarios)	Effectiveness	Directly addresses KR-ICT-1 - disruption risk from extreme weather - and plans for RCP 8.5-level climate impacts (heatwaves, floods, infrastructure failure).	☑☑☑ (Very strong, crucial sector under extreme scenarios)
	Flexibility	High: actions are modular, scalable, and technology-forward. Distributed systems and cloud services improve resilience across threat scenarios.	

¹¹⁸ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹¹⁸
Unintended Spillover Effects (Positive & Negative)	Positive	Drives digital innovation, supports green job growth, enhances public engagement with climate data.	▲ (Moderate - mitigable with cross-sectoral planning)
	Negative	Overdependence on centralized digital services creates systemic vulnerabilities; failure to coordinate environmental and tech planning could reduce resilience.	

3.3.4. Cluster Built Environment and Spatial Planning

Cultural heritage

The **Cultural Heritage** sector includes two types of artefacts, 1) physical or tangible artefacts, assets and spaces like architecture, monuments, sites, landscapes, parks, gardens, artwork, other archives and 2) other expressions of human creativity that are intangible like traditions, practices and knowledge. Cultural heritage can be public or private as well as digitised and analogue. Both tangible and intangible cultural heritage may hold the potential to support the implementation of adaptation measures^{119 120}.

Summary

Preserving tangible cultural heritage, such as historical buildings, museums, and archives, requires a proactive approach considering the impacts of climate change. Regular maintenance and climate-adapted servicing are essential to ensure the long-term preservation of these irreplaceable assets. By implementing preventive measures, such as climate-controlled storage and regular inspections, the risks of damage from factors like temperature fluctuations, humidity, and pests can be mitigated. Furthermore, investing in research and innovation can help develop advanced conservation techniques to protect these treasures for future generations.

Intangible cultural heritage, including traditions, customs, and oral histories is also at risk from climate change (e.g. due to disbanding of communities or loss of specific landscapes). To ensure its survival, it is crucial to document, promote, and revitalise these cultural practices. By supporting cultural festivals, workshops, and educational programs, a sense of cultural identity and pride can be fostered. Additionally, digital technologies can be used to preserve and disseminate intangible heritage, making it accessible to a wider audience. Intangible cultural heritage can play an important role as a source of resilience, recovery, preparedness and prevention measures to reduce vulnerability and exposure to risks associated with climate change, and in the mitigation of carbon emissions¹²¹.

Aligning with EU policies (e.g. EU Floods Directive), the Open Method of Coordination group of Member States' experts on strengthening cultural heritage resilience for climate change and international standards, such as those set by UNESCO, can strengthen Slovakia's cultural heritage management framework. Slovakia should reflect investment needs to climate-proof design and retrofitting and reinforcement of buildings and sites with cultural value or historical significance in all strategic and programming documents. This includes developing legal frameworks, establishing clear responsibilities, and allocating adequate resources. International cooperation is also crucial for sharing knowledge, expertise, and best practices, as well as for addressing transboundary threats to cultural heritage. Slovakia can also contribute to global efforts to safeguard cultural heritage for future generations by collaborating with other countries.

Multi criteria analysis

Key Actions:

- Implement a national preventive maintenance program for cultural heritage sites, integrating climate-adaptive measures
- Safeguard and promote intangible cultural heritage for cultural continuity and local identity

¹¹⁹ European Commission (2024b). EU Policy for cultural heritage. <https://culture.ec.europa.eu/cultural-heritage/eu-policy-for-cultural-heritage><https://culture.ec.europa.eu/cultural-heritage/eu-policy-for-cultural-heritage>. Accessed 15 April 2024.

¹²⁰ UNESCO Institute of Statistics (2024). Cultural heritage: Definition. <https://uis.unesco.org/en/glossary-term/cultural-heritage>. Accessed 15 April 2024.

¹²¹ <https://ich.unesco.org/en/climate-change>.

- Establish effective governance frameworks for the protection of cultural heritage

Table 18: MCA Cultural Heritage

Criteria	Aspect	Assessment	Rating ¹²²
Economic Costs and Benefits	Costs	Medium to high: includes structural retrofitting, adaptive maintenance, monitoring systems, training programs, and digital preservation platforms.	✓✓✓ (Very strong with high return on preventive maintenance and tourism)
	Benefits	High: avoids costly damage to heritage sites, supports cultural tourism, creates skilled jobs, and maintains cultural assets that drive regional economies.	
	Funding Sources	ERDF, LIFE Programme, Horizon Europe, Creative Europe, ESF+, LEADER (within CAP Rural Development), UNESCO partnerships, Recovery and Resilience Facility (RRF), municipal co-financing.	
Ecosystem Impacts	Benefits	Integration with natural heritage protection supports biodiversity, landscape aesthetics, and sustainable material use in restoration.	✓✓ (Strong if integrated with natural heritage strategies)
	Risks	Misuse of non-resilient materials or neglect of environmental context (e.g., moisture, erosion) may harm both heritage and surrounding ecosystems.	
Social Outcomes	Benefits	Strengthens identity and community ties, promotes intergenerational learning, preserves minority cultural expressions, and builds civic pride.	✓✓✓ (Very strong with civic, cultural, and equity outcomes)
	Risks	Exclusion of local stakeholders or over-commercialization may reduce authenticity and equity in heritage preservation.	
Climate Risk Management (Across Scenarios)	Effectiveness	High: protects against humidity, temperature shifts, fires, landslides, and extreme events that threaten cultural and natural assets under both RCP 4.5 and 8.5.	✓✓✓ (Very strong, highly relevant to extreme and chronic climate effects)
	Flexibility	High: modular programs for risk assessment, digital archiving, and restoration can be tailored to site-specific and climate-specific needs.	

¹²² ✓ = Moderate

✓✓ = Strong

✓✓✓ = Very Strong

△ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹²²
Unintended Spillover Effects (Positive & Negative)	Positive	Stimulates green tourism, promotes sustainable practices, empowers marginalized voices through cultural storytelling and participation.	△ (Manageable with inclusive governance and safeguards)
	Negative	Over-tourism or inadequate policy follow-through could degrade assets; misaligned efforts between conservation and climate actors may hinder effectiveness.	

Spatial planning

Spatial Planning is understood as the public task of coordinating the demands for the use of space, with the view of influencing the future distribution of activities^{123 124}. It aims to create a rational territorial organisation, that balances demand for development with the need to protect the environment and achieve development objectives. Thus, an interdisciplinary approach is required to balance the competing demands. Structures created through spatial planning transcend political and administrative boundaries.

Summary

Managing climate related risks on infrastructure and settlements in Slovakia relies on the appropriate use of a range of instruments where spatial planning accompanied by regulations and policies play a crucial role. Land use planning is identified as one of the most effective processes to facilitate local adaptation to climate change. Decision-making and related public participation processes relevant to spatial planning and land use, must be informed by the latest scientific data on climate change and extreme events. Areas at risk because of climate related events may differ from what is currently outlined in regulations and sectoral plans. Incorporating empirical data into planning and decision-making ensures resilient infrastructure to future climate conditions. This involves considering factors such as increased precipitation, and more frequent and intense heatwaves.

Spatial development plans and land-use management instruments should be aligned with climate mitigation and adaptation goals. This means reviewing official plans, zoning, and/or development permits based on scientific data to minimise the municipal development risks stemming from the predicted impacts of increased floods, wildfires, landslides, and/or other natural hazards. Spatial planning based on climate adaptation needs to be reflected in strategic concepts, zoning plans, or density regulations that affect settlement patterns. Maladaptive practices and lock-in effects should be avoided by using Strategic and Environmental impact assessment tools. This requires a long-term perspective and a willingness to adapt to changing circumstances. By integrating climate considerations into spatial planning, more resilient and sustainable communities can be created.

To ensure the long-term sustainability of our environment, land use planning is crucial to protect ecologically relevant areas, water, land, and soil reserves. By preserving these areas and establishing ecological corridors, biodiversity can be maintained, ecosystem services safeguarded and vulnerabilities to climate change reduced. Sustainable land-use practices, such as reforestation, afforestation, and soil conservation, can help mitigate climate change and enhance ecosystem resilience (see cluster Bioeconomy).

¹²³ Danielzyk, R., Münter, A., 2018. Spatial planning. https://www.arl-international.com/sites/default/files/dictionary/2021-09/spatial_planning_raumplanung.pdf.

¹²⁴ UNECE, 2008. Spatial Planning: Key Instrument for Development and Effective Governance with Special Reference to Countries in Transition. https://unece.org/fileadmin/DAM/hlm/documents/Publications/spatial_planning_e.pdf.

Multi criteria analysis

Key Actions:

- Establish and enhance ecologically relevant areas and bio-corridors
- Integrate latest climate impact and risk science into decisions on infrastructure
- Integrate Climate Adaptation Strategies into Spatial Development Plans

Table 19: MCA Spatial Planning

Criteria	Aspect	Assessment	Rating ¹²⁵
Economic Costs and Benefits	Costs	Medium: policy reform, zoning updates, urban redesign, and data integration require coordination, investment, and long-term commitment.	☑☑ (Strong long-term resilience ROI)
	Benefits	High: reduces long-term disaster recovery costs, unlocks investment in green infrastructure, prevents maladaptive urban expansion.	
	Funding Sources	EU structural and cohesion funds, national urban resilience initiatives, green municipal bonds.	
Ecosystem Impacts	Benefits	Protects biodiversity by preserving habitat connectivity; supports climate regulation via urban forests, wetlands, and bio-corridors.	☑☑☑ (Very strong with NbS integration and zoning protections)
	Risks	Risk of land-use conflict or insufficient implementation capacity could delay ecological gains or reduce enforcement of buffer zones.	
Social Outcomes	Benefits	Inclusive urban design, reduced vulnerability to heat and flooding, better health outcomes, and greater public engagement in local planning.	☑☑☑ (Very strong, inclusive and community-focused when well-implemented)
	Risks	Gentrification or exclusion from climate-smart areas if affordability or equity are not addressed. Poor engagement with vulnerable communities may reduce uptake.	
Climate Risk Management (Across Scenarios)	Effectiveness	Very high: spatial planning guides where infrastructure and development can occur safely; crucial for adaptation to heat, flooding, and erosion under RCP 4.5 and 8.5.	☑☑☑ (Very strong, essential for managing urban heat, floods, land-use exposure)

¹²⁵ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹²⁵
	Flexibility	High: plans can be reviewed regularly with updated hazard data, allowing dynamic responses to shifting risk profiles.	
Unintended Spillover Effects (Positive & Negative)	Positive	Empowers local governance, links climate and nature goals, and promotes innovation in urban design and public infrastructure.	⚠ (Moderate - requires regular updates and local flexibility)
	Negative	Zoning rigidity or overreliance on projections may lead to misaligned development, stranded assets, or social inequity if not regularly updated.	

Transport, Infrastructure and Buildings

The **transport sector** represents companies that provide services to move people or goods and construct and maintain transportation infrastructure. It includes road, rail, and marine transport, logistics, airlines and the corresponding infrastructure¹²⁶.

The **infrastructure sector** is defined as the basic equipment, utilities, productive enterprises, installations and services essential for the development, operation and growth of a city or nation. It comprises public and private physical structures such as roads, railways, bridges, tunnels, water supply systems, sewers, electrical grids and telecommunications. Infrastructure also includes green and blue infrastructure, such as sports grounds, parks and water treatment facilities. It corresponds to the built environment, representing everything people live in and around. The transport and buildings sectors are subsystems of the infrastructure sector.

The **building sector** represents an industry associated with erecting, renovating, repairing, maintaining, or altering and completing buildings. This includes residential, commercial, institutional and public buildings¹²⁷.

Summary

Adapting the transport sector in Slovakia to the challenges posed by climate change is essential to enhance resilience, reduce greenhouse gas emissions, and ensure sustainable mobility. Slovakia's unique geographical and economic conditions, including its role as a transit country in Central Europe, make this adaptation particularly critical.

Climate change will have a long-term effect on the existing and planned transport infrastructure and is increasingly causing loss and damage from extreme weather events. Extreme weather-related hazards are especially affiliated with floods, wildfires, erosion and landslides. Heatwaves and thermal expansion represent additional costs for roads maintenance and railways. Prolonged heatwaves can warp railway tracks, degrade asphalt, and increase maintenance costs. Climate change related disruptions to transit and logistics hindering international and domestic trade flows are a risk also for the EU as Slovakia's position as a key transit corridor. Risks for overall riverine transport are highest in the southern Danube region. Therefore, the Lower Danube

¹²⁶ Hayes, A. (2021). Transportation Sector and Transportation Industry Investments. <https://www.investopedia.com/terms/i/infrastructure.asp>. Accessed 10 June 2024.

¹²⁷ EEA, 2024b. European Climate Risk Assessment. EEA report 01/2024, Copenhagen. <https://www.eea.europa.eu/publications/european-climate-risk-assessment>. Accessed 11 March 2024.

Green Corridor Project¹²⁸, improving the ecological sustainability and climate resilience of inland waterway transport, should be fully implemented. The EU macro-regional Strategy for the Danube Region (EUSDR¹²⁹) adopted by the European Commission in December 2010 should also be implemented.

Slovakia faces several structural conditions adversely affecting adaptation in the transport sector. Firstly, it is aging infrastructure, as a substantial share of the of Slovakia's transport infrastructure, including roads and railways, was built decades ago and is ill-equipped to handle climate extremes.

To ensure the long-term sustainability and resilience of the transport sector, effective governance frameworks and adequate funding schemes are essential. By investing in climate-resilient infrastructure and implementing sustainable transport policies, the sector can reduce its carbon footprint and enhance its ability to withstand the impacts of climate change. Reliable and sustainable transport systems will enhance Slovakia's role as a transit hub in Central Europe.

Adaptation measures will need to be properly **considered in the construction planning process** or the modernisation of transport infrastructure. This involves adopting climate-resilient design and construction practices, using sustainable materials and technologies, and implementing effective maintenance strategies. Re-evaluation of current planning processes, technical norms and guidance for material usage is required for better infrastructure planning. It assesses the climate fitness of building codes and design standards and if needed it is recommended to update them increase resilience to extreme weather events. For example, investing in resilient infrastructure, such as flood or landslide resistant railways, roads and bridges, can minimise disruptions caused by extreme weather events. There are emerging opportunities to incorporate green infrastructure, such as vegetation buffers and natural water retention areas, to mitigate climate impacts on transport networks. In the planning process the incorporation of EU methodological recommendations (such as EU Sustainable and Smart Mobility Strategy 2020) and the methodological recommendation linked to negative consequences of climate change developed by the Slovak Environmental Agency in 2023¹³⁰ into processes at the level of strategic and environmental assessment (SEA and EIA) may provide important impetus for increasing resilience of the transport infrastructure.

Water transport in the Danube needs to be ensured in line with the Water Framework Directive (WFD) objectives by maintaining existing waterworks and regularly cleaning them from sediments. It is essential to invest in the sustainable development of the Danube River for freight transport, while ensuring adaptation to low water levels during droughts. If necessary, part of the riverbed could be modified– deepening the navigation channel and constructing anti-flood dams and barriers along the watercourse, that prevent, among other things, the creation of navigational obstacles (tree trunks due to flooding).

Special attention needs to be paid to towns and municipalities, which are in Slovakia responsible for local roads and railways. These are vulnerable to climate change impacts and municipalities need assistance from the State in financing preventive measures and damage control. Given the demographic trends and tendencies of urban sprawl, it will be necessary to promote compact urban development to reduce travel distances and enable effective public transport systems using concepts of Transit-Oriented Development (TOD) and align urban planning with public transport hubs to encourage sustainable and adapted mobility patterns.

To avoid long-term blocking of transport, due to extreme events or accidents caused by increased frequency of weather events, monitoring by the Slovak Hydrometeorological Institute should be ensured, together with

¹²⁸ <https://www.icpdr.org/publications/ten-years-green-corridor>.

¹²⁹ <https://danube-region.eu/>.

¹³⁰ <https://www.klima-adapt.sk/metodicke-usmernenia>.

timely subsequent reporting of danger in areas where floods, increased storm activity and ice formation regularly occur.

Multi criteria analysis

Key Actions:

- Develop and Implement Governance Frameworks for Climate-Resilient Transport, Infrastructure, and Buildings
- Enhance the Climate Resilience of Transport, Infrastructure, and Buildings through Materials, Technology, and Nature-Based Solutions

Table 20: MCA Transport, Infrastructure and Buildings

Criteria	Aspect	Assessment	Rating ¹³¹
Economic Costs and Benefits	Costs	High: includes retrofitting, new construction standards, digital monitoring systems, and risk mapping. Costs grow if adaptation is delayed.	☑☑☑ (Very strong ROI in resilience, economic continuity)
	Benefits	Very high: long-term savings in maintenance and disaster recovery, improved property values, economic continuity, and attraction of investment via resilient infrastructure.	
	Funding Sources	EU Cohesion Fund, ERDF, Green Climate Fund, PPPs, National Recovery and Resilience Plan (NRRP) and National Resilience Programme.	
Ecosystem Impacts	Benefits	Significant with nature-based solutions (e.g., permeable pavements, wetland buffers). Reduces runoff, enhances biodiversity, mitigates the urban heat island effect.	☑☑ (Strong with nature-based and integrated design)
	Risks	Infrastructure that ignores ecological contexts may increase soil erosion, reduce water quality, or fragment habitats.	
Social Outcomes	Benefits	Improves public safety, urban liveability, and resilience for vulnerable groups (children, elderly, outdoor workers). Builds trust in governance.	☑☑☑ (Very strong, essential for equity and urban safety)
	Risks	Risk of inequality: green zones and resilient infrastructure may benefit only wealthier areas if not equitably planned.	

¹³¹ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹³¹
Climate Risk Management (Across Scenarios)	Effectiveness	Very high: directly targets very high-risk scenarios (RCP 8.5), including pluvial floods, heatwaves, and infrastructure collapse.	✓✓✓ (Very strong, core resilience pillar under high-risk scenarios)
	Flexibility	High: modular design, smart monitoring, and flexible materials enable scalable, iterative adaptation.	
Unintended Spillover Effects (Positive & Negative)	Positive	Catalyses innovation, job creation in green construction, and fosters public-private cooperation. Urban cooling co-benefits from vegetation and reflective materials.	⚠ (Manageable with green focus and inclusive design)
	Negative	If high-tech or grey solutions dominate without community input or green elements, there is a risk of exclusion, ecological degradation, or low uptake.	

3.3.5. Cross-cutting aspects

Urban areas

Urban areas are densely populated regions that include cities and towns, where infrastructure, buildings, and public services are concentrated. The Organisation for Economic Co-operation and Development (OECD), in collaboration with Eurostat, has developed a harmonized definition of urban areas, focusing on Functional Urban Areas (FUAs). An FUA consists of a densely inhabited city and its surrounding travel-to-work areas, reflecting the economic and social integration of the region. This approach transcends administrative boundaries, providing a more accurate representation of urbanization¹³².

Summary

Urban zoning and land-use planning play a crucial role in mitigating and adapting to climate change. The build-up environment, the proportion of reinforced and unpaved surfaces, the spatial distribution of green surfaces, shading and morphological properties of the terrain conditioning the airflow play an important role in forming microclimatic conditions and are therefore key for climate adaptation.

By strategically planning the development and use of urban land, cities can create more resilient and sustainable environments. This involves incorporating green spaces, such as parks, gardens, and green roofs, into urban landscapes. Green infrastructure helps to regulate temperature, reduce air pollution, and mitigate the urban heat island effect. Additionally, it can improve water quality, reduce stormwater runoff, and provide wildlife habitats. This approach will be strengthened in the future.

Nature-based solutions, such as urban forests and wetlands, should also be integrated into urban planning. These solutions mimic natural processes to provide multiple benefits, including climate regulation, flood control, and biodiversity conservation. By protecting and restoring natural ecosystems within urban areas, cities can enhance their resilience to climate change.

¹³² https://www.oecd.org/content/dam/oecd/en/publications/reports/2019/12/the-eu-oecd-definition-of-a-functional-urban-area_cef4a128/d58cb34d-en.pdf.

Furthermore, urban zoning and land-use planning can help to reduce greenhouse gas emissions by promoting compact development, encouraging the use of public transportation, and locating renewable energy sources strategically.

To mitigate the urban heat island effect, urban planning must incorporate climate-adaptive measures. Modifying building codes and building regulations that consider factors such as building orientation, green roofs, and urban green spaces can contribute to reducing heat stress. Additionally, climate-resilient infrastructure, such as sponge cities can help mitigate the impact of extreme weather events.

To better implement most of the measures mentioned above, a crucial factor will be the establishment of an improved (in some elements, new) legislative framework and its successful implementation. The framework will be based on several layers of legislations. The reforms will improve landscape planning, spatial planning and building permit processes including environmental impact assessment processes¹³³.

Furthermore, the incorporation of EU methodological recommendations (e.g. see [Climate ADAPT Resource catalogue](#) or tools and resources from the EU Green Capital Future-proof Toolkit¹³⁴) and predominantly, all the methodological recommendations from the set of 10 methodologies for assessment of investment risks linked to negative consequences of climate change developed by the Slovak Environmental Agency in 2023¹³⁵ could substantially improve the planning processes from climate resilience point of view.

Based on this bottom legislative layer is another legislative layer, stemming from EU laws and which concerns every building in the country. The most important legislations are the revised Energy Performance of Buildings Directive (EPBD), revised Energy Efficiency Directive (EED), revised Renewable Energy Directive (RED), transposition of the new emissions trading system (revised EU ETS Directive) into Slovak legislation. All of them are EU directives falling into the category of climate mitigation legislation or energy legislation and need to be transposed into national legislation. However, their transposition offers a good opportunity to strengthen the adaptation framework since there are many synergies between energy efficiency gains and adapting the physical infrastructure and buildings to climate change.

However, implementation of these legislations will require also support by financial instruments such as the State Fund of Housing Development under the Authority of the Ministry of Transport of the Slovak Republic (MD SR). The long-term Renovation Strategy lists existing financial measures currently in place with the largest amount of financial support targeted at the renovation of the residential buildings. Slovakia's Recovery and Resilience Plan was updated on 14 July 2023 to also introduce reforms and investments that address REPowerEU objectives, including to support green transition through an investment of €446,5 million for a large-scale renovation to make at least 25 164 family houses more energy efficient. Under the Recovery and Resilience Facility (RRF) there are also temporary funds available for renovation (Obnov dom and Obnov dom mini). Equally, renovation of public buildings is conducted mainly via the Recovery and Resilience Facility and administrated by the MD SR and some smaller mechanisms under the Slovak Innovation and Energy Agency (SIEA) and Envirofond¹³⁶ (L-measure). However, since the current criteria for selection of RRF funded projects are mostly based on energy efficiency gains, a revision is needed in order to ensure alignment with adaptation needs.

¹³³ Slovakia is still struggling to stabilize the legislative framework for crucial national legislations such as Environmental Impact Assessment law, Landscape Planning and Construction Act. All of them were revised in 2024, but as of now there is still going on a legislative process to revise them all again in 2025. Only exemption is the new Spatial Planning Act and a proposal for a Building Act: <https://www.nrsr.sk/web/Default.aspx?sid=zakony/zakon&ZakZborID=13&CisObdobia=9&CPT=694>.

¹³⁴ https://environment.ec.europa.eu/topics/urban-environment/european-green-capital-award/about-awards/toolkits/eu-green-capital-future-proof-toolkit_en

¹³⁵ <https://www.klima-adapt.sk/metodicke-usmernenia>.

¹³⁶ <https://envirofond.sk/>.

These measures would strengthen the connection between adaptation efforts and climate mitigation benefits, enhancing the effectiveness of adaptation actions. Additionally, they would help prioritize the assessment of funding gaps and investment needs while supporting the development of physical infrastructure and improving public awareness campaigns on the benefits of adaptation measures.

Multi criteria analysis

Key Action:

- Integrate climate change risks into urban planning to reduce impacts of urban flooding, drought, and the urban heat island effect

Table 21: MCA Urban areas

Criteria	Aspect	Assessment	Rating ¹³⁷
Economic Costs and Benefits	Costs	Medium to high: investment needed in infrastructure upgrades, regulatory reform, smart tech, and awareness campaigns.	☑☑☑ (Very strong, high long-term ROI with green jobs and resilience gains)
	Benefits	Very high: reduced disaster recovery costs, higher real estate value, energy savings through passive cooling, urban job creation in green sectors.	
	Funding Sources	Smart Cities Initiative, , National Recovery and Resilience Plan (NRRP), national and municipal co-financing, PPPs.	
Ecosystem Impacts	Benefits	Very high: expansion of urban green and blue spaces improves air quality, biodiversity, stormwater absorption, and mitigates heat islands.	☑☑☑ (Very strong, ecological co-benefits from urban greening)
	Risks	Low if well-managed. Poor maintenance or mono-species planting could limit ecological benefits.	
Social Outcomes	Benefits	Improves health, comfort, and safety for vulnerable groups; promotes equity in access to cooling, shade, and infrastructure; boosts civic pride and participation.	☑☑☑ (Very strong, equity-enhancing if well targeted)
	Risks	Potential gentrification if greening increases property values and displaces low-income residents. Requires safeguards for affordability.	
Climate Risk Management (Across Scenarios)	Effectiveness	Directly targets key risks from heat, floods, and drought - especially in high-density areas under RCP 8.5.	☑☑☑ (Very strong, core priority under RCP 8.5 and beyond)
	Flexibility	High: GIS tools, smart systems, zoning reforms, and adaptive infrastructure allow for responsive management as climate evolves.	
Unintended Spillover Effects (Positive & Negative)	Positive	Catalyses smart urban innovation, improves mental health, promotes urban biodiversity, and enhances city competitiveness.	⚠ (Moderate - requires inclusive planning and monitoring)

¹³⁷ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹³⁷
	Negative	Risks of over-reliance on tech, under-maintenance of green infrastructure, and poorly targeted incentives. Needs local contextualization.	

Social issues

Climate change is not just an environmental issue; it has profound social implications, particularly for vulnerable groups¹³⁸. The most vulnerable individuals and communities, often marginalised due to age, health, location, or socioeconomic status, are disproportionately affected by climate change. They have limited capacity to adapt to these impacts and are frequently overlooked in adaptation planning and implementation. While adaptation actions can mitigate some of these inequalities, they also risk exacerbating existing disparities.

Summary

At national level, linking national social policies and instruments with adaptation policies, can improve the use of horizontal funding instruments. It can also have beneficial impact on local communities, which are the most vulnerable. The issue of vulnerable communities is often interlinked with the problem of energy poverty. The issue of energy poverty is becoming a big problem and with rising energy prices its magnitude will only rise if left unaddressed. Based on the latest proposal on the methodology on how to define who falls under energy poverty in Slovakia, 8,2% of all households in Slovakia fall under this definition¹³⁹.

There are already a few examples of funding instruments which link the aspects of social, climate and energy vulnerability. In 2024, two new programs were launched addressing house renovation and deployment of renewable energy sources for socially vulnerable citizens. These instruments already have some adaptation elements; however, they are lacking stronger links to climate adaptation. Another example is the Social Climate Fund under preparation. All three instruments are/will address adaptation issues from an energy poverty point of view. It is therefore crucial to develop more funding instruments, where social vulnerability is to be strongly linked with climate adaptation.

National instruments, if properly developed, could have a positive spillover effect on the regional levels and on local communities. One example of such instruments could be affordable housing projects with stronger links to energy poverty and adaptation. Affordable housing projects are developed and implemented by local governments and local communities.

To ensure a just and equitable transition, it is essential to adopt a "leave no one behind" approach to climate change adaptation. This involves considering issues of "justice in adaptation" and "just resilience" to avoid maladaptive practices, the redistribution of risk, and the creation of further inequalities¹⁴⁰. This also involves empowering local communities. Slovakia needs to address substantial regional disparities in Slovakia, significantly influencing the ability of municipalities to finance and implement adaptation measures. A more resilient and equitable future could be achieved by prioritising the needs of vulnerable groups and implementing inclusive adaptation strategies.

¹³⁸ <https://www.worldbank.org/en/topic/social-dimensions-of-climate-change#:~:text=As%20the%20impacts%20of%20climate,health%20effects%2C%20food%2C%20water%2C>

¹³⁹ <https://www.urso.gov.sk/urso-komunikoval-vlade-sr-konkretny-navrh-definicie-energetickej-chudoby/>.

¹⁴⁰ https://www.eionet.europa.eu/etcs/etc-cca/products/etc-cca-reports/tp_2-2021

In order to increase resilience and decrease vulnerability to climate change, Slovakia should focus on three dimensions of just transition: distributive (policies of addressing roots of inequalities), procedural (processes leading to decision-making), and recognition justice (involvement of inhabitants regardless of their socio-economic or ethnic status). Addressing inequalities through a combination of policies and measures have several benefits, ranging from improving the capacity to recover from climate related extreme weather to the ability to invest in preventive measures.

Multi criteria analysis

Key Action:

- Social inclusive program for vulnerable groups

Table 22: MCA Social issues

Criteria	Aspect	Assessment	Rating ¹⁴¹
Economic Costs and Benefits	Costs	Moderate: requires social program funding, subsidies for retrofits, health and housing investments, and outreach campaigns. High return on investment	☑☑☑ (Very strong long-term social ROI)
	Benefits	Reduces public health spending, increases labour productivity, and boosts resilience in economically weaker areas. Long-term savings by avoiding maladaptation costs.	
	Funding Sources	Social Climate Fund (SCF; operational as of 2026); European Social Fund Plus (ESF+); Cohesion Fund; European Regional Development Fund (ERDF); Just Transition Fund (JTF); LIFE Programme; Recovery and Resilience Facility (RRF)	
Ecosystem Impacts	Benefits	Encourages nature-based solutions (e.g. green spaces in underserved neighbourhoods), improves urban microclimates, and supports biodiversity.	☑☑ (Strong, indirect but meaningful through urban greening)
	Risks	Minimal if green infrastructure is inclusive and well maintained; risks may arise from neglect or poor planning.	
Social Outcomes	Benefits	Very high: improves living conditions, access to services, and emergency preparedness; fosters equity, inclusion, trust, and participation.	☑☑☑ (Very strong, foundational for equity and justice)
	Risks	If not tailored culturally/linguistically, or if outreach is poorly coordinated, risk of exclusion or low uptake. One-size-fits-all may backfire.	

¹⁴¹ ☑ = Moderate

☑☑ = Strong

☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁴¹
Climate Risk Management (Across Scenarios)	Effectiveness	Very high: targets groups most at risk from extreme heat, floods, health shocks, housing instability, and insurance inaccessibility under RCP 8.5.	☑☑☑ (Very strong, targets most exposed groups)
	Flexibility	High: measures include scalable programs (mobile teams, subsidies, social safety nets) that can be rapidly adjusted to shifting needs.	
Unintended Spillover Effects (Positive & Negative)	Positive	Reduces social fragmentation, stimulates green jobs, and aligns economic, health, and environmental goals through climate equity.	⚠ (Manageable with community co-design and monitoring)
	Negative	Risk of misallocation of funding if not monitored; risk of dependence on temporary aid without systemic reform.	

Education and Society refer to the integration of educational initiatives and societal engagement to build awareness, capacity, and resilience to climate change impacts. Education fosters understanding of climate risks and equips individuals with skills for effective adaptation, while societal engagement ensures inclusive participation in adaptation planning and decision-making processes. According to the European Environment Agency (EEA, 2022¹⁴²), embedding education within national adaptation strategies empowers communities to address vulnerabilities and promotes climate justice by prioritizing marginalized groups. The United Nations also highlights the importance of education in promoting long-term climate resilience by fostering informed citizenry and intergenerational equity (UNESCO, 2021¹⁴³). Together, education and societal inclusion strengthen a nation's adaptive capacity and ensure the success of adaptation strategies.

Summary

Education and societal shifts are pivotal in adapting to climate change. Schools and universities must integrate climate change education into their curricula, equipping students with the knowledge and skills to understand the complexities of climate change, its impacts, and potential solutions. By incorporating climate science, sustainable practices, and critical thinking into lessons, educational institutions can foster a generation of environmentally conscious citizens.

Beyond formal education, societal awareness and behavioural changes are crucial. Public campaigns and media initiatives can raise awareness about climate change, its consequences, and individual actions to mitigate its effects. Promoting sustainable lifestyles, such as reducing energy consumption, conserving water, and preventing and minimising waste, can significantly contribute to climate adaptation. Additionally, community-based initiatives can empower individuals to take collective action, such as organising clean-up campaigns, planting trees, and advocating for sustainable policies.

Ultimately, a holistic approach that combines education, societal engagement, and policy action is fostered to effectively adapt to climate change. By empowering individuals, communities and governments to work together, a more resilient and sustainable future can be built.

Specific programs targeted for experts and decision-makers in different fields of economy, urban development, energy and infrastructure planning or health should help to develop capacities of the state and municipal administrations.

Multi criteria analysis

Key Action:

- Integrating Climate Change Adaptation into Educational Curricula, Public Awareness Campaigns and Trainings

¹⁴² European Environment Agency (EEA). (2022). Towards a just resilience: leaving no one behind in climate adaptation. European Environment Agency. Available at <https://www.eea.europa.eu/publications/just-resilience-leaving-no-one-behind/>.

¹⁴³ UNESCO. (2021). *Education for Sustainable Development and Climate Action*. United Nations Educational, Scientific and Cultural Organization. Available at <https://www.unesco.org/en/climate-change/education>.

Table 23: MCA Education and Society

Criteria	Aspect	Assessment	Rating ¹⁴⁴
Economic Costs and Benefits	Costs	Low to moderate: includes development of curricula, teacher training, digital tools, and awareness campaigns.	✓✓✓ (Very strong, future-proofing and low-cost, high-impact investment)
	Benefits	Very high: builds future workforce capacity for adaptation, reduces long-term costs of maladaptation, supports innovation and green jobs.	
	Funding Sources	Ministry of Education, Horizon Europe, Erasmus+, national innovation grants.	
Ecosystem Impacts	Benefits	Indirect effects through increased public understanding of NbS, biodiversity, and personal ecological responsibility.	✓✓ (Strong, indirect outcomes via education and behaviour change)
	Risks	Minimal, unless education is misaligned with environmental principles or over-relies on digital-only access.	
Social Outcomes	Benefits	Extremely strong: increases equity, builds intergenerational knowledge transfer, empowers marginalized communities, and supports civic resilience.	✓✓✓ (Very strong, equity and empowerment at all levels)
	Risks	If access is uneven (e.g., rural or minority groups not reached), social divides may persist. Risk of "climate fatigue" without engaging formats.	
Climate Risk Management (Across Scenarios)	Effectiveness	High: underpins all sectors by improving preparedness, awareness, and behavioural adaptation - especially under worsening RCP 8.5 scenarios.	✓✓✓ (Very strong, foundational for all adaptation capacity)
	Flexibility	Very high: curricula, campaigns, and training modules are modular and updateable across regions and timeframes.	
Unintended Spillover Effects (Positive & Negative)	Positive	Encourages social innovation, increases democratic participation, drives cultural shift toward sustainability and adaptation.	⚠ (Low but addressable with inclusive, tailored content)
	Negative	Overreliance on awareness without infrastructure support may limit behavioural	

¹⁴⁴ ✓ = Moderate

✓✓ = Strong

✓✓✓ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁴⁴
		change. Misalignment with local needs may reduce relevance.	

Research

Research within a national adaptation strategy refers to systematic investigation aimed at continuously advancing knowledge on climate change impacts, vulnerabilities, and effective adaptation measures. This research is essential for informing policy and planning decisions, developing innovative solutions, and enhancing a nation's capacity to respond to climate-related challenges. The United Nations Framework Convention on Climate Change (UNFCCC) emphasizes that adaptation involves adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects, necessitating informed changes in processes, practices, and structures to moderate potential damage or benefit from opportunities associated with climate change (UNFCCC n.d.¹⁴⁵).

Summary

Scientific and research activities funded by the EU, transboundary and national sources, estimating the vulnerability of ecosystems and selected sectors of economic activities to climate change, together with proposals for suitable adaptation measures, have taken place in Slovakia for a long time and in various implementation teams. The results of these activities are regularly published in the proceedings of the National Climate Program of the Slovak Republic, but also in the National Reports of the Slovak Republic on Climate Change submitted to the Secretariat of the UNFCCC.

Key institutions involved in adaptation research are:

- Slovak Academy of Sciences (SAV), which conducts multidisciplinary research on climate impacts, focusing on ecosystems, water management, and adaptation strategies and socio-economic aspects of adaptation. Comenius University in Bratislava doing research on climate modelling, hydrological changes, and socio-economic impacts of climate change.
- The Slovak Hydrometeorological Institute (SHMÚ) plays crucial role in monitoring climate data and provides essential research for understanding climate impacts and supporting policy development.
- Technical University in Zvolen, with growing research on forestry and land management, researching adaptation strategies for forests and biodiversity under changing climate conditions.
- The Slovak University of Agriculture in Nitra conducts research on the impacts of climate change on agriculture and water resources, exploring adaptation in crop production and soil management.

Awareness and coordination among different research activities is rather weak. Slovakia should better incorporate and interlink adaptation research priorities with key strategic documents like Research and Innovation Strategy for Smart Specialization of the Slovak Republic (RIS3) and with the goals of the National Strategy for Research, Development and Innovation 2030. It will be necessary to strengthen adaptation as a priority in research supported by the domestic grant agencies, especially the Slovak Research and Development Agency.

¹⁴⁵ <https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/introduction>.

However, as the updated Vulnerability and Risk Assessment (VRA) shows, several research gaps remain. The research often lacks dedicated financial resources, relying heavily on EU funding rather than substantial national investment. Slovakia is lagging in participation in the EU research schemes. There is a need for more comprehensive climate data and modelling specific to Slovakia's unique geographical and ecological conditions. Research on socio-economic impacts of climate change and adaptation needs to be substantially expanded. Priorities are also in leveraging digital tools and big data for better climate modelling and risk assessment and strengthening research on the socio-economic aspects of adaptation, particularly related to vulnerable populations and sectors.

These knowledge gaps hinder effective adaptation and mitigation planning. By understanding the complex interactions between climate systems, human societies, economy and ecosystems, the Slovakian society can better prepare for the challenges ahead and build a more resilient future. Therefore, further research and international exchange and inclusion in EU research are needed.

Lack of application of knowledge in practice is a chronic problem. Better integration is needed between researchers, policymakers, and local governments to translate research findings into actionable adaptation measures. Adaptation research often struggles to gain traction among policymakers and the public, where climate change is still seen as a distant issue. Not to omit, social science research on climate denialism and proper communication strategy in the context of Slovak and Central-European policy and societal framework, is necessary. What is also missing, however, is a framework to ensure better coherence of these activities and mutual information between the relevant institutions. This should be improved by better information exchange via the Slovakian adaptation portal¹⁴⁶ and other exchange formats.

¹⁴⁶ www.klima-adapt.sk.

Multi criteria analysis

Key Action:

- Develop a national climate change adaptation research agenda and program

Table 24: MCA Research

Criteria	Aspect	Assessment	Rating ¹⁴⁷
Economic Costs and Benefits	Costs	High: development of long-term research programs, infrastructure upgrades, coordination among ministries and research bodies.	☑☑☑☑ (Very strong, high ROI through improved planning and reduced losses)
	Benefits	Very high: reduced climate-related losses, improved investment targeting, boosted R&D sector competitiveness, access to international funding.	
	Funding Sources	National budgets, EU research programs, Horizon Europe, private sector contributions.	
Ecosystem Impacts	Benefits	Enables evidence-based protection of ecosystems, biodiversity, and land through informed adaptation strategies and NbS development.	☑☑☑☑ (Very strong, informs NbS and ecological resilience)
	Risks	Low: only if scientific findings are not applied to policy, or lack of ecological focus in research priorities.	
Social Outcomes	Benefits	Improves public access to climate knowledge, supports climate education, and enhances inclusiveness in decision-making and research design.	☑☑☑☑ (Very strong, enables inclusive, knowledge-based adaptation)
	Risks	Disparities in access or engagement if research remains disconnected from local needs or underserved communities.	
Climate Risk Management (Across Scenarios)	Effectiveness	Foundational for informed planning across all sectors, especially under uncertain or high-risk RCP scenarios.	☑☑☑☑ (Very strong, foundational to all adaptation sectors and scenarios)
	Flexibility	High: research agendas are updateable, scenario-driven, and responsive to changing evidence and global partnerships.	

¹⁴⁷ ☑ = Moderate

☑☑ = Strong

☑☑☑☑ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁴⁷
Unintended Spillover Effects (Positive & Negative)	Positive	Stimulates scientific innovation, facilitates green technology development, empowers societal adaptation through transparent data dissemination.	△ (Minor - requires policy alignment and knowledge translation)
	Negative	Potential delays in implementation, or low uptake of findings if not aligned with policymaker and community needs. Risk of research being too abstract or narrow.	

Governance

Summary

Climate neutrality and adaptation should be incorporated as a development goal and as a cross-cutting priority into strategies and policies, with increased emphasis on the implementation of the measures taken. Slovakia needs a long-term political vision across the political spectrum and political consensus on the basic needs and principles of the transformation and adaptation.

EU framework

The European Climate Law¹⁴⁸ and the EU Adaptation Strategy¹⁴⁹ set out the initial legal foundations to ensure implementation of the EU's commitments on adaptation (alongside those on mitigation) under the UNFCCC and the Paris Agreement. The Government of the Slovak Republic should be committed to the framework. Slovakia should also implement all other upcoming EU legislation relevant to adaptation.

Further, the next Multiannual Financial Framework (MFF) discussions present an opportunity for Slovakia to align future EU funding instruments with the priorities outlined in the revised National Adaptation Strategy. Funding mechanisms should be explored across all sectors of the strategy, including e.g. how instruments such as the European Social Climate Fund can support its implementation through well-designed support criteria and effective models for broad or targeted assistance.

Strengthening Institutional Capacity and Coordination

Implementing adaptation to climate change requires the coordination between ministries and has to be undertaken on both political and technical level. Yet climate change policymaking lacks a proper horizontal, vertical and cross-border coordination of its sectoral politics in Slovakia so far. Previous forms of political coordination (Committee for Coordination of the Climate policies in Slovakia and Governmental Committee for European Green Deal established in 2020) failed at some stage. With the current revision of the strategy the multi-sectoral working group for adaptation, established in 2012, composed of representatives of ministries and their professional organisations, other central government bodies, academia, and the non-governmental sector is being reactivated and reformed to oversee and align actions across sectors (see also chapter 3.4.2, in particular milestone 1).

¹⁴⁸ https://climate.ec.europa.eu/eu-action/european-climate-law_en.

¹⁴⁹ https://climate.ec.europa.eu/eu-action/adaptation-climate-change/eu-adaptation-strategy_en.

Further, municipalities should be equipped with the financial resources, technical expertise, and training needed to develop and implement adaptation strategies tailored to their local contexts. To enhance coordination and cooperation on a different level, it would be useful to build on good practices such as the project “Strategy for mitigation of floods for Bodrog River Basin”.

Also, the enhancement of skills and expertise of public officials and other stakeholders to handle the complexities of climate adaptation planning and implementation should be increased.

Policy integration and mainstreaming adaptation

Policy integration and mainstreaming adaptation are critical for building climate resilience and ensuring a sustainable future. By effectively integrating climate change considerations into all aspects of decision-making, Slovakia can better prepare for the challenges of a changing climate and create a more sustainable and equitable future for all. This should be achieved through:

- **Cross-sectoral Collaboration:** Fostering collaboration among different sectors to identify and address climate risks and opportunities.
- **Mainstreaming into Existing Processes:** Integrating climate change considerations into existing planning, budgeting, and decision-making processes.
- **Capacity Building:** Enhancing the capacity of policymakers, planners, and other stakeholders to understand and address climate change risks.
- **Data and Information Sharing:** Ensuring access to and sharing of climate data, information, and knowledge across sectors.
- **Monitoring and Evaluation:** Regularly monitoring and evaluating the effectiveness of policy integration and adaptation measures.

Local coordination and implementation

Large regional differences in Slovakia create demand for better governance. It will be necessary to further prepare, test and implement targeted regional and local adaptation strategies, involving local governments, regions and cities and using examples of good practice. Other options of how to reinforce the role of the local government, are to be inspired by the draft of the Climate Change Law, which proposed that municipalities with population above 2000 inhabitants and self-governing regions will be obliged to develop strategic climate plans in accordance with regional strategies. In the draft of the Climate Change Law, the municipalities and self-governing regions were encouraged to take an integrated approach and combine both mitigation and adaptation strategies in close coordination and under the methodology of the Ministry of Environment and. Regional Centres for Sustainable Energy were to be set up and maintained with the help of the European funds. Such approach would align regional adaptation policies and adaptation funding in regions more with regional energy and climate change policies.

Public participation

In order to increase public participation, the Slovakian Ministries will go beyond simple information provision. To actively solicit public input through surveys, workshops, focus groups, and public hearings will be ensured and the input provided will genuinely considered in the decision-making process.

Monitoring and assessment

Slovakia will develop a system that allows to monitor, evaluate and learn from the implementation of adaptation options. See chapter 3.6.

Multi criteria analysis

Key Actions:

- Reform the Working Group on Adaptation and designate focal points for adaptation in competent ministries, self-governing regions and municipalities
- Development of regional and local climate adaptation plans in coordination with the National Adaptation Strategy

Table 25: MCA Governance

Criteria	Aspect	Assessment	Rating ¹⁵⁰
Economic Costs and Benefits	Costs	Low to moderate: institutional reform, training programs, and coordination mechanisms require sustained resources.	✓✓ (Strong, leverage for funding and efficiency)
	Benefits	High: reduces duplication, increases policy efficiency, aligns investments with climate priorities	
	Funding Sources	Unlocks access to external funding (EU, international finance)	
Ecosystem Impacts	Benefits	Enables integration of climate and environmental data into decision-making and supports ecosystem-based adaptation through improved cross-sector cooperation.	✓✓ (Strong, key enabler of integrated environmental planning)
	Risks	Low, provided that coordination mechanisms support environmental standards and stakeholder engagement.	
Social Outcomes	Benefits	High: strengthens public trust, facilitates inclusive participation, ensures responsiveness to community needs, and supports vulnerable groups through better representation.	✓✓✓ (Very strong, highly inclusive and empowering when well implemented)
	Risks	Potential for social exclusion if local authorities lack capacity or are not fully engaged. Poor outreach may hinder public buy-in.	
Climate Risk Management (Across Scenarios)	Effectiveness	Very high: adaptive governance structures are critical to coordinating responses to escalating risks under RCP 8.5 and beyond.	✓✓✓ (Very strong, crucial cross-cutting coordination role)

¹⁵⁰ ✓ = Moderate

✓✓ = Strong

✓✓✓ = Very Strong

△ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁵⁰
	Flexibility	High: governance measures are flexible, iterative, and designed for continual adjustment based on new risk data.	
Unintended Spillover Effects (Positive & Negative)	Positive	Promotes institutional resilience, cross-sector learning, and long-term sustainability of adaptation efforts.	⚠ (Minor - manageable with oversight and continuity planning)
	Negative	Risk of bureaucratic inertia or inefficiency without clear mandates and performance monitoring. Political shifts could delay continuity.	

Regional and Cross-Border Cooperation

Summary

Regional and cross-border cooperation is crucial for effective climate change adaptation, particularly in a country like Slovakia, where many climate change impacts, such as extreme weather events, water scarcity, and biodiversity loss, transcend national borders. Aligning Slovakia's adaptation efforts with broader EU strategies and directives, such as the EU Climate Adaptation Strategy, the country needs to work in coordinated approaches with its neighbours.

Regional and cross-border cooperation is implemented through regional conventions such as the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention), or the Convention on Cooperation in the Protection and Sustainable Use of the Danube River (Convention on the Protection of the Danube River). These cooperations should be further strengthened and actively supported.

By actively engaging in regional and cross-border cooperation, Slovakia can enhance its resilience to climate change, strengthen its international standing, and contribute to a more sustainable future. This is particularly important for biodiversity protection and for transboundary water management.

Multi criteria analysis

Key Action:

- Strengthen International Cooperation

Table 26: MCA Regional and Cross-Border Cooperation

Criteria	Aspect	Assessment	Rating ¹⁵¹
Economic Costs and Benefits	Costs	Low to moderate: participation in international initiatives, capacity building, and project development entail administrative and logistical costs.	✓✓✓ (Very strong, access to

¹⁵¹ ✓ = Moderate

✓✓ = Strong

✓✓✓ = Very Strong

⚠ = Potential Risk (needs monitoring/mitigation)

Criteria	Aspect	Assessment	Rating ¹⁵¹
Ecosystem Impacts			finance, trade, and innovation)
	Benefits	High: access to external funding, joint project implementation, technology exchange, and enhanced economic resilience via shared infrastructure and markets.	
	Funding Sources	Interreg (European Territorial Cooperation – ETC), LIFE Programme, Connecting Europe Facility (CEF) – Environment and Water Projects, EU Solidarity Fund (EUSF), Danube Strategy (EUSDR), Common Agricultural Policy (CAP) – Cross-border Landscape and Ecosystem Projects	
	Benefits	Regional agreements facilitate ecosystem-based approaches, especially for river basins and transboundary habitats like the Carpathians.	✓✓✓ (Very strong, supports river basin and shared habitat adaptation)
	Risks	Minor: potential for conflict or misalignment in management approaches between countries if governance mechanisms are weak.	
Social Outcomes	Benefits	Broad societal benefits through enhanced disaster response coordination, regional solidarity, and inclusion of local communities in adaptation dialogues.	✓✓ (Strong through inclusion and regional solidarity)
	Risks	If initiatives are not grounded in local contexts or lack transparency, there may be public resistance or low engagement.	
Climate Risk Management (Across Scenarios)	Effectiveness	Very high: critical for managing shared energy and water-related risks under RCP 8.5. Enhances regional preparedness and reduces systemic vulnerabilities.	✓✓✓ (Very strong, key for transboundary energy and water risks)
	Flexibility	High: bilateral and multilateral cooperation allows for dynamic, evolving risk responses across political boundaries.	
Unintended Spillover Effects (Positive & Negative)	Positive	Boosts international reputation, facilitates peacebuilding, increases market opportunities for climate technologies, and enhances global leadership on climate.	⚠ (Low to moderate - manageable with good diplomacy)

Criteria	Aspect	Assessment	Rating ¹⁵¹
	Negative	Overemphasis on global agendas may divert attention from local priorities. Risk of fragmented approaches if coordination is weak or inconsistent.	

3.3.6. Cross-Sector Multi-Criteria Synthesis Matrix

Table 27: Multi-Criteria-Synthesis Matrix

Sector	Economic (ROI ¹⁵² , cost-efficiency, funding access)	Ecosystem (positive or negative environmental impact)	Social (equity, inclusion, community resilience)	Risk Management (ability to address RCP scenarios)	Unintended Spillover Effects (key risks or concerns)
Agriculture	✓✓ (Efficient, especially with green practices)	✓✓✓ (Soil health, biodiversity gains)	✓✓ (Supports livelihoods, but access varies)	✓✓✓ (Very strong for drought, erosion)	⚠ (Tech access gap, irrigation overuse)
Biodiversity, Ecosystems and Natural Heritage	✓✓ (Avoided degradation costs)	✓✓✓ (Core ecological resilience)	✓✓ (Community awareness, land-use trade-offs)	✓✓✓ (Species migration, NbS scaling)	⚠ (Land conflicts, greenwashing risk)
Forestry	✓✓ (Timber security, risk reduction)	✓✓✓ (Carbon sinks, species diversity)	✓✓ (Jobs, co-management potential)	✓✓✓ (Storm, fire, drought resilience)	⚠ (Monoculture risk, digital divide)
Geological Environment & Soil	✓✓ (Low-cost, high impact)	✓✓✓ (Erosion control, nutrient cycling)	✓✓ (Flood/landslide protection)	✓✓✓ (Maps + NbS = high flexibility)	⚠ (Maintenance gaps, risk of misuse)
Hydrological Regime & Water Resource Management	✓✓✓ (Avoided flood/drought costs)	✓✓✓ (Wetlands, aquifers restored)	✓✓✓ (Health, access, safety)	✓✓✓ (Multi-scenario ready)	⚠ (Grey infra overuse, land-use tensions)
Economy & Industry	✓✓ (Resilience + green growth)	✓ (Indirect via emissions cuts)	✓✓ (Workforce, transition risk)	✓✓✓ (Protects assets & supply chains)	⚠ (Tech lock-in, uneven benefits)
Energy	✓✓✓ (Efficiency + security)	✓✓ (Low-carbon but siting matters)	✓✓ (Access, pricing risks)	✓✓✓ (Core for risk reduction)	⚠ (Siting conflicts, centralization risk)

¹⁵² ROI = Return on Investment. In this context, it refers to the long-term economic value or cost-efficiency of an adaptation measure relative to its upfront cost. High ROI indicates strong financial justification through avoided damages, improved productivity, or resource savings.

Sector	Economic (ROI ¹⁵² , cost-efficiency, funding access)	Ecosystem (positive or negative environmental impact)	Social (equity, inclusion, community resilience)	Risk Management (ability to address RCP scenarios)	Unintended Spillover Effects (key risks or concerns)
Financial & Insurance System	✓✓✓ (System-wide protection)	✓✓ (NbS via insurance incentives)	✓✓ (Risk literacy & access)	✓✓✓ (Macro & micro risk mitigation)	⚠ (Affordability, underinsurance)
Tourism	✓✓ (Diversification potential)	✓✓ (Nature tourism, but pressure possible)	✓✓ (Jobs, local culture)	✓✓✓ (Loss of snow, overheating)	⚠ (Over-tourism, misaligned investments)
Disaster Risk Management, Civil Protection and Critical Infrastructure	✓✓✓ (Damage prevention, continuity)	✓✓ (With NbS buffers)	✓✓✓ (Protects most vulnerable)	✓✓✓ (Central to extreme events)	⚠ (Overengineering, data gaps)
Health care	✓✓✓ (Avoided health costs)	✓✓ (Water safety, green design)	✓✓✓ (Equity & resilience)	✓✓✓ (Heat, disease, WASH)	⚠ (Urban-rural access gaps)
Information and Communication Technology	✓✓✓ (Digital continuity & efficiency)	✓✓ (Smart monitoring, reduced emissions)	✓✓ (Digital divide risk)	✓✓✓ (Critical infrastructure resilience)	⚠ (Tech dependence, accessibility gaps)
Cultural Heritage	✓✓✓ (Tourism, avoided loss)	✓✓ (Natural heritage aligned)	✓✓✓ (Identity, wellbeing)	✓✓✓ (Humidity, heat, wildfires)	⚠ (Over-commercialization, capacity limits)
Spatial Planning	✓✓ (Long-term cost avoidance)	✓✓✓ (Habitat, NbS integration)	✓✓✓ (Urban equity, health)	✓✓✓ (Directs safe development)	⚠ (Zoning rigidity, outdated data)
Transport, Infrastructure and buildings	✓✓✓ (Protects mobility & assets)	✓✓ (With green infrastructure)	✓✓✓ (Access, emergency continuity)	✓✓✓ (Core physical resilience)	⚠ (Exclusion if not inclusive/green)
Urban Areas	✓✓✓ (Cooling, jobs, resilience)	✓✓✓ (Blue-green networks)	✓✓✓ (Inclusive planning)	✓✓✓ (Addresses all urban risks)	⚠ (Gentrification, uneven service access)

Sector	Economic (ROI ¹⁵² , cost-efficiency, funding access)	Ecosystem (positive or negative environmental impact)	Social (equity, inclusion, community resilience)	Risk Management (ability to address RCP scenarios)	Unintended Spillover Effects (key risks or concerns)
Social Issues	✓✓✓ (Productivity + avoided crisis costs)	✓✓ (Urban greening)	✓✓✓ (Core to climate justice)	✓✓✓ (Heat, health, housing)	⚠ (Exclusion if not co-designed)
Education & Society	✓✓✓ (Future skills, low cost)	✓✓ (Behavioural change)	✓✓✓ (Empowerment & awareness)	✓✓✓ (Supports all sectors)	⚠ (Low uptake without relevance/access)
Research	✓✓✓ (Informs policy & investment)	✓✓✓ (Enables NbS & impact modelling)	✓✓✓ (Knowledge equity)	✓✓✓ (Scenario planning & innovation)	⚠ (Poor implementation linkage)
Governance	✓✓ (Policy alignment, funding efficiency)	✓✓ (Enabler of env. integration)	✓✓✓ (Transparency, participation)	✓✓✓ (Drives coordination)	⚠ (Inertia, weak mandates)
Regional & Cross-border Cooperation	✓✓ (Shared funding & projects)	✓✓✓ (Landscape-scale adaptation)	✓✓ (Community & knowledge exchange)	✓✓✓ (Shared river basins, migration)	⚠ (Coordination imbalance, project dependency)

3.3.7. Overall risk management of unintended effects

In the Cross-Sector Synthesis Matrix (see Table 27), the **Risk Management** column evaluates the ability of each sector's proposed adaptation actions to **effectively anticipate, reduce, and manage climate-related risks** across a range of future climate scenarios, including high-risk futures such as RCP 8.5. Strong risk management capabilities are critical for sectors dealing with acute hazards (e.g., flooding, wildfires, extreme heat) and those protecting critical societal functions like health, energy, water, or finance. Thus, high ratings in this column reflect sectors whose proposed measures actively mitigate risks such as floods, droughts, heatwaves, biodiversity loss, or economic disruption through proactive, flexible, and resilient strategies.

Importantly, while strong risk management strategies lower climate-related impacts, they **may also generate unintended effects** if not carefully designed. These can include **maladaptation risks** (e.g., grey infrastructure that increases ecological degradation), **equity concerns** (e.g., measures that unintentionally benefit only wealthier groups), or **lock-in effects** (e.g., rigid systems that become less adaptable over time). Identifying these unintended effects is essential for robust risk management because it highlights where additional safeguards, monitoring, or flexible design approaches are needed to maintain the long-term resilience and social acceptability of adaptation investments.

Recommendations for risk management across sectors

To maximize the effectiveness of climate adaptation while minimizing unintended negative effects, the following cross-sectoral risk management recommendations are proposed:

- **Embed Flexibility and Iteration:**
Ensure adaptation measures are designed with flexibility so they can be adjusted as new climate data emerges or if unexpected effects materialize. Regular review cycles (please see chapters **Error! Reference source not found.** Implementation Management and 4.3 Monitoring, evaluation and learning) should be built into sectoral strategies.
- **Promote Nature-Based Solutions (NbS) as a Priority:**
Prioritize green and blue infrastructure (wetlands, forests, green roofs) over grey, engineered solutions where possible. NbS provide multiple resilience benefits (e.g., flood protection, biodiversity support) while minimizing environmental harm.
- **Implement Multi-Benefit Approaches:**
Design adaptation actions to deliver **co-benefits** - such as social equity, ecosystem health, and economic opportunity - alongside risk reduction. For example, urban greening can address heat risks and improve public health.
- **Strengthen Stakeholder Participation and Equity Safeguards:**
Engage vulnerable groups early and continuously in adaptation planning to ensure that risk reduction measures are equitable. Specific attention must be given to rural communities, low-income groups, and marginalized populations.
- **Invest in Early Warning Systems and Risk Communication:**
Across sectors like DRM, Health, Water, and Agriculture, early warning systems (for floods, heatwaves, vector-borne diseases) should be scaled up. Risk communication strategies must be transparent, multilingual, and tailored to different audiences.
- **Avoid Technological Lock-in:**
In sectors like ICT and Energy, avoid reliance on single-point, high-risk technologies (e.g., centralised data centres without backups). Diversify systems and invest in redundancies to improve resilience.

- **Integrate Ecosystem and Social Monitoring:**
Establish real-time monitoring of ecological and social indicators (e.g., soil moisture, habitat health, insurance coverage rates) to detect early signs of maladaptation or unintended impacts.
- **Mainstream Climate Risk into All Policy Domains:**
Risk management should not be siloed into "climate policy" alone. Climate risk considerations must be embedded into economic planning, healthcare, infrastructure design, education systems, and financial regulations.
- **Enhance Cross-Border Cooperation:**
Especially for water, biodiversity corridors, and disaster risk, transboundary risk management (with Austria, Hungary, Czech Republic, Poland) must be a priority to avoid fragmented responses and maximize regional resilience.
- **Secure Sustainable Funding Mechanisms:**
Ensure that financing instruments (insurance models, public-private partnerships, EU funds) are climate-risk sensitive and designed to support flexible, scalable adaptation pathways rather than rigid projects.

Recommendations for risk management per sector and cross-cutting aspects

The **unintended effects** identified through the Multi-Criteria Analysis highlight critical points where adaptation measures could cause new risks if not carefully designed or monitored. Risk management should proactively address these by applying tailored safeguards for each sector. Specific recommendations include:

Cluster Bioeconomy

- **Agriculture:** To prevent overuse of irrigation water and unequal technology access, promote water-efficient farming practices (e.g., precision agriculture) and support smallholder farmers with financing and training programs.
- **Biodiversity, Ecosystems and Natural Heritage:** To mitigate land-use conflicts and avoid ineffective "greenwashing", prioritize robust ecosystem monitoring, transparent land-use planning, and strict validation of nature-based solutions (NbS) outcomes.
- **Forestry:** To avoid monocultures and resilience loss, promote diversified, climate-adapted reforestation practices and ensure continuous education for forest managers on ecological resilience principles.
- **Geological Environment & Soil:** To minimize maintenance failures and soil misuse, implement community-based monitoring programs and embed soil protection standards into agricultural subsidies.
- **Hydrological Regime & Water Resource Management:** To prevent over-dependence on grey infrastructure and conflicts over land use, combine grey solutions with nature-based approaches (like wetlands restoration) and engage stakeholders early in water basin planning.

Cluster Economy

- **Economy & Industry:** To avoid technological lock-in or uneven distribution of benefits, ensure flexible incentive schemes that support innovation at both SME and large enterprise levels, and promote diversification.

- **Energy:** To manage site conflicts and centralization risks, integrate spatial planning tools that consider biodiversity, community input, and climate justice in siting new renewable energy infrastructure.
- **Financial and Insurance System:** To counter affordability issues and underinsurance risks, design inclusive insurance models (e.g., microinsurance, public-private schemes) and create adaptation-specific financial literacy programs.
- **Tourism:** To avoid over-tourism and misaligned infrastructure, develop climate-resilient tourism strategies that diversify destinations and seasons, with strong visitor caps and local benefit-sharing.

Cluster Safety and Well-being

- **Disaster Risk Management, Civil Protection and Critical Infrastructure:** To avoid maladaptive overengineering and data gaps, promote integrated, ecosystem-based risk reduction measures and maintain updated, open-access risk maps.
- **Health care:** To bridge urban–rural access gaps, expand mobile health units, digital health services, and community-based early warning systems particularly in underserved areas.
- **ICT:** To minimize digital divide and over-reliance risks, integrate redundancy (backup systems) into critical ICT infrastructure and promote equitable digital literacy initiatives.

Cluster Built Environment and Spatial Planning

- **Cultural Heritage:** To prevent over-commercialization and protect authenticity, engage local communities in cultural tourism planning and prioritize the conservation of intangible heritage.
- **Spatial Planning:** To reduce zoning rigidity and outdated hazard data risks, update local spatial plans regularly using the latest climate data and flexible, scenario-based zoning approaches.
- **Transport, Infrastructure & Buildings:** To prevent social exclusion and ecological degradation, embed green design principles and universal accessibility standards into all transport and building upgrades.

Cross-cutting aspects

- **Urban Areas:** To manage risks of gentrification and uneven access to urban resilience infrastructure, implement inclusive urban greening plans and prioritize cooling and nature-based solutions in vulnerable neighbourhoods.
- **Social Issues:** To avoid exclusion or non-use of social adaptation programs, co-create all social resilience measures with target communities and apply culturally sensitive communication strategies.
- **Education & Society:** To counter low uptake of climate education, tailor educational materials to different socio-economic groups and integrate experiential learning approaches (e.g., community projects).
- **Research:** To avoid poor translation of scientific findings into policy, foster closer ties between research institutions and policymakers, and create applied research programs with concrete pilots.
- **Governance:** To prevent bureaucratic inertia and weak mandates, establish clear responsibilities, performance monitoring systems, and stable long-term governance structures from the national to the local level for adaptation across levels.

- **Regional & Cross-border Cooperation:** To avoid coordination imbalances or dependency on temporary projects, build permanent cross-border governance bodies with sustained funding and legal mandates.

3.4. Roadmap towards 2025

3.4.1. Implementation plan

The National Climate Change Adaptation Strategy is implemented through a National Adaptation Plan (NAP). Such an approach is taken in most EU Member States¹⁵³.

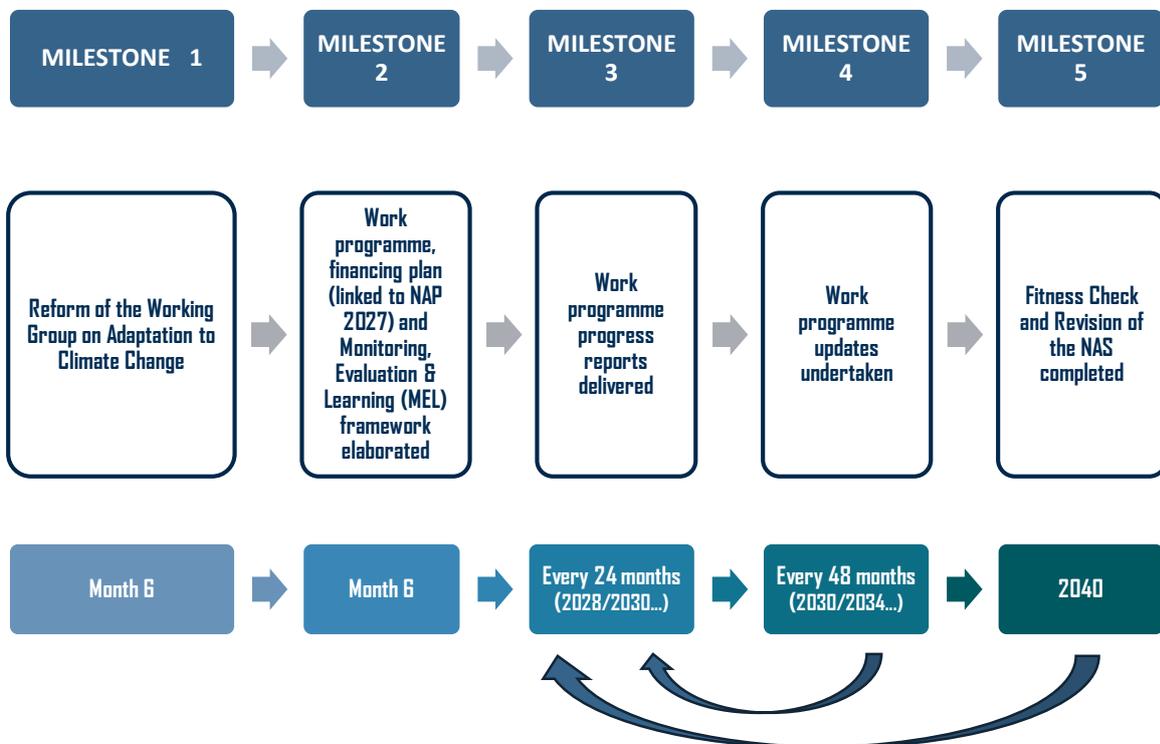
NAPs operationalize national adaptation strategies into actionable plans, often informed by Climate Risk Assessments (CRAs) to address specific vulnerabilities. NAPs usually include specific measures, timeframes and resource allocations needed to achieve adaptation goals. They provide operational guidance on how to implement broader strategies, often including sector-specific adaptation measures. Having a NAP in place provides for a stepwise iterative approach, allowing for ongoing updates and improvements based on new scientific findings, monitoring results (see chapter 3.6) and evolving climate risks.

3.4.2. Implementation timeline

The overall timeline for the NAS is up to 2040 with its Vision 2050. Within this timeline, responsibilities and setting implementation priorities for adaptation measures lie with respective competent authorities. For each of the measures, a specific timeline for implementation is proposed (see PART 2: Factsheets on adaptation measures for updating and further developing the National Action Plan (NAP) for Slovakia).

The revised National Adaptation Strategy timeline is illustrated in Figure 6 and further described below.

Figure 6: National Adaptation Strategy implementation plan and timeline



¹⁵³ See Leitner M., Johnson K., Lexer W., Munck af Rosenschöld J., Dworak T., Tamášová A., Nikolova A., Vanneuville W., (2024) "Draft Characteristics and conditions of adaptation policy in European Environment Agency member and cooperating countries" European Topic Centre on Climate change adaptation and LULUCF (ETC-CA) Technical Paper x/24.

Below is a description of the milestones and timeline. The months refer to an expected official approval date of end 2025 (Month 1).

Milestone 1: Reform of the Working Group on Adaptation to Climate Change. (month 6)

Nomination of **climate adaptation focal points** in each relevant authority and update to the mandate of the **Working Group on Adaptation (WGA)**. This WGA reform should be completed six months after the strategy comes into force and will foresee its enlargement and change in structures. The current WGA provided valuable inputs to the adaptation process. Based on the evaluation of the work, and assessment of cooperation¹⁵⁴, the MoE will update the status and structure of the group and its workplan to reflect goals and measures of the revised NAS for the new period of validity until 2040. This update will be focused on improving the ability for more expert exchanges and to include provisions for a mechanism to link the national, sectoral, regional and local adaptation plans (e.g., creating an expert commission supporting the WGA with screening, assessing and evaluating adaptation materials and adaptation measures on a larger scale). The update of the WGA mandate should also go hand-in-hand with a reform of the responsibilities of local and regional governments. The change in structure would be the establishment of subgroups based on sectors and cross-cutting issues proposed for the NAS revision.

The WGA will be composed of representatives from ministries and their expert organizations and may involve other central public bodies, regional governments, the academic community, and the non-governmental sector.

The WGA will promote further activities related to NAS across sectors and on the regional and local level, including the development and implementation of regional and municipal climate adaptation strategies.

The WGA will, together with the MoE, provide inputs to the *Government Council for the European Green Deal* and/or other interministerial platforms.

Milestone 2: Elaboration of Work programme, financing plan and MEL framework (month 6)

Based on part 2 of this report, a work programme and financing plan will be developed by month 6 after the NAS entered into force (in parallel with Milestone 1) for detailing and potentially add new measures identified as high priority in each sector (and linked to the existing NAP, valid until 2027). This work programme should not have a legally binding character but should be seen as a self-commitment of different stakeholders/Competent authorities involved. It will lay the groundwork for the implementation of new / revision of existing measures that have been identified for the implementation period.

Both short and longer-term financing mechanisms will be identified. The MoE will, in collaboration with responsible bodies of the government (especially the Ministry of Investment, Regional Development and Informatics of the Slovak Republic), evaluate existing and foreseen opportunities for financing adaptation using e.g. the European Structural and Investment Funds, the Recovery and Resilience Plan, and Just Transition Mechanism as well as exploring the potential of the newcoming Modernization Fund and Social-Climate Fund. Additional financial resources should be generated through collaboration with LIFE+ (LIFE Climate Action sub-programme), EEA and Norway Grants, The European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD) and the World Bank (WB).

¹⁵⁴ Trinomics (2024). Revision and update of the national strategy on adaptation to climate change in Slovakia. Deliverable 2.2: Report on the state of play of the climate adaptation policies and governance framework and proposal for a stakeholder engagement plan – Final Report. https://www.klima-adapt.sk/cms/documents/2024/state-of-play_67330086d1201.pdf.

Besides state budget and support from the EU funds, the implementation of the NAP will require reflection of the adaptation priorities in:

- Common Agricultural Policy and its implementation in Slovakia.
- Funding of research and application projects and include adaptation as a priority for research funding.
- Create incentives for local governments to invest in adaptation measures (e.g. through co-financing of the ESIF, by making financial resources conditional on the adoption of adaptation strategies and plans).
- Support to generate private resources and investments in the insurance sector, and small and medium-sized enterprises, and banking sector.

In parallel, the MEL system as suggested in chapter 4.3 will be refined and established for reporting.

The WGA will be consulted on the interim work and financing plan as well as the MEL system.

The NAS (and work programme) will be used for discussion on Slovak position and priorities for the next Multiannual Financial Framework (MFF) 2028-2034 and anticipated budgetary priorities.

Milestone 3: Work programme biannual Progress Reports delivered (Every 24 months)

A first progress report on implementation of the work programme – based on the results of the monitoring, evaluation, and learning framework described in chapter 4.3 – should be ready after 24 months and thereafter every 2 years following the reporting requirements under the European Climate Law. The report aims to monitor and evaluate work programs. The progress reports will also include an overview on budget provisions and spendings for implementation of the foreseen measures.

Milestone 4: Work programme updates undertaken (Every 48 months)

The results of the biannual Progress Report will inform the update of the work programme in 2030. A second update should be made four years later.

Milestone 5: Fitness check and revision of the NAS completed (2040)

A **revision of the strategy** should be carried out in 2039/2040 before the end of the NAS validity. The revision should incorporate possible new climatic and socio-economic developments and lessons learned from years of implementation.

3.4.3. Institutions responsible for implementation

The development and implementation of the NAP as implementation plan of the NAS is coordinated by the Ministry of Environment (MoE) with support from the Working Group on Adaptation (WGA). The MoE will use opportunities provided by the Competence Act and implicit coordination mechanism included in the legislation.

The implementation will further use tools of legislation available – especially the mechanism of inter-governmental commenting valid for all strategic and implementation documents (including legislation, laws, decrees) as the entry point for improving adaptation to climate change in the national strategy and policy framework and in line with the goals and objectives of NAS.

While the overall responsibility for the implementation of the NAS falls within MoE, the accompanying work programme further designates specific competent ministries and authorities as responsible for the implementation of each of the listed measures. Given the cross-sectoral nature of many of the measures proposed, the role of the WGA will be crucial to ensure monitoring of implementation progress across all sectors and respective alignment (under the updated WGA mandate).

3.4.4. Results and outcomes of implementation

The expected results and outcomes of each proposed measure are described in the sectoral fact sheets in chapter 5 Factsheets of this report. Overall, the measures of the strategy should increase Slovakia's climate resilience (please see MCA in chapter 3.3).

3.5. Financing adaptation

The economic, social and environmental transformation required to adjust national development patterns and make Slovakia more resilient to climate change necessitates the mobilisation of significant financial resources. This is recognised by the EU Adaptation Strategy¹⁵⁵ – “the gravity of the adaptation challenge makes it a whole-government and whole-society endeavour. It is vital for the private and public sectors to work together more closely, in particular on financing adaptation”.

The variety of adaptation measures proposed in this NAS report to address the identified sectoral risks and impacts as well as cross-cutting topics, and the wide variety of public and private actors concerned, require the mobilisation of a wide range of diverse financial mechanisms. Some measures identify specific funding mechanisms, such as, for instance, a tourism tax. Other measures may not require additional funding sources, as they only imply governance or institutional reforms or update of processes, plans, or policies. However, they require human resources that may demand financial commitments if they cannot be covered with existing resources. During the development of the work programme, it will be key to determine what can be achieved by (further) mainstreaming climate change adaptation into existing initiatives and actions and in which cases there is a need for significant new resource mobilization. For some measures, EU funds or international funds have been identified, but for others no specific funding mechanisms are yet explored.

The following chapters briefly describe some potential funding sources and mechanisms that can be leveraged to finance adaptation action (for more details on financial estimates and mechanisms please see Annex 3).

3.5.1. European sources of funding for adaptation measures

The EU finances adaptation to climate change in Europe through a wide range of instruments. The Multiannual Financial Framework 2021-2027 ensures that at least 25% of the European budget is climate-related expenditure. Therefore, climate adaptation actions in Slovakia must be integrated into all the major EU spending programmes, and a tracking system put in place to guarantee these objectives are met. On 16 July 2025, the European Commission presented its proposals for the next long-term EU budget, known as the Multiannual Financial Framework (MFF), covering the period 2028-2034¹⁵⁶. Slovakia can access these funds by aligning national, regional and local policies with EU climate adaptation goals.

EU research funding can also be accessed to support the various knowledge generation actions - research and studies, risk assessments etc. – that are proposed in the measures.

3.5.2. National sources of funding for adaptation

Overall priority setting which budgets are allocated to various administrations is strongly related to the adaptation effort that can be implemented. The adaptation efforts in the different sectors imply several types of actions with different financial and budgetary implications:

¹⁵⁵ European Commission. (2021). The new EU Strategy on Adaptation to Climate Change. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN>.

¹⁵⁶ https://commission.europa.eu/strategy-and-policy/eu-budget/long-term-eu-budget/eu-budget-2028-2034_en#protecting-people-and-building-preparedness-and-resilience-to-face-new-challenges

- Review and reform of current lines of actions, operations, strategies, policies and plans so they incorporate climate change factor.
- Capacity building and training to enhance knowledge and practical approaches for implementation of adaptation measures in the different sectors.
- Investments in transformational measures – public works, nature-based solutions, restoration works, etc.
- Use of the EU Taxonomy classification system and work on criteria for economic activities that are aligned with a net zero trajectory by 2050.
- Use of green taxes, especially those of the ‘polluter pays’ variety (e.g., strengthen water pricing, CO2 taxes).

In all cases, a relevant part of adaptation effort in terms of public spending must be carried out through the existing budgets of the different public administrations (national, ministerial departments, regions, municipalities). In many cases, the introduction of new adaptive criteria will necessarily lead to a substantial increase in spending, or a reorganisation of its distribution. For the implementation of the work programme along with the NAP 2021, the implementing bodies must therefore assess the economic impact of the actions (i.e., cost/benefits of action implementation) and, if appropriate, to integrate them into their respective budgets.

3.5.3. Mobilising private funding for adaptation

Mobilising private finance for climate adaptation is crucial to bridge the funding gap. Public authorities, financial institutions, and the private sector must work together to unlock private capital and channel it towards climate-resilient investments. This can be achieved through a variety of mechanisms, including:

- **Public-private partnerships for adaptation projects:** Creating formalised public-private partnerships (PPPs) for implementing adaptation measures outlined in the NAP.
PPPs are critical because the public sector alone will not be able to fill in the infrastructure gap without mobilising private sector expertise, innovative thinking, investment capacity, and finance¹⁵⁷. Under the leadership of the local/regional government, those partnerships can become bearers of NAP measures and are jointly responsible for their implementation.
- **Green bonds and climate finance instruments:** Developing innovative financial instruments to attract private investment in climate-resilient infrastructure and projects. Incorporating climate risks into investment decision-making strengthens the signal to the private sector about the need to build and demonstrate climate preparedness. New financial products such as green bonds, resilience bonds, and climate-focused impact investments can mobilise capital specifically for adaptation projects.
- **Risk transfer mechanisms:** Using insurance and other risk management tools to reduce the financial risks associated with climate change impacts.
A recommended precondition is proper and open access for insurance companies and the private sector to reliable climate data and tools to assess risk and make informed decisions on adaptation investments.
- **Blended Finance Models:** Blending public and private funds can de-risk adaptation projects and encourage private sector participation.
For example, public funds can be used as first-loss capital, encouraging private investors to commit by reducing their exposure to risk.
- **Policy and regulatory frameworks:** Creating supportive policy and regulatory environments that encourage private sector investment in climate adaptation.

¹⁵⁷ <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099120004052270615/p1746330d584ff0210a9670dcf49a5becb0>.

Offer incentives like tax breaks, grants, or subsidies to reduce the perceived financial risks of adaptation investments.

- **Capacity building and technical assistance:** Providing technical assistance and capacity building to all businesses to help them identify and implement climate-resilient strategies.

By leveraging private sector finance, the implementation of climate adaptation measures and building a more resilient future can be accelerated. Each responsible actor for NAP implementation shall investigate which options are more suitable.

3.6. Monitoring, evaluation and learning

The Monitoring, Evaluation and Learning (MEL) framework provides a structured approach to track progress, assess effectiveness, and enhance climate resilience efforts. This framework ensures that adaptation measures are implemented efficiently, remain responsive to changing climate conditions, and contribute to long-term sustainability. The EU Adaptation Strategy recognises that “Monitoring, reporting and evaluation are essential to setting a robust baseline against which to measure progress on adaptation”¹⁵⁸. The aims of the MEL framework presented in this report include:

- **Monitoring** – Develop and establish key indicators to systematically track progress in implementing adaptation actions, measure climate impacts, and assess sectoral resilience.
- **Evaluation** – Develop and establish an approach to analyse the effectiveness, efficiency, and relevance of adaptation measures, ensuring they align with national priorities and international commitments.
- **Learning** – Facilitate continuous improvement through knowledge sharing, stakeholder engagement, and integration of best practices into policy and practice. Identify and define data needs for further work and or for further development of the monitoring system.

Adaptation challenges often require actions taken across different sectors and institutional levels. Several proposed measures of the NAS will need to be implemented at a local or regional level but also contribute to the national strategic goals. Therefore, the national MEL framework also needs to consider information about adaptation initiatives that take place at sub-national and local levels. As a result, the MEL approach is based on two reporting streams: one on the national level, and one from the local level through regional governments to the national level.

Figure 7: Levels of Monitoring Adaptation

¹⁵⁸ European Commission. (2021). The new EU Strategy on Adaptation to Climate Change. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN>.

National government monitoring

- Climate parameters
- Changes in climate variability and socio-ecological systems relevant to adaptation
- Implementation progress on national activities and measures

Local/regional monitoring

- Implementation progress on adaptation projects and regional measures

3.6.1. Set of indicators

To support effective MEL, a comprehensive framework with a broad set of different indicators shall be used to track progress, assess effectiveness, and enhance learning. The set of indicators is proposed to be structured at three levels: **impact-level indicators**, which reflect long-term changes and progress toward the 2050 Vision; **outcome-level indicators**, which assess short- to medium-term progress in achieving the strategic objectives and directions; and **performance-level indicators**, which measure the implementation of specific actions as outlined in the Factsheets in PART 2 of this report. To ensure clarity and coherence, the indicators are presented in a tabular format, linking each indicator to the vision, strategic objectives and directions, and adaptation actions across the five clusters. The full list of indicators is provided in Annex 4.

3.6.2. Management of the MEL framework

The focal point for all information and coordination of MEL is the Ministry of Environment with support of the Working Group on Adaptation (WGA). It is recommended – on the basis of the NAP – to nominate focal points for adaptation in all competent ministries responsible for implementing adaptation measures (referring to the national implementation level) as well as in the eight self-governing Autonomous Regions (*samosprávne kraje*) (supporting with the sub-national and local implementation level).

All competent authorities will work together in the WGA under the leadership of the Ministry of Environment, regularly inform each other about their implementation activities and the adaptation results. The Slovak Hydrometeorological Institute provides new information on observed climatic changes and impacts.

In addition to regular communication between focal points, the WGA shall meet at least twice a year.

3.6.3. Reporting frequencies

A structured reporting frequency ensures timely tracking, evaluation, and learning from adaptation efforts. Thus, it is recommended to maintain a combination of **annual tracking and biennial and multi-year reporting cycles** for ensuring a balance between timely decision-making and in-depth evaluation of long-term adaptation impacts.

Monitoring indicators shall mostly be tracked **annually** for financial utilization and implementation progress, including for all climate parameters and climate impacts. For sectoral adaptation measures the status

(prepared/started/implemented) is also proposed to be tracked on an annual basis in order to allow for corrective intervention if needed. Adaptation result (outcome) indicators should be reported on a **biennial basis**.

For **Evaluation indicators**, cost-effectiveness assessments, policy implementation efficiency, community resilience levels and alignment with EU/UN commitments shall be evaluated **biennially**, while comprehensive assessments of adaptation effectiveness and policy revisions based on new climate data should be aligned with the timeline of NAS/NAP implementation and next review (e.g. mid-term evaluation and final evaluation).

Learning indicators shall be tracked **annually** through research studies, case study documentation, and policy adjustments informed by scientific data. Community awareness surveys and best practice adoption in policy revisions can be assessed **biennially** to inform biannual Progress Reports.

3.6.4. Information flow

The focal point for all information is the Ministry of Environment (MoE). It collects the information centrally. Progress of adaptation actions should be reported in a standardized form/template from each implementing organization to MoE at the prescribed frequencies. The information should be collected in a centralized Database.

The information reported will be put together into a biannual Progress Report, which will be discussed at government level and made publicly available. Producing such progress reports on climate change adaptation efforts offers a multitude of benefits for both the public and regional governments.

Public Benefits:

- **Transparency and Accountability:** Progress reports foster transparency by making adaptation efforts visible to the public. This helps build trust and ensures that governments are held accountable for their commitments to climate.
- **Informed Decision-Making:** By sharing information about adaptation strategies, progress reports empower individuals and communities to make informed decisions about their own climate resilience. They can understand the risks they face and take steps to protect themselves and their property.
- **Increased Engagement:** Progress reports can spark public interest and engagement in climate action. They can inspire individuals to take personal actions to reduce their carbon footprint and advocate for stronger climate policies.

Regional Governance Benefits:

- **Improved Policy and Planning:** Progress reports provide valuable feedback on the effectiveness of existing regional adaptation strategies. This information can be used to refine and improve policies and plans, ensuring they are aligned with the latest science and best practices.
- **Resource Allocation:** By tracking progress, regions can identify areas where resources are most needed and allocate funds effectively. This helps optimize the impact of adaptation investments.
- **Collaboration and Partnerships:** Progress reports can facilitate collaboration between public administration, NGOs, and the private sector. They can highlight successful initiatives and encourage knowledge sharing, leading to more efficient and effective adaptation efforts.

The results will also be used for staff training and capacity-building actions (see actions in PART 2, 4.5.5 governance).

PART 2: Factsheets on adaptation measures for updating and further developing the National Action Plan (NAP) for Slovakia

4. Factsheets

The sectoral Factsheets of proposed adaptation actions for the revised National Adaptation Strategy of Slovakia have been developed to support informed, effective, and forward-looking climate adaptation planning across key sectors and cross-cutting aspects. These concrete actions were selected through a comprehensive review of relevant sources, ensuring national relevance while aligning with European and international good practices.

Sources of information included:

- **Stakeholder inputs** gathered through participatory workshops under Deliverable D2.2 and consultations with the Working Group on Adaptation (WGA), integrating national, regional, and local knowledge, practitioner experience, and diverse perspectives.
- **Slovakia's existing policy framework**, including measures from the 2018 National Adaptation Strategy (NAS) and the 2021 National Action Plan (NAP), reflecting prior policy commitments and the country's adaptation planning baseline.
- **National sectoral strategies and policy documents**, which helped identify adaptation priorities and ongoing initiatives within and across sectors.
- **Adaptation strategies of peer countries** facing similar climate risks and vulnerabilities - namely Germany, Austria, Poland, Hungary, and the Czech Republic - offering comparative insights and enhancing the transferability of proven measures.
- **EU-level resources**, such as the EU Mission on Adaptation to Climate Change Portal and the Climate-ADAPT platform, which provided a broad database of evidence-based and tested adaptation options.
- **Expert judgment**, applied to refine, validate, and contextualize the measures based on scientific understanding, national priorities, and feasibility considerations.

Disclaimers for each of the clusters and cross-cutting aspects summarize in brief the approach taken, the sources consulted, and the number of actions identified per sector and across cluster. These disclaimers also outline the distribution of responsible actors, proposed timeframes for implementation (short-, medium-, or long-term), and the geographical scope of the suggested measures. Final disclaimers will be added once all actions have been reviewed and agreed upon.

4.1. Cluster Bioeconomy

This cluster represents the ecological and productive sectors, focusing on nature-based resilience, sustainable land and resource use, and the long-term viability of the bioeconomy. The adaptation actions proposed in these sectors are based on a combination of national policy documents - including the 2018 National Adaptation Strategy (NAS), the 2021 National Action Plan (NAP), the Rural Development Programme, the National Forest Strategy, and the Water Management Plan. These were complemented by EU-level resources such as the Climate-ADAPT database and the EU Mission on Adaptation portal, as well as successful measures from other Central European countries with similar ecological conditions and vulnerabilities, such as Austria, Hungary, the Czech Republic, Poland, and Germany. Stakeholder engagement and expert assessments also played a significant role in identifying priority actions.

In total, this cluster includes 11 adaptation actions, distributed across the sectors as follows: one action in Agriculture, three in Biodiversity & Ecosystems, four in Forestry, one in Water Resource Management, and two in Soil & Geological Environment. While relatively few in number, these actions are often systemic in scope - supporting multi-functional landscapes, ecological connectivity, sustainable biomass use, improved water retention, erosion control, and agroecological transformation.

Responsibility for implementing these actions is distributed among a wide network of actors. Key institutions include the Ministry of Environment, Ministry of Agriculture and Rural Development, the Slovak Water Management Enterprise, the State Nature Conservancy, and regional water and forest authorities. Practical implementation also relies on farmers, foresters, landowners, protected area managers, NGOs, and academic and research institutions specializing in soil, biodiversity, and ecological restoration.

Timeframes for implementation span the full adaptation horizon. Several actions are already actionable in the short term, such as awareness campaigns, biodiversity monitoring, or sustainable water management practices. Medium-term activities include reforestation and soil health improvement programs, while long-term objectives target deeper structural transitions - such as integrated catchment planning, the restoration of ecological corridors, and the full-scale adoption of nature-based solutions in land and water use. The geographical scope is national, but actions are particularly relevant in flood-prone river basins, mountainous and forested regions, areas vulnerable to drought or soil degradation, and key biodiversity hotspots.

4.1.1. Agriculture

The sector Agriculture encompasses the cultivation of crops (cereal, fruit, citrus, vegetables, olives, wine, etc.) and production of animal products, such as dairy, meat and others. It includes issues of food security and safety for humans as well as animal health and welfare. Spatially, it covers all agriculturally used land, greenhouses, pastures and spaces for animal husbandry and livestock farming¹⁵⁹.

Impacts and Risks

Slovakia's agricultural land, including its fertile and diverse soils, is a vital national asset, put under pressure by various climate impacts. Heat and drought waves as well as rising temperatures in general lead to stress for plants and animals. These temperature related impacts also adversely affect the irrigation and water retention system and may lead to water scarcity, highlighting the need for covering increasing needs for irrigation. Hence, there is a severe risk of malfunctioning and failure of water management systems in agriculture (KR-A-3) that should be addressed by the implementation of climate-resilient water management.

Temperature and precipitation related climate extremes are associated with an increased natural hazard potential, potentially leading to heightened insurance costs and yield losses. These climate impacts, along with others such as an increase in pests and harmful organisms, indicate that there is a risk of loss of livelihoods and income from agriculture (KR-A-2). Besides, there is a risk of loss of agricultural land (KR-A-1) resulting from factors such as soil erosion due to droughts, heavy precipitation and wind and decreasing soil fertility, structure and stability or shifting cultivation areas. Rather underdeveloped livestock sector in Slovakia will face similar challenges caused by high temperatures, drought, soil erosion and fertility loss. Structural changes will be needed in Agriculture sector in Slovakia in order to diversify farming methods, introduce new crops and overcome various type of challenges.

In general, climate change induced impacts and their adverse and multifaceted consequences for the agricultural sector pose a risk of decreased food security and lack of food for the Slovak population, expected to be very high by the end of the century under a pessimistic scenario (RCP8.5).

Actions

Strategic direction addressed:

- SD-A-1: Agricultural land in Slovakia including soils and its biodiversity is valued and protected. Related practices are adapted to EU-level and national governance frameworks and policies are implemented to prevent degradation (e.g. soil erosion). (NAP 2.1, 2.2, 2.3, 2.6)
- SD-A-2: Agricultural crop production and livestock farming practices are sustainable and adapted to changing climatic conditions (i.e. climate-smart) and nutrient runoff is reduced by increased fertilisers efficiency. Investments are made to ensure climate-resilient irrigation and water-retention systems. Farmers and other agriculture-related businesses are aware of climate-related risks and hazards and have sufficient know-how to mitigate and react to them, including nature-based solutions. (NAP 2.1, 2.4, 2.5)

¹⁵⁹ FAO (2021). The State of Food and Agriculture 2021. Making agrifood systems more resilient to shocks and stresses. FAO, Rome.

- SD-A-3: People in Slovakia have access to sufficient regional, high-quality food and agricultural products, the production of which is supported through governance and funding, valuing the historical role of agriculture, while at the same time protecting the livelihoods of farmers and the cultural landscape itself.

Action	Climate resilient agriculture						Existing
Aim of the action: Achieve complex agricultural land protection in Slovakia, through a multifaceted approach to safeguard soil fertility, prevent degradation, and mitigate the impacts of erosion							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁶⁰	Funding line	Output indicator	Link to other national activities
Ministry of Agriculture and Rural Development	Ministry of Environment	National	2026-2040	High	National (Public Budget), EU funds (CAP, ESIF)	<p>Hectares of agricultural land under improved sustainable land and soil management practices (1, 2, 3)</p> <p>Number of farmers and stakeholders trained or reached through awareness and capacity-building activities (1, 4)</p> <p>Number of sustainable technologies or practices adopted and/or supported (1, 2, 3)</p> <p>Area of land under protective</p>	Common Agricultural Policy Strategic Plan

¹⁶⁰ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						<p>infrastructure or natural systems for erosion and water control (2, 3)</p> <p>Number of soil monitoring, research, or policy support actions implemented (4, 5)</p>	
<p>Description of the Action:</p> <p>Activities include:</p> <p><u>Soil Conservation and Fertility Enhancement:</u></p> <ul style="list-style-type: none"> Promote sustainable agricultural practices such as crop rotation, reduced tillage, and the use of organic fertilizers to maintain soil structure and nutrients. Encourage the application of soil testing and precision agriculture technologies to optimise resource use and improve crop yields without overburdening the land. <p><u>Erosion Control:</u></p> <ul style="list-style-type: none"> Implement contour farming and terracing in hilly areas to minimise water runoff and soil loss. Establish Green Infrastructure in the form of windbreaks and shelterbelts, particularly in regions vulnerable to wind erosion, to stabilise the soil and protect crops. Encourage the planting of cover crops during off-seasons to reduce bare soil exposure and enhance organic matter content. <p><u>Irrigation and water retention management in agricultural landscape:</u></p> <ul style="list-style-type: none"> Invest in efficient irrigation systems that reduce water wastage and prevent soil salinisation. Protect wetlands and natural water retention areas to improve water infiltration and reduce flooding risks that contribute to soil erosion. <p><u>Policy and Awareness:</u></p> <ul style="list-style-type: none"> Enforce land-use regulations in the frame of spatial planning that prevent the conversion of fertile agricultural land to urban or industrial uses. Increase public and farmer awareness of soil conservation techniques through education and extension services. Provide financial incentives for adopting conservation practices, such as subsidies for sustainable farming methods or grants for erosion control infrastructure. <p><u>Monitoring and Research:</u></p> <ul style="list-style-type: none"> Enhance and maintain a comprehensive soil monitoring program to track changes in soil health and identify areas at risk of degradation. Support research into innovative soil protection technologies and adapt them to Slovak agricultural conditions. <p><u>Training and Capacity Building:</u></p> <ul style="list-style-type: none"> Establish training programs for farmers on soil conservation, erosion control, and efficient irrigation methods. Provide continuous professional development for extension workers, technicians, and researchers. Set up demonstration farms and field schools as practical learning hubs. Incorporate soil protection modules into agricultural education curricula. 							

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁶¹
<p>Strengthens rural resilience through sustainable farming education and maintains jobs</p> <p>Enhances farmer knowledge and engagement in climate adaptation</p> <p>Promotes cooperation between landowners, communities, and agricultural advisors</p> <p>Builds awareness of soil stewardship and its societal benefits</p>	<p>Supports long-term agricultural productivity and food security</p> <p>Reduces input costs through efficient resource use</p> <p>Encourages investment in sustainable technologies and practices</p> <p>Offers potential for green job creation and rural economic diversification</p>	<p>Prevents land degradation and biodiversity loss</p> <p>Enhances soil health and ecosystem services</p> <p>Reduces water pollution and runoff</p> <p>Supports carbon sequestration through improved soil organic matter</p>	<p>Short-term: 1–3 years for awareness, training programs, and pilot projects baseline, soil monitoring, and initial policy enforcement.</p> <p>Medium-term: 4–7 years for Widespread adoption of conservation practices, expansion of infrastructure, continued farmer and technician training, and measurable improvements in soil fertility and erosion control.</p> <p>Long-term: 8–15 years for Systemic change in agricultural landscapes, resilient soil and water management, institutionalised monitoring and research, and sustained capacity-building embedded in education systems.</p>	<p>Risk of inequitable access to new technologies and incentives</p> <p>Potential over-reliance on irrigation and over abstraction of groundwater if not managed sustainably</p> <p>Misapplication of conservation practices without proper training</p> <p>Risk of policy misalignment without integrated land-use planning</p>

4.1.2. Biodiversity, Ecosystems and Natural Heritage

Biodiversity circumscribes “the variability among living organisms from all sources including, among other things, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems”¹⁶². This encompasses three levels of biodiversity as defined by the Convention on Biological Diversity: species, ecosystems and genetic diversity.

Ecosystems are defined as “a functional unit consisting of living organisms, their non-living environment and the interactions within and between them.”¹⁶³.

Natural Heritage is one part of Cultural Heritage including aspects such as landscapes, forests and the geological environment.

¹⁶¹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

¹⁶² IPCC (2021). Annex VII: Glossary. In: IPCC (Ed.) *Climate Change 2021 – The Physical Science Basis*. Cambridge University Press, pp. 2215–2256.

¹⁶³ *ibid*

Impacts and Risks

The loss of biodiversity and species, driven by climate change and human activities, is a critical and urgent issue. Key contributing factors include habitat degradation, shifts in species composition due to changing temperatures, and the increased extinction risk of sensitive species. These dynamics negatively impact genetic diversity, ecosystem functions, provision of ecosystem services and soil health, which emphasize the need for improved landscape connectivity, implementation of conservation measures, habitat and ecosystem restoration, including through implementation of the EU Nature Restoration Law and innovative strategies like assisted migration and population restoration measures. The extension of the vegetation period and shifts in phenological phases in general, multiplication of negative effects and rising temperatures including in streams also have significant but poorly understood impacts on ecosystems, especially aquatic organisms.

Governance frameworks and financial capabilities are rated by participants to the workshops (see chapter 1.5 Action 3) as low to medium in addressing these challenges, with a high urgency to act. Two key risks (KR) in the Biodiversity & Ecosystems sector have been identified, including the loss of biodiversity and habitats (KR-B-1) and decreased ecosystem service provision (KR-B-2). Both are exacerbated by climate impacts, harmful human practices, and insufficient legislative frameworks. The spread of invasive alien species, landscape and habitat fragmentation, and implementation of nature-based solutions lagging behind, leading to a further worsening of these risks. The risks are projected to increase throughout the century, potentially reaching high or very high levels in the future. Reducing surface water runoff and enhancing water infiltration and retention in landscapes, improved governance, and climate-resilient ecosystem and habitat management, including for protected areas, are essential to mitigate these impacts.

With respect to natural heritage, currently receiving less attention compared to other heritage sites, climate impacts such as indigenous pathogens/emergence of new pathogens, as well as vegetation damage and loss of biodiversity, are relevant. When assessing damage to vegetation, one must consider the health status of vegetation, especially trees. In addition, changing climatic conditions can lead to the disappearance of traditional and local varieties of fruits and herbs, with invasive plants putting additional pressure on this type of flora. Hence, identified risks associated with biodiversity loss and decreasing ecosystem services have to be considered in the context of natural heritage as well.

Actions

Overall adaptation measures should be aimed at preserving and restoring ecosystems, ensuring the connectivity of habitats, safeguarding species diversity, and maintaining ecosystem services essential for both nature and human well-being. By integrating climate adaptation into biodiversity management and protecting Slovakia's rich natural heritage, these measures contribute to sustaining ecological balance and mitigating the adverse effects of climate change on ecosystems and their functions.

Strategic direction addressed:

- SD-B-1: The value of a rich biodiversity of ecosystems, species, genes and soils is recognised as an important parameter to foster resilience against climate change. Effective and targeted legislative frameworks support the preservation and protection of sensitive ecosystems, with special consideration of sustainable use of agricultural land and forests. (NAP: 4.2, 4.3, 4.4, 4.5)

Action	Build a robust legislative framework to enhance ecosystem preservation and strengthen enforcement mechanisms						Existing
Aim of the action: To establish a comprehensive and effective legislative framework that prioritises the preservation of ecosystems, biodiversity, species, genes and soil health, while ensuring robust enforcement of these laws to prevent degradation and promote sustainable land use and management practices.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁶⁴	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Ministry of Agriculture and Rural Development State Nature Conservation Agency Administrations of National Parks National Forestry Centre Ministry of Finance	National	2026-2040	Medium to High ¹⁶⁵	National (Public Budget), EU funds (ESIF)	Number of legislative documents revised that include provisions for climate robust conservation and restoration Number of enforcement mechanisms put in place Area (in hectares) restored through mandatory revitalization measures for degraded ecosystems. Total value of financial incentives disbursed for sustainable practices (e.g., agroecology,	National Biodiversity Strategy National Restoration Plan (to be adopted) Protected Areas management plans

¹⁶⁴ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

¹⁶⁵ Long-term costs will depend on enforcement and the scale of economic incentives offered.

						biodiversity offsets).	
<p>Description of the Action:</p> <p>This action seeks to develop, refine, and implement legal instruments that safeguard sensitive ecosystems, protect biodiversity, and maintain the ecological balance necessary for climate resilience. The legislative framework will address key gaps in current relevant laws, integrate provisions for biodiversity and gene pool conservation and incorporate principles of climate resilient development. Additionally, it will enhance enforcement mechanisms through increased funding for evaluation and monitoring, improved capacity building for enforcement agencies, and multi-stakeholder collaboration.</p> <p>By strengthening compliance and accountability measures, this framework will support the long-term health of ecosystems, ensuring they can continue to provide critical services such as carbon sequestration, water filtration, and soil fertility. Furthermore, it will foster alignment with international and EU commitments, such as the Convention on Biological Diversity, the EU Nature Restoration Law under the EU Biodiversity Strategy, while addressing national priorities outlined in the Slovak National Adaptation Plan.</p> <p>Activities include:</p> <p><u>Legislative framework drafting:</u></p> <ul style="list-style-type: none"> • Review existing legislation and identify gaps or inconsistencies, aligning Slovakia’s commitments to international agreements and EU directives. • Draft and incorporate provisions in relevant legislation following principles of: <ul style="list-style-type: none"> ○ Adopting an Ecosystem-Based Approach: Principle of integrated ecosystem management, emphasising biodiversity conservation, restoration, and sustainable use. ○ Recognition of Ecosystem Services: Principle of incorporating of ecosystem services valuation and accounting, recognising the economic value and introducing mechanisms for compensating landowners for ecosystem service preservation (e.g., through Payment for Ecosystem Services (PES) schemes). Landscape Connectivity and Ecological Stability: Principle of protecting ecological stability and variability of the landscape by maintaining, revitalising, and restoring ecological networks and building of new ones (e.g. as Green Infrastructure measures), thus increasing the connectivity (interconnection) of the landscape. Ensuring the implementation of the elements of the territorial system of ecological stability (ÚSES) at all levels, and especially where they are to prevent the loss and fragmentation of habitats and connection between protected areas. ○ Safeguarding Critical Habitats and Connectivity: Principle of legally defined buffer zones around high-quality habitats and sensitive ecosystems, stricter controls on harmful activities, maintaining/restoring migration corridors and wildlife connectivity links, preventing new barriers (e.g., roads, railways, urban sprawl, artificially channelled streams), and mitigating existing ones. ○ Protected Area System Integrity: Principle of regular monitoring, review, and adaptation of protected areas in line with EU requirements, international standards, and best practice. No Net Loss of Biodiversity: Principle of offsetting unavoidable habitat loss through restoration/conservation of equivalent biodiversity, supported by substantial penalties for violations (illegal logging, habitat destruction, pollution). Ecosystem Restoration and Resilience: Principle of incentivising ecosystem restoration (e.g., inclusion in National Restoration Plan) to restore degraded ecosystems and strengthen resilience of damaged ecosystems not only in protected areas. ○ Sustainable Land Management: Principle of combining spatial planning, land adjustments, and ecosystem restoration to enhance ecological stability and adaptive capacity, especially on land with public utility functions. ○ Agroecological Transition: Principle of supporting agroecological practices (crop rotation, cover crops, reduced tillage, organic farming) and safeguarding traditional/local genetic resources for climate-resilient crops, livestock, and forest trees. (linking to measures under 5.1.1 Agriculture). ○ Land Sealing Limits: Principle of restricting land sealing for infrastructure projects and requiring compensation via green infrastructure initiatives. ○ Integration in Planning and Assessments: Principle of strengthening EIA/SEA and integrating biodiversity and soil health into spatial and urban planning. ○ Green Infrastructure: Principle of mandating integration of Green Infrastructure in cities and towns (e.g., green roofs, permeable pavements, natural corridors to maintain ecosystem connectivity). Adaptive Governance: Principle of ensuring flexibility in nature protection legislation and institutions to respond to emerging priorities and changing conditions. <p><u>Enforcement, Institutional Strengthening and Capacity Building:</u></p>							

- Create an inter-ministerial coordination committee to ensure implementation, law enforcement and support capacity building for participating agencies; monitor progress in implementation.
- Equip environmental agencies (i.e., the State Nature Conservancy, Administrations of National Parks and the National Forestry Centre) with sufficient resources, authority, and training programs for effective law enforcement and operational capacity.
- Incentivise compliance through economic measures (e.g. subsidies for sustainable practices, payment for ecosystem services (PES) schemes, tax for investments in environmental protection) and promote eco-certification (such as EU Ecolabel) for businesses and municipalities that meet adaptation and biodiversity standards, while building capacity to implement and monitor these schemes.
- Leverage funding through EU mechanisms like LIFE and Horizon Europe and similar sources for enforcement, targeted research, training, and capacity-building projects.
- Involve local authorities, landowners, administrators of protected areas, professionally focused non-governmental organisations, the scientific sector and other relevant organisations in the preparation of local adaptation strategies, action plans or catalogues of adaptation measures that also concern protected areas including training and guidance to ensure alignment with management plans or other nature conservation documentation.
- Engage businesses in biodiversity offset schemes and green supply chains, providing guidance, training, and support to ensure effective participation and compliance.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁶⁶
<p>Encourages inclusive stakeholder participation in nature protection</p> <p>Raises public awareness of ecosystem services and conservation duties</p> <p>Strengthens local community roles in adaptation and land stewardship</p> <p>Promotes environmental responsibility across all societal levels</p>	<p>Incentivises sustainable land use and green business practices</p> <p>Supports funding channels for nature-based solutions and restoration</p> <p>Introduces compensation schemes like PES for conservation contributions</p> <p>Aligns with EU green funding mechanisms to unlock investment opportunities</p>	<p>Safeguards biodiversity, habitats, and genetic resources</p> <p>Prevents ecosystem fragmentation and promotes landscape connectivity</p> <p>Enhances ecological resilience to climate impacts</p> <p>Promotes long-term soil health, water retention, and carbon storage</p>	<p>Short-term: 1–2 years for legislative review and framework drafting</p> <p>Medium-term: 3–6 years for adoption, enforcement setup, and capacity building</p> <p>Long-term: 7–15 years for measurable ecosystem restoration and landscape-level integration</p>	<p>Risk of bureaucratic delays or poorly coordinated enforcement</p> <p>Possible resistance from stakeholders due to perceived land-use restrictions</p> <p>Ineffective implementation without adequate funding or local buy-in</p> <p>Risk of greenwashing if eco-certification and offsets are not rigorously monitored</p>

Strategic direction addressed:

¹⁶⁶ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

- SD-B-2: Management practices in agriculture, fishery, forestry and other related fields are adapted with the objective of ensuring the optimal provision of ecosystem services from terrestrial and aquatic ecosystems. Relevant information and awareness-raising initiatives support practitioners in adapting their activities and increasing their sustainability. (NAP: 4.1, 4.6, 4.7)

Action	Foster Adaptive Management Practices for Ecosystem Services Sustainability in key sectors						Existing
Aim of the action: To integrate adaptive management practices in key economic sectors that mitigate climate change impacts while ensuring the long-term sustainability and optimal provision of ecosystem services, ensuring the health and resilience of both terrestrial and aquatic ecosystems.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁶⁷	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Ministry of Agriculture and Regional Development State Nature Conservancy of the Slovak Republic Administrations of National Parks Slovak Environment Agency	National	2026-2040	Medium	National (Public Budget), EU Funds (ESIF, R&D)	Number of sector-specific guidelines developed and published Number of ecosystem and climate monitoring datasets uploaded and accessible through the centralised information system. Percentage of stakeholders trained to use these guidelines Total funding mobilised for sustainable	National Biodiversity Strategy National Restoration Plan (to be adopted) Protected Areas management plans

¹⁶⁷ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						management activities, including restoration, monitoring, and awareness campaigns.	
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Description of the Action:

Develop and Implement Sustainable Management Guidance

- Create and promote sector-specific guidelines for climate resilient management practices, including for:
 - Grassland habitats and pastures in conjunction with support for sheep and goat farming in Slovakia's foothill and mountain areas and support for measures to protect migratory species and their habitats in the use of agricultural land
 - Sustainable Management of Wetlands and Water Systems, including restoration of degraded wetlands (revitalisation of peatlands, restoration of disturbed water regimes, prevention of overgrowth by trees), creation and enhancement of wetland areas (creation of water bodies, increase of inundation and retention capacity in upper and middle streams, restoration of meanders in upper streams), maintenance and protection measures (repair and maintenance of drainage objects along forest roads to prevent soil erosion, use of inundation (flooding) areas to maintain water quality and enable the natural dynamics of flows)
 - Slope stabilisation to stop the progress of soil erosion and landscape destruction and approaches for improved management of water flows in times of water scarcity and excess. (see for details chapter 0)
 - Agroforestry transition providing approaches for integrating agroforestry systems on agricultural or forest land.
 - Restoration of degraded ecosystems through reforestation, wetland conservation, and soil health initiatives.
 - Traditional land-use practices with recommendations for maintaining biodiversity and contributing to Slovakia's natural heritage, such as traditional pastoral systems in mountainous regions.
 - Agrobiodiversity promotion by supporting the use of heritage crop varieties and livestock breeds that are more resilient to changing climate conditions.
- Strengthen Capacity for Climate-Smart Practices
 - Establish training programs and workshops to present guidelines to practitioners and offer hands-on advice and support on climate-resilient practices and technologies.

Enhance Monitoring and Decision-Making Tools

- Develop a centralised and open-access information system to provide real-time data on ecosystem health and climate impacts, utilizing GIS and remote sensing technologies to monitor the status of land and water resources.
- Include in this centralised system systematic, long-term mapping and monitoring of the spread of invasive species accelerated by climate change, prevention of their penetration and spread through corridors, ensuring systemic and effective removal and elimination in case of outbreaks.

Awareness and Education Campaigns

- Conduct national and regional campaigns to increase awareness of the importance of ecosystem services for climate resilience.
- Develop educational materials and curricula for schools and community programs focused on the interconnection between livelihoods and ecosystem health.
- Highlight success stories and best practices through media channels.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁶⁸
<p>Promotes community stewardship of ecosystems and cultural landscapes</p> <p>Supports knowledge-sharing between farmers, foresters, and conservationists</p> <p>Revives traditional land-use practices with ecological value</p> <p>Enhances local engagement through education and participatory monitoring</p>	<p>Strengthens climate resilience in agriculture, forestry, and water sectors</p> <p>Unlocks eco-tourism and green business opportunities tied to ecosystem services</p> <p>Reduces long-term costs of land degradation and flood damage</p> <p>Encourages sustainable livelihoods via support for heritage crops and grazing systems</p>	<p>Restores degraded ecosystems and enhances landscape stability</p> <p>Conserves biodiversity and maintains ecosystem connectivity</p> <p>Improves soil health, water retention, and carbon sequestration</p> <p>Reduces invasive species spread and supports native species conservation</p>	<p>Short-term: 1–3 years for guideline development, training, and pilot projects</p> <p>Medium-term: 4–7 years for broad adoption of adaptive practices and functioning monitoring systems</p> <p>Long-term: 8–15 years for measurable ecological improvements and ecosystem service sustainability</p>	<p>Risk of poor implementation if adaptive practices are not locally tailored</p> <p>Potential dependency on outdated traditional methods without modernization</p> <p>Risk of inadequate monitoring leading to ineffective or misdirected actions</p> <p>Overreliance on volunteers or underfunded institutions may weaken long-term sustainability</p>

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-B-3 : The connectivity of terrestrial ecosystems is ensured and ecologically relevant 							
Action	Establish and Expand Ecological Corridors and enhance their connectivity						Existing
Aim of the action: To enhance the connectivity of terrestrial ecosystems and landscapes by creating and restoring ecological corridors that link fragmented habitats, supporting biodiversity, genetic diversity and sustaining ecosystem services							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁶⁹	Funding line	Output indicator	Link to other national activities
Ministry of Environment	State Nature Conservancy of	National	2026-2040	Medium	National (Public Budget), EU funds (ESIF), Private	Number of green infrastructure elements	Relevant to future National Restoration Plan

¹⁶⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

¹⁶⁹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

	the Slovak Republic Administrations of National Parks Slovak Environment Agency					established to enhance connectivity (e.g., wildlife crossings, buffer zones, or natural corridors). Number of climate refugia integrated in the network of protected areas Percentage of ecological corridors integrated into spatial planning and land-use regulations.		
<p>Description of the Action: This action involves identifying priority areas where ecosystem connectivity is disrupted and implementing measures to establish or restore ecological corridors. Activities include:</p> <ul style="list-style-type: none"> • Reforestation of degraded lands to create continuous greenways. • Restoration of riverbanks and riparian zones to serve as natural corridors for species migration. • Building wildlife crossings (e.g., overpasses or underpasses) at critical road or railway intersections to reduce habitat fragmentation and improve safe species movement. • Integrate ecological network preservation and development (restore/create new green/blue infrastructure) in land-use planning to maintain habitat permeability. • Expanding and strengthening the network of protected areas and incorporating climate refugia to ensure species' survival under future climate scenarios, including innovative approaches such as stepping stones areas, ecological management of powerline corridors or introduction of other effective area-based conservation measures. Collaboration with local communities and stakeholders to align agricultural or urban development with ecological connectivity goals. 								
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁷⁰				
Strengthens cooperation between landowners, planners, and conservation actors	Prevents costly biodiversity loss and ecosystem degradation	Reduces habitat fragmentation and supports species migration under climate change	Short-term: 1–3 years for mapping, planning, and stakeholder consultations	Risk of isolated or poorly placed corridors offering limited ecological function				

¹⁷⁰ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

<p>Increases public awareness of wildlife movement and habitat needs</p> <p>Encourages community participation in habitat restoration and land-use decisions</p> <p>Enhances quality of life through accessible green spaces and natural landscapes</p>	<p>Supports sustainable land management and eco-tourism opportunities</p> <p>Reduces economic damage from wildlife-vehicle collisions via safe crossings</p> <p>Leverages EU green infrastructure funding and nature-based investment streams</p>	<p>Enhances genetic diversity and long-term ecosystem resilience</p> <p>Restores natural hydrological functions and improves landscape permeability</p> <p>Contributes to carbon sequestration and water cycle regulation through reforestation and wetland buffer zones</p> <p>Allows water retention</p>	<p>Medium-term: 4–7 years for infrastructure implementation and initial landscape integration</p> <p>Long-term: 8–20 years for full functional connectivity and ecological benefits to manifest</p>	<p>Possible conflicts with infrastructure or development priorities without integrated planning</p> <p>Risk of invasive species spreading through corridors if not properly managed</p> <p>Potential land-use resistance without adequate incentives or stakeholder alignment</p>
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Strategic direction addressed:							
SD-CH-3: Tangible natural heritage is mapped, linked to landscape management and sufficiently protected, considering climate-change related, destructive impacts.							
Action	Protecting Slovakia’s Natural Heritage through Climate-Resilient Landscape Management						New
Aim of the action: Enhance the resilience and protection of Slovakia’s tangible natural heritage by integrating it into landscape management strategies, ensuring its sustainability amid climate change threats.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)¹⁷¹	Funding line	Output indicator	Link to other national activities
Ministry of Environment	State Nature Conservancy of the Slovak Republic (SNC) Ministry of Agriculture and Rural Development	National	2026-2040	High	National (Public Budget), EU funds (ESIF, CAP, R&D)	Percentage of mapped and climate-adapted natural heritage sites integrated into landscape management plans	National Strategy for the Protection of Biodiversity Green Infrastructure Strategy for Slovakia

¹⁷¹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

	Slovak Environment Agency (SEA)						UNESCO World Heritage and Natura 2000 Programs
	Local and Regional Governments						
<p>Description of the Action: This action includes the following activities:</p> <p><u>Mapping and Monitoring:</u></p> <ul style="list-style-type: none"> • Develop a comprehensive GIS-based inventory of natural heritage sites, including caves, rock formations, wetlands, and old-growth forests. • Establish a national monitoring system to assess climate-induced risks such as erosion, biodiversity loss, and extreme weather damage (see chapter 5.3.1) <p><u>Integration with Landscape Management:</u></p> <ul style="list-style-type: none"> • Embed natural heritage protection in national and regional land-use planning policies. • Strengthen collaboration between environmental agencies, urban planners, and cultural heritage organizations. <p><u>Climate-Resilient Conservation Actions:</u></p> <ul style="list-style-type: none"> • Restore degraded natural heritage ecosystems using nature-based solutions (e.g., afforestation, sustainable water management). • Implement buffer zones around vulnerable sites to mitigate human and climate impacts. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁷²			
<p>Enhances cultural identity and connection to natural landscapes</p> <p>Encourages community involvement in heritage and landscape stewardship</p> <p>Promotes environmental education and awareness of unique natural features</p> <p>Builds partnerships between conservationists,</p>	<p>Boosts eco-tourism and heritage-based rural development</p> <p>Reduces climate-related costs through preventive landscape management</p> <p>Aligns with EU funding for cultural and natural heritage conservation</p> <p>Supports job creation in restoration, monitoring, and sustainable tourism sectors</p>	<p>Safeguards iconic ecosystems from climate-related degradation</p> <p>Preserves biodiversity hotspots and geodiversity features</p> <p>Enhances resilience of landscapes to erosion, drought, and extreme weather</p> <p>Maintains ecosystem functions critical for adaptation, like water regulation and soil protection</p>	<p>Short-term: 1–2 years to develop inventory, risk assessments, and pilot actions</p> <p>Medium-term: 3–6 years for integration into planning policies and landscape-scale implementation</p> <p>Long-term: 7–15 years for full resilience of heritage sites and sustainable management outcomes</p>	<p>Risk of heritage site neglect without sustained funding or policy follow-through</p> <p>Over-prioritization of select sites may leave others vulnerable</p> <p>Poor integration with spatial planning may lead to development pressures on heritage zones</p> <p>Mismanaged restoration efforts could harm local biodiversity or cultural values</p>			

¹⁷² Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

planners, and local residents				
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4.1.3. Forestry

The sector Forestry encompasses ecosystems mainly covered by tree species, but also by non-forest woodland and associated ecosystem elements such as other species and soils. The sector also includes forest products such as wood and processed wood by-products. Within the sector, the human role is to manage forests and woodlands as well as to economically evaluate forests and their products and services¹⁷³.

Impacts and Risks

Slovakian forests are highly vulnerable to disruptive ecological processes, altered species interactions, and shifting ecosystem dynamics, especially due to a complex mix of historical forest management practices and accelerating climate change.

In the past, much of forest management traditionally focused on establishing monoculture plantations, especially of Norway spruce, due to its economic value and rapid growth¹⁷⁴. However, monocultures are less resilient to pests, diseases, and extreme weather, lacking the biodiversity that stabilises forest ecosystems. In addition, forest ecosystems face disruptions due to erosion, loss of soil fertility, and habitat fragmentation. Historical forestry practices altered natural succession patterns, resulting in forest compositions that diverge significantly from native, mixed forests. These simplified structures as well as adverse impacts due to pollution make forests more susceptible to climate-driven stressors, such as drought and pest invasions, and have interrupted complex ecological relationships.

Rising temperatures and decreasing precipitation are challenging water-dependent species such as the two most represented species in Slovakia (spruce and beech). As they decline, forest dynamics shift, which is especially visible in non-native spruce forest stands. This climate change induced stress changes in the competitive balance, favouring species that are more drought-tolerant, which may not support the same diversity of flora and fauna. An increase in frequency and intensity of disturbances like wildfires, storms, and pest outbreaks further destabilise forest ecosystems by removing large swathes of tree cover and leading to cascading effects on biodiversity and ecological processes. Further, the combination of reduced canopy cover from dying trees, historical clear-cutting, and erosion lessens the capacity of soils for water retention, nutrient availability, and overall forest resilience, making it harder for forests to recover naturally. Another factor exacerbating vulnerability of degraded forests relates to their reduced ability to sequester carbon, creating a feedback loop where declining forests contribute to climate change, which in turn further stresses forests. As trees die from

¹⁷³ European Commission (2021c). New EU Forest Strategy for 2030.

¹⁷⁴ Keeton, W.S., P. Angelstam, M. Baumflek, Y. Bihun, M. Chernyavskyy, S. M. Crow, A. Deyneka, M. Elbakidze, J. Farley, V. Kovalyshyn, B. Mahura, S Myklush, J. R. Nunery, I. Solovity, and L. Zahvoyska. (2013). Sustainable forest management alternatives for the Carpathian Mountain region, with a focus on Ukraine. Pages 331-352 in J. Kozak, K. Ostapowicz, A. Bytnerowicz, and B. Wyzga (eds.) The Carpathians: Integrating Nature and Society Towards Sustainability. Springer-Verlag, Berlin and Heidelberg, Germany.

pests, drought, and fires, high-quality timber production is negatively affected with substantial economic impacts on Slovakia's forestry sector and the rural communities reliant on it.

As a result of these impacts, identified key risk address the loss of ecosystem services provided by forests (e.g. water regulation, carbon sequestration, forest timber and non-timber products) due to forest degradation and forest disturbances (KR-FO-1). Besides, there is a risk of inadequate forest management (e.g. due to lack of knowledge and insufficient flexibility of legislation; KR-FO-2), in particular under changing climate conditions and climate change induced pressure put on forests are associated with a risk of economic viability of forestry (KR-FO-3). Both the risk of inadequate forest management and the risk of loss of ecosystem services are already at high levels, whereby a very high risk is expected for the latter in the far future.

Actions

Overall adaptation measures are following the vision of the Slovak National Forest Plan (NFP) for the period 2025-2030 "FORESTS FOR SOCIETY" towards managing forests and forestry based on timely and accurate information, an interdisciplinary approach and the participation of stakeholders at all levels, ensuring the preservation of biodiversity, sustainable development and the quality of life of Slovakia's population. Achievement of the NFP targets will be supported by correlating actions which - implemented in tandem – help build forests' resilience, and ensure they continue to provide critical ecosystem services like carbon sequestration, water regulation, biodiversity habitat, and soil stabilisation. Adopting measures such as introducing close-to-nature forest management at 25% of forest area in Slovakia has also a long-term potential for economic benefits¹⁷⁵. Developing and implementing **comprehensive Forest Health Monitoring** will serve as a basis for identifying current and tracking future forest conditions under climate change and making informed management decisions. **Targeted Restoration Efforts** will prioritise the rehabilitation of degraded forest ecosystems by planting drought-tolerant and pest-resistant species that can thrive under new conditions to support ecosystem resilience. Adaptive silviculture shall be favoured as a proactive approach that combines traditional silvicultural techniques with innovative, flexible practices tailored to the demands of climate change. By focusing on resilience, ecological health, and sustainable resource use, adaptive silviculture supports forests' ability to provide ecosystem services even under a range of possible future climatic conditions. Transitioning to **Sustainable Forest Management** will further ensure to balance among multiple objectives, such as sustainable timber production, wildlife habitat conservation, water balance and carbon sequestration, disturbance processes and recreational opportunities, based on the specific context and goals of forest management. The measures included in the NAS will contribute to the coordination of adaptation measures among Forestry and Biodiversity sectors as forests in National Parks are managed by their administrations which are organisations under the Ministry of Environment. Additionally, coordination of efforts is needed for development and implementation of the National Restoration Plan.

Strategic direction addressed:

¹⁷⁵ Štěrbová, M., Barka, I., Kulla, L., Roessiger, J., 2024. The Effect of Transition to Close-to-Nature Forestry on Growing Stock, Wood Increment and Harvest Possibilities of Forests in Slovakia. Land 13, 1714. <https://doi.org/10.3390/land13101714>.

- SD-FO-1: Sufficient and effective measures are implemented to ensure climate-resilient forests and their associated ecosystem services, including monitoring, restoration and protection. (NAP: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.3, 4.5, 4.7)

Action		Enhance Forest Health Monitoring and Early Warning Systems					Existing
Aim of the action: Enable a comprehensive approach to forest health monitoring, leveraging technology, data analytics, community involvement, and proactive management to protect forests from climate impacts and risks.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁷⁶	Funding line	Output indicator	Link to other national activities
Ministry of Agriculture and Rural Development	Ministry of Environment National Forestry Center Forest owners and managers	National	2026-2040	Low to Medium	National (Public Budget), EU funds ESIF, EAFRD)	Percentage of enhanced monitoring network (or number of added/enhanced monitoring plots) Number of additional Wildfire Detection and Prevention Measures Number of pest and disease monitoring activities conducted annually (e.g., pheromone trap deployments, tree sampling events, and genetic analyses performed)	National Forest Plan (NFP) Synergies with Biodiversity and NATURA 2000 species and habitats monitoring

¹⁷⁶ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Description of the Action:

Establish a Forest Health Monitoring Network:

- Set up a network of regional monitoring stations equipped with sensors to track key indicators (e.g., temperature, humidity, soil moisture) and to collect consistent, real-time data on forest conditions.
- Implement pilot monitoring projects in selected forest areas to test methodologies, calibrate equipment, and refine data collection protocols before scaling up nationally.
- Engage local communities and forest owners in participatory monitoring programs, allowing them to report observations and help collect data.
- Combine forest health data with climate information (temperature, precipitation patterns) to understand how climate trends influence forest health and use predictive models to identify areas likely to experience outbreaks of pests, diseases, or wildfire, enabling proactive management.
- Launch citizen science projects where volunteers can collect data on forest conditions, such as reporting unusual tree mortality or pest sightings.
- [*Optional – depending on funds available:*] Use satellite data and drones equipped with high-resolution cameras and multispectral sensors to monitor canopy health¹⁷⁷, detect stress signals, map areas affected by drought, and spot early signs of pests or disease outbreaks. Employ LiDAR technology to measure forest structure, tree height, and canopy density, enabling detailed monitoring of changes over time and detection of issues like tree mortality or structural changes. Deploy thermal imaging to monitor temperature variations within forest stands, which can signal early drought stress or pest infestations.

Increase Wildfire Detection and Prevention Measures:

- Install fire detection cameras and thermal sensors in high-risk areas according to wildfire risk mapping¹⁷⁸ to quickly detect and report fires.
- Monitor climate conditions, fuel moisture levels, and vegetation density to assess fire risk, issuing warnings when conditions favour wildfires.
- Develop communication protocols to quickly inform nearby communities, forest managers, and emergency responders about fire risk levels and ongoing incidents.

Enhance Pest and Disease Monitoring Programs:

- Use pheromone traps to monitor insect populations like bark beetles, allowing for early detection of rising pest levels.
- Conduct regular tree sampling to check for signs of disease or pest infestations, particularly in vulnerable stands or during high-risk seasons.
- Use genetic analysis to detect pathogens in soil and tree samples, providing an early warning for disease outbreaks before visible symptoms appear.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁷⁹
Encourages community-based forest stewardship and observation Promotes public participation through	Minimises economic losses from pests, disease, and wildfire through early detection	Strengthens resilience of forest ecosystems to climate stressors Helps prevent large-scale degradation through proactive intervention	Short-term: 1–2 years for network setup, community engagement, and pilot monitoring Medium-term: 3–5 years to expand data coverage, integrate modelling tools, and scale warning systems	Risk of data overload or underuse if monitoring systems aren't well-integrated with decision-making Potential equity issues if technology access excludes smaller forest owners

¹⁷⁷ **Canopy health** refers to the overall condition and vitality of the canopy layer of trees in a forest. The canopy is the uppermost layer of trees and vegetation, formed by the crowns of trees that create a dense network of leaves and branches. Canopy health involves the assessment of factors such as tree growth, leaf density, biodiversity, pest and disease presence, and the tree's ability to withstand environmental stressors like drought, pollution, and extreme weather events. Healthy canopies provide essential ecosystem services, such as air and water purification, temperature regulation, carbon sequestration, and habitat for wildlife.

¹⁷⁸ E.g., using EFFIS Wildfire risk viewer: <https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/> or ThinkHazard!: <https://thinkhazard.org/en/report/223-slovak-republic/WF>.

¹⁷⁹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>citizen science and local reporting</p> <p>Builds trust and collaboration between forest managers and residents</p> <p>Raises public awareness of forest threats and climate change impacts</p>	<p>Reduces long-term forest management and disaster recovery costs</p> <p>Supports forest-dependent livelihoods by maintaining ecosystem health</p> <p>Attracts funding for smart technology and innovation in forest monitoring</p>	<p>Supports biodiversity by safeguarding habitat integrity</p> <p>Enhances carbon sink function of forests by reducing mortality and degradation</p>	<p>Long-term: 6–15 years to enable adaptive forest management based on comprehensive trend data</p>	<p>Inaccurate models or false alarms could lead to mismanagement or public distrust</p> <p>Surveillance technology may overlook local ecological knowledge or low-tech solutions</p>
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Strategic objective addressed:							
<ul style="list-style-type: none"> SD-FO-1: Sufficient and effective measures are implemented to ensure climate-resilient forests and their associated ecosystem services, including monitoring, restoration and protection. (NAP: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.3, 4.5, 4.7) 							
Action	Forest Restoration and Protection through adaptive silviculture						Existing
Aim of the action: Restore forest cover in areas that have been deforested or significantly degraded due to clearing, logging, fire, or other disturbances. It involves the replanting or natural regeneration of trees towards restoring ecological integrity and functionality of forest ecosystems, including their connectivity.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)¹⁸⁰	Funding line	Output indicator	Link to other national activities
Ministry of Agriculture and Rural Development	Ministry of Environment National Forestry Center Forest owners and managers	National	2026-2040	Low to Medium	National (Public Budget), EU funds ESIF, EAFRD)	Percentage of forest area with implemented measures (e.g. 25% from NFP)	National Forest Plan (NFP) Synergies with National Biodiversity Strategy
Description of the Action:							
<u>Reforestation with Native and Climate-Resilient Species:</u>							
<ul style="list-style-type: none"> Introduce close-to nature forestry management in 25% of forest area in Slovakia. Transform non-native spruce forest stands to mixed species stands with tree species well-adapted to local conditions and high tolerance to drought, pests, and temperature extremes to promote robustness making use of climate forecasts to estimate future site-specific growing conditions. Support natural regeneration processes by systematically removing invasive species, controlling herbivores, and protecting soil quality. Establish ground-covering plants or cover crops in early restoration stages to protect soil from erosion and enhance soil organic matter. Introduce and support forest liming with the aim of reversing acidification of forest soil to improve chances of transforming of monocultural forest into more resilient mixed forest stands. Manage overpopulation of ungulates disturbing natural regeneration processes. 							
<u>Increase Forest Structural Diversity:</u>							
<ul style="list-style-type: none"> Encourage multi-layered canopies through selective harvesting and targeted thinning to create multi-layered canopy structures, thereby reducing competition for light, water, and nutrients. Managing canopy conditions will also increase resistance against pests and pathogens, e.g., maintaining closed-canopy conditions to reduce the ability of light-loving invasive species to enter the understory or keeping canopy more open to reduce the spreading of species or pathogens that prefer conditions of shade, less wind, and higher humidity. Leave logs, stumps, and deadwood to support habitat diversity for wildlife and enrich the soil, aiding in nutrient cycling and providing habitats for wildlife in areas where wildfire risks are low. 							

¹⁸⁰ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Promote Forest Genetic Conservation:

- Designate natural forests, seed stands, and research plots as in situ genetic conservation areas.
- Support the ex-situ conservation of genetic material (seed banks, clone archives).

Create connectivity corridors between forest patches to support wildlife movement and genetic diversity, linking restored areas with larger forest landscapes.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ^{181k}
<p>Promotes sustainable forestry traditions and intergenerational stewardship</p> <p>Engages local communities and forest owners in adaptive restoration</p> <p>Enhances public appreciation for multifunctional and biodiverse forests</p> <p>Builds resilience in rural areas dependent on forest resources</p>	<p>Reduces future costs from forest dieback, pest outbreaks, and soil degradation</p> <p>Supports climate-resilient timber production and forest-based industries</p> <p>Attracts green funding for ecosystem restoration and carbon sequestration</p> <p>Promotes jobs in forest management, genetic conservation, and native species cultivation</p> <p>Attracts funding through alignment with EU Green Deal, CAP</p>	<p>Increases forest ecosystem resilience to climate extremes and biological threats</p> <p>Enhances biodiversity by restoring native species and structural complexity</p> <p>Boosts carbon storage and soil health through natural regeneration and mixed stands</p> <p>Conserves forest genetic diversity critical for long-term adaptability</p> <p>Shadowing of water courses increases water quality</p>	<p>Short-term: 1–3 years to begin reforestation pilots, initiate spruce stand transformation, establish cover crops, and start invasive species removal, herbivore control, and forest liming.</p> <p>Medium-term: 4–10 years for to achieve noticeable improvements in forest structure, species mix, and soil quality through regeneration, thinning, and deadwood retention.</p> <p>Long-term: 11–15 years to consolidate ecological functioning and climate resilience with diverse mixed-species forests, stable soils, and connected habitats.</p>	<p>Poor species selection could reduce forest resilience or ecosystem services</p> <p>Lack of deer/herbivore control may undermine regeneration success</p> <p>Overreliance on one silvicultural approach may reduce adaptability to changing conditions</p> <p>Inadequate stakeholder engagement could slow adoption and reduce effectiveness</p>

Strategic objective addressed:

- SD-FO-2: Provisioning forest ecosystem services (including sustainable timber production) are appropriately supported as a tool to mitigate climate change.

Action	Promote and transition to Sustainable Forest Management Practices	Existing
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¹⁸¹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Aim of the action: Maintain or enhance ecological and economic functions of forest ecosystems, balancing multiple objectives, such as timber production, wildlife habitat conservation, water balance and carbon sequestration, disturbance processes and recreational opportunities, based on the specific context and goals of forest management.

Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁸²	Funding line	Output indicator	Link to other national activities
Ministry of Agriculture and Rural Development of the Slovak Republic	Ministry of Environment National Forestry Center Forest owners and managers	National	2026-2040	Medium	National (Public Budget), EU funds ESIF, EAFRD), Private	Percentage of forest area (in ha) with implemented measures	Synergies with NFP and National Biodiversity Strategy

Description of the Action:

Promote Sustainable Logging and Harvesting Approaches:

- Implement selective logging techniques to harvest only certain trees (e.g., only mature, commercially valuable, or diseased trees are removed) to maintain the overall health and structure of the forest ecosystem. Use low-impact logging practices, such as reduced-impact logging (RIL), to minimise soil compaction, damage to surrounding trees, and disruption to the forest floor, preserving the forest’s natural regeneration capacity.

Align Forest Management with Broader Conservation Goals:

- Design timber production zones to incorporate protected areas and wildlife corridors, allowing natural ecosystems to coexist alongside managed forests and supporting biodiversity while enabling sustainable timber yields.
- Apply Ecosystem-Based Forest Management (EBFM) principles to manage forests not only for timber but also for water, wildlife, and recreation. This holistic approach helps maintain ecosystem health and function, enhancing resilience to climate impacts.
- Integrate timber management within broader landscape-level planning to optimise ecosystem service provision, balancing timber production with conservation and climate resilience goals.

Foster Agroforestry and Forest-Pasture Restoration:

- Establish silvopasture systems in rural areas combining reforestation with grazing to create a mutually beneficial system. Tree species commonly used include hardwoods like oak, walnut, and fruit-bearing trees, which offer additional economic benefits through diversified products. A forage layer enhances soil fertility through nitrogen fixation and improves livestock health.
- Promote forest-crop interplanting through integrating native trees with agricultural crops in select areas to improve soil fertility, increase water retention, and enhance resilience to climate extremes.
- Foster natural regeneration of tree species alongside crop production, maintaining ecosystem diversity and providing a continual supply of timber without compromising the forest’s ecological function.

¹⁸² Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Incentivise Sustainable Timber Production:

- Provide incentives for forest owners and timber industries to produce long-lasting timber products that sequester carbon, reinforcing the link between sustainable forest management and climate benefits.
- Encourage the use of sustainably harvested wood as a renewable and low-carbon alternative to more carbon-intensive materials like concrete, steel, and plastic. This substitution effect can reduce overall greenhouse gas emissions in sectors such as construction.
- Establish or participate in carbon credit schemes that financially compensate forest owners for sustainable forest management practices and carbon sequestration, incentivising the maintenance of carbon-storing forests and sustainable timber harvesting.
- Develop and implement Payments for Ecosystem Services (PES) programs, or innovative market-based instruments such as Nature Credits or Carbon Offsetting Schemes that reward landowners and managers for preserving ecosystem services, such as water regulation and biodiversity, in addition to timber production.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁸³
<p>Supports traditional forestry knowledge while fostering modern resilience practices</p> <p>Encourages rural revitalisation through sustainable land-based livelihoods</p> <p>Engages forest owners, farmers, and local communities in adaptive land management</p> <p>Enhances public understanding of forests as multifunctional, climate-critical landscapes</p>	<p>Diversifies income streams through agroforestry and silvopasture models</p> <p>Strengthens timber sector competitiveness through sustainable value chains</p> <p>Attracts green investment and participation in carbon and ecosystem service markets</p> <p>Promotes long-term forest productivity while reducing restoration costs from degradation</p> <p>Attracts funding through alignment with EU Green Deal, CAP</p>	<p>Maintains forest biodiversity and habitat connectivity under climate stress</p> <p>Enhances carbon sequestration through extended rotations and natural regeneration</p> <p>Improves soil quality, water retention, and landscape resilience through integrated planning</p> <p>Reduces deforestation pressure and promotes multifunctional land use across rural areas</p>	<p>Short-term: 1–3 years to develop incentive mechanisms, pilot silvopasture systems, and begin knowledge transfer</p> <p>Medium-term: 4–10 years to see structural changes in managed forests and measurable ecosystem co-benefits</p> <p>Long-term: 10–30+ years for full integration of sustainable practices and stable carbon storage gains</p>	<p>Inadequate technical guidance may lead to poor implementation or ecological damage</p> <p>Market reliance without safeguards could encourage unsustainable harvesting under the guise of sustainability</p> <p>Overemphasis on carbon benefits could overlook biodiversity and ecosystem function trade-offs</p> <p>Weak stakeholder coordination may result in inconsistent practices across forest ownership types</p>

¹⁸³ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

4.1.4. Geological environment & Soil

The Geological Environment and Soil sector focuses on the study, protection, and sustainable management of geological formations and soil resources. It encompasses soil composition, erosion, contamination, land stability, and resource extraction, playing a crucial role in environmental protection, agriculture, construction, and climate change mitigation. This sector integrates geology, hydrogeology, geotechnical engineering, and soil science to assess environmental risks and promote sustainable land-use practices (European Environment Agency, 2020).

Impacts and Risks

For the sector Geological Environment & Soil extreme events (mainly droughts and landslides and mudslides) are among those climate impacts affected the key risk *soil degradation, including erosion*. As such events are expected to increase in terms of frequency and intensity, the risk becomes more severe and is rated a *high* (optimistic scenario) and *very high* (pessimistic scenario) for the far future. The regional distribution and occurrence depend however on the bedrock and topography, among others. The risk of decreasing groundwater availability and quality is associated with climate impacts such as fluctuation/lowering of the groundwater level and change in groundwater quality, impacted by changes in precipitation patterns, droughts/heat waves as well as an overall rise temperature.

Actions

The strategic directions focus on the resilience of soil and its capacity to provide ecosystem services, highlighting the necessity to work across sectors and are related to some specific objectives of the current NAP (Ministry of Environment of the Slovak Republic, 2021). Currently underestimated hazards (landslides/mudslides) are addressed as well, considering the importance of comprehensive mappings to assess risks.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-GES-1: The ecosystem service provision of soils is secured through sustainable management practices, especially considering agriculture, forest soils and urban soils, to protect water retention capacity and limit excess surface runoff, reduce evapotranspiration and thus improve the overall soil water balance. (NAP 2.1, 2.2, 7.1) 							
Action	Foster sustainable soil and water balance management practices						Existing
Aim of the action: To enhance the ecosystem services of soils by implementing sustainable management practices that improve water retention, limit surface runoff, and reduce evapotranspiration, thereby strengthening the overall soil water balance in agricultural, forest, and urban areas.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)¹⁸⁴	Funding line	Output indicator	Link to other national activities

¹⁸⁴ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Ministry of Agriculture and Rural Development	Ministry of Environment National Forestry Centre State Nature Conservancy of the Slovak Republic Municipal Governments and Urban Planning Authorities	National	2026-2040	Medium to High	National (Public Budget), EU funds CAP, ESIF, EAFRD), Private	Hectares of agricultural and forest areas with soil erosion control measures implemented (measured per year). Percentage of urban green infrastructure coverage (e.g., number of green roofs, rain gardens, and permeable surfaces installed per year).	National Agriculture and Rural Development Strategy (2023-2030) National Forest Plan (NFP) National Biodiversity Strategy
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Description of the Action:

Sustainable Soil Management in Agriculture:

Agricultural soils play a crucial role in regulating the water cycle, but intensive farming practices often lead to soil degradation, reduced water infiltration, and increased evapotranspiration. To address this, the following practices are recommended:

- Conservation tillage to minimize soil disturbance, preserve moisture, and improve soil structure.
- Cover cropping to reduce evaporation, prevent erosion, and enhance soil organic matter.
- Agroforestry systems that integrate trees and shrubs into farmland to increase shade, lower soil temperatures, and reduce water loss.
- Contour farming and terracing in sloped areas to slow down water runoff and enhance infiltration.

Protection of Forest Soils and Hydrological Cycles:

Forested areas play a key role in maintaining water balance by reducing surface runoff and promoting groundwater recharge. The following measures are recommended:

- Sustainable logging practices to prevent soil compaction and maintain forest floor integrity.
- Afforestation and reforestation in degraded areas to enhance soil stability and improve water retention capacity.
- Preservation of humus-rich topsoil to increase soil moisture storage and reduce drought vulnerability.
- Erosion control measures, such as maintaining buffer strips and preserving natural vegetation cover, to stabilize slopes and protect water sources.

Enhancing Water Retention in Urban Soils:

Urbanization leads to soil sealing, reducing natural infiltration and increasing surface runoff, which can contribute to flooding and lower groundwater recharge. To counteract these effects, the following solutions are recommended:

- Green infrastructure, including permeable pavements, green roofs, and rain gardens, to facilitate rainwater absorption.
- Tree planting in urban areas to provide shade, reduce surface temperatures, and minimize evapotranspiration losses.

- Soil decompaction and remediation in green spaces to improve infiltration capacity and enhance the resilience of urban landscapes to extreme weather.
- Rainwater harvesting and storage to reduce dependency on groundwater and improve overall water balance in cities.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁸⁵
<p>Strengthens climate resilience of rural communities through improved land stewardship</p> <p>Promotes nature-positive farming traditions and intergenerational knowledge transfer</p> <p>Empowers landowners and urban residents with climate-smart water conservation practices</p> <p>Enhances public health and well-being through better flood control and cleaner environments</p>	<p>Increases long-term agricultural productivity through healthier, water-retentive soils</p> <p>Reduces irrigation and land degradation costs through natural resource efficiency</p> <p>Supports green job creation in soil restoration, water management, and green infrastructure</p> <p>Attracts funding through alignment with EU Green Deal, CAP, and water resilience initiatives</p>	<p>Protects and restores soil fertility critical to carbon storage and ecosystem health</p> <p>Enhances groundwater recharge and balances hydrological cycles in rural and urban areas</p> <p>Prevents erosion and water pollution, safeguarding biodiversity and aquatic systems</p> <p>Builds ecological resilience to droughts, floods, and extreme rainfall events</p>	<p>Short-term: 1–3 years to roll out training, demonstration projects, and regulatory incentives</p> <p>Medium-term: 4–10 years to achieve measurable improvements in soil structure and water retention</p> <p>Long-term: 10–30+ years for widespread adoption and lasting benefits across landscapes and sectors</p>	<p>Over-engineering of water solutions without ecological integration could disrupt natural cycles</p> <p>Improper implementation of soil techniques may lead to compaction or nutrient depletion</p> <p>Urban green infrastructure may underperform if maintenance or design is insufficient</p> <p>Failure to engage farmers and landowners may limit uptake and reduce overall impact</p>

¹⁸⁵ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-GES-2: Areas at risk for landslides and mudslides are mapped, considering future climate developments and their relevance for hazard and risk maps. 							
Action	Advance risk mapping to account for increasing climate-related geohazards						Existing
Aim of the action: To improve the identification and assessment of areas at risk for landslides and mudslides by integrating future climate projections into hazard and risk mapping, thereby enhancing early warning systems, land-use planning, and disaster prevention strategies.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁸⁶	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Authority for Spatial Planning and Construction of the Slovak Republic Slovak Hydrometeorological Institute State Geological Institute	National	2026-2040	Low	National (Public Budget), EU funds ESIF, R&D)	Percentage of Slovakia covered by updated landslide risk maps incorporating climate projections (target: 100% by 2030). Number of municipalities integrating climate-adjusted landslide risk maps into spatial planning and development regulations (target: 80% by 2040). Number of landslide early	National Geological Hazard Risk Assessment National Spatial Development Plan National Disaster Risk Reduction Strategy Water Policy Concept and/or Water Plan of Slovakia ¹⁸⁷

¹⁸⁶ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

¹⁸⁷ https://www.minzp.sk/files/sekcia-vod/kvps2030_web.pdf and <https://www.minzp.sk/voda/vodny-plan-slovenska/>

						<p>warning systems established and operational.</p> <p>Hectares of slopes stabilized or treated with nature-based solutions (e.g., afforestation, bioengineering, vegetation cover) to reduce landslide risk.</p> <p>Number of landslide risk mitigation measures implemented on infrastructure and vulnerable sites (e.g., slope stabilization, protective barriers, nature-based solutions).</p>	
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Description of the Action:

Landslides and mudslides pose significant risks to infrastructure, human settlements, and natural ecosystems, especially in mountainous and hilly regions of Slovakia. Climate change is expected to intensify these hazards due to increased extreme rainfall events, soil saturation, and shifts in freeze-thaw cycles. This adaptation action focuses on the development of comprehensive, climate-informed landslide and mudslide risk maps that will support proactive risk management and planning.

Advanced Hazard Mapping and Climate Modelling:

- Integrate climate projections into existing geological and hydrological models to predict future landslide-prone areas under different climate scenarios.
- Utilize remote sensing and geospatial analysis (e.g., satellite imagery, LiDAR, and GIS-based assessments) to enhance the accuracy of landslide susceptibility mapping.
- Develop real-time monitoring systems using rainfall thresholds, soil moisture sensors, and ground movement detection technologies.

Strengthening Early Warning Systems (see also chapter 4.3.1):

- Establish a nationwide landslide and mudslide early warning system based on real-time data and climate-adjusted risk maps.
- Improve communication channels between scientific institutions, local governments, and emergency response teams to ensure timely alerts and community preparedness.

<ul style="list-style-type: none"> Conduct regular risk assessments to update hazard maps and adapt early warning thresholds to changing climate conditions. <p><u>Integration into Spatial Planning and Infrastructure Development</u> (see also chapters 4.4.2 and 4.4.3):</p> <ul style="list-style-type: none"> Incorporate climate-informed landslide risk maps into spatial planning regulations to prevent construction in high-risk zones. Develop risk-sensitive building codes and slope stabilization measures for existing and planned infrastructure in vulnerable areas. Promote nature-based solutions, such as afforestation, bioengineering techniques, and slope vegetation, to reduce landslide risks. 				
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁸⁸
<p>Protects lives and livelihoods in vulnerable communities, especially in mountainous regions</p> <p>Enhances public safety through early warning systems and informed emergency response</p> <p>Builds community awareness and preparedness against climate-driven geohazards</p> <p>Supports equitable development by preventing exposure of marginalized populations to high-risk zones</p>	<p>Reduces long-term costs of disaster response, recovery, and infrastructure repair</p> <p>Informs risk-sensitive infrastructure investment, lowering insurance and maintenance burdens</p> <p>Supports sustainable land development and resilient tourism in geologically sensitive areas</p> <p>Attracts climate adaptation funding from EU and international disaster resilience frameworks</p>	<p>Promotes nature-based risk reduction (e.g., afforestation, slope vegetation) to stabilize terrain</p> <p>Prevents degradation of ecosystems caused by landslides and slope destabilization</p> <p>Reduces sediment runoff into water bodies, protecting aquatic ecosystems and water quality</p> <p>Enhances landscape-level planning that balances conservation and safety priorities</p>	<p>Short-term: 1–3 years for integrating climate projections into hazard models, initiating remote sensing data collection, and piloting real-time monitoring systems in high-risk areas.</p> <p>Medium-term: 4–7 years for establishing nationwide early warning systems, embedding risk maps into spatial planning and building codes, and scaling slope stabilization measures.</p> <p>Long-term: 8–15 years for systemic integration of landslide risk management into infrastructure planning, maintaining dynamic risk maps, and implementing large-scale nature-based solutions.</p>	<p>Over-reliance on hard infrastructure without green solutions may lead to ecosystem damage</p> <p>Static risk maps may become outdated if not regularly updated with climate data</p> <p>Early warning systems may fail if not accompanied by public education and local response capacity</p> <p>Inaccurate modelling or poor data quality could lead to misplaced development restrictions or false security</p>

4.1.5. Hydrological Regime & Water Resource Management

The sector Hydrological Regime & Water Resource Management addresses freshwater systems and their management including drinking water, irrigation water and wastewater. Water resources are directly linked to climate change as the hydrological cycle is highly dependent on climatic factors. Changes in rainfall patterns, and

¹⁸⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

temperature have implications on the availability of surface and subsurface water, as volume and timing of precipitation, as well as evaporation are driving factors of the water balance.

Impacts and Risks

Several high-priority issues were identified for the Hydrological Regime and Water Resource Management sector. The increase in extreme events, particularly pluvial and flash floods, and the resulting damages are of significant concern. There is also a critical reduction in the yield of drinking water from springs and a general decrease in the availability and supply of drinking water. Some municipalities have already had to import drinking water by tankers during dry seasons in the last five years.

Another significant problem is the changed seasonal distribution of precipitation and runoff patterns, with increased winter and spring runoff and decreased summer and autumn runoff. This affects groundwater recharge, sewer systems, treatment plants and energy production based on hydropower. Water conservation efforts and the interest in retaining water within the country have led to sewers struggling with waste dilution during droughts. Additionally, during short-term heavy rains, wastewater treatment plants must process larger volumes of wastewater than designed for and simultaneously remove increased amounts of hormone-based pharmaceuticals and microplastics.

The climate risk assessment revealed a total number of four key risks addressing the identified climate impacts such as potentially adverse effects related to floods (KR-WM-1), water supply and well-functioning wastewater infrastructure as well as groundwater availability (KR-WM-2, KR-WM-3, KR-WM-4). There is also a risk of damage to infrastructure due to extreme flood events, expected to increase under climate change conditions. Areas that are currently not affected by such events might be in the future. Therefore, regulating ecosystem services have to be considered, i.e. (natural or nature-based) flood protection and water retention. These risks are expected to increase in course of the 21st century, in particular under a pessimistic scenario (RCP8.5).

Actions

Overall adaptation measures should be aimed both at compensating for the manifestations of drought, i.e. the decrease in flows and yields of water resources, as well as at minimising the negative consequences of floods, especially flash floods in mountain and foothill areas. This should lead to reduced vulnerabilities of the population and economic activities. At the same time, win-win solutions to improve biodiversity and nature should be created (green infrastructure elements, green structural approaches and non-structural adaptation concepts)

Strategic direction addressed:		
<ul style="list-style-type: none"> SD-WM-2: Nature-based water retention measures support infrastructural flood protection (e.g. sponge city approaches) and are themselves supported by healthy and resilient ecosystems and soils. (NAP: 1.1, 1.4, 1.7). 		
Action	Climate-Integrated Hydrological Planning and Monitoring	Existing
Aim of the action: Deepen the integration of climate change into hydrological planning and mapping and integrated water cycle management, giving special priority to the management of extreme events (droughts and floods).		

Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ¹⁸⁹	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Hydrometeorological institute Water Management Authority Regional governments	National	2026-2040	High	National (Public Budget), EU funds ESIF, CAP, R&D), Investment Loans (EIB)	<p>Number of flood risk maps and scenarios updated to reflect local climate projections</p> <p>Length (km) of restored watercourses and removed barriers for ecological continuity</p> <p>Area (ha) of wetlands, floodplains, and natural vegetation restored</p> <p>Volume (cubic meters) of rainwater captured and reused in urban environments</p> <p>Percentage of agricultural land under soil-friendly or water-retention-enhancing</p>	<p>Strategic plan of the CAP</p> <p>Action Plan of the National Forestry Programme of the Slovak Republic (2025-2030)</p> <p>National Biodiversity Protection Strategy</p> <p>Water Policy Concept and/or Water Plan of Slovakia¹⁹⁰</p> <p>Flood Risk management Plan</p>

¹⁸⁹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

¹⁹⁰ https://www.minzp.sk/files/sekcia-vod/kvps2030_web.pdf and <https://www.minzp.sk/voda/vodny-plan-slovenska/>

						practices (e.g., no-till, crop diversification)	
						Established and operational centralised hydrological and climate impact database	
<p>Description of the Action:</p> <ul style="list-style-type: none"> • The issue of climate change will be better addressed in the third and updated 3rd Flood risk and hazard maps and the flood risk management plans as set out under the Floods Directive. For this, specific climate scenarios should be taken into account for modelling flood discharges. Development and assessment of available water resources and demand should be estimated to increase the understanding of hydrological balances. This shall also include a central registry of water permits and monitoring of water abstractions. The collection of key parameters for monitoring the impacts of climate change should be strengthened for the hydrological cycle, water use and extreme events. This should be done on a national level in order to allow the creation of homogeneous data, digital mapping, creation and centralisation of databases that are comparable between individual regions. • Increased support for natural water retention in line with the EU Nature Restoration Law and the EU Biodiversity Strategy. This covers: <ul style="list-style-type: none"> ○ maintenance and restoration of vegetation with an emphasis on forests in mountain areas, floodplain forests and mountain meadows, ○ Restoration of wetlands and floodplains, ○ Creation of conditions to ensure the continuity of watercourses and remove barriers in water courses, strengthen biodiversity, ○ ensuring appropriate methods of land use where there is an increased risk of erosion and flooding, apply correct agricultural practices - tillage, sowing practices, ensure permanent vegetation cover in exposed locations. • Construction, maintenance, repair and reconstruction of protective dams and polders, removal of deposits from the watercourse bed, removal of obstacles in the flow. • Limit the creation of impervious surfaces in urbanised areas, prioritise the possibilities of absorbing and capturing rainwater both on buildings and on ground and using it for utility purposes. • Increased support for natural water retention in soil and decrease of water erosion of soil used for agricultural purposes, both in line with the CAP. Not only physical infrastructure on the agricultural land but also new agricultural techniques, such as no-till farming and diversification in the use of different crops should be utilised. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective			Systemic risks ¹⁹¹	
Safeguards lives and public health by reducing	Prevents costly damage to infrastructure, agriculture,	Enhances biodiversity through wetland and floodplain restoration	Short-term: 1–3 years for updating flood risk maps with climate scenarios, enhancing			Excessive focus on hard infrastructure solutions like dams and polders - without	

¹⁹¹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>flood risks in both urban and rural areas</p> <p>Protects essential infrastructure (e.g., housing, transport, water supply) in vulnerable communities</p> <p>Increases public confidence in government capacity to manage extreme weather events</p> <p>Builds resilience in marginalized or low-income populations who are often disproportionately impacted by flooding</p>	<p>and businesses through proactive risk reduction</p> <p>Encourages more sustainable agricultural productivity by mitigating flood-related crop loss and soil degradation</p> <p>Supports long-term economic planning by reducing flood-related disruptions to energy, logistics, and supply chains</p> <p>Leverages EU funding mechanisms linked to the Floods Directive, Nature Restoration Law</p>	<p>and natural water retention measures</p> <p>Protects aquatic ecosystems by improving continuity and connectivity of watercourses</p> <p>Reduces sedimentation and pollution through better land use practices and erosion control</p> <p>Restores hydrological balance through reforestation, soil moisture retention, and barrier removal</p>	<p>hydrological data collection, and initiating pilot projects on natural water retention and wetland restoration.</p> <p>Medium-term: 4–7 years for widespread implementation of nature-based solutions (e.g. forest restoration, wetland rehabilitation), reconstruction of protective infrastructure, and integration of sustainable land-use practices.</p> <p>Long-term: 8–15 years for full integration of climate-informed flood risk management across regions, systemic reduction of impervious surfaces, and large-scale adoption of resilient agricultural practices to preserve soil moisture and prevent erosion.</p>	<p>integrating nature-based solutions - could disrupt ecosystems, increase downstream flood risks, and reduce long-term adaptability.</p> <p>If spatial planning does not fully incorporate updated flood risk maps and climate projections, developments may still occur in vulnerable areas, leading to increased exposure over time.</p> <p>Applying inappropriate or poorly adapted soil retention and farming techniques (e.g. monoculture cover crops or unsuitable no-till methods) might reduce soil quality or fail to achieve water retention goals.</p> <p>Lack of coordination or interoperability in data collection and hydrological monitoring could lead to inconsistent or misleading flood risk assessments, weakening planning effectiveness.</p> <p>Prioritizing immediate structural repairs or sediment removal without investing in systemic watershed management could result in recurrent vulnerabilities and escalating maintenance costs.</p> <p>If natural water retention and land use regulations disproportionately affect certain landowners or communities without adequate support, it may increase vulnerability or resistance to adaptation efforts.</p>
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Strategic direction addressed:

<ul style="list-style-type: none"> SD-WM-3: Water and wastewater infrastructure is fixed, maintained and adapted to changing climatic conditions (e.g. heat, aridity, floods) to secure a reliable supply of safe water. 							
Action	Assess, climate proof, improve and maintain water and waste water infrastructure						Existing
Aim of the action: Ensure safe drinking water supply and meet the standards of the new EU Waster Wastewater Directive (Directive (EU) 2024/3019)							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Public water supply	National	2026-2040	High	National (Public Budget), EU funds ESIF)	<p>Number of water and wastewater infrastructure projects completed or upgraded to meet climate resilience and updated regulatory requirements</p> <p>Percentage reduction in freshwater consumption achieved through water reuse, low-water technologies, and improved distribution efficiency</p> <p>Number of water bodies meeting Water Framework Directive quality</p>	<p>National Drinking water Regulations, CAP strategic plans</p> <p>Water Policy Concept and/or Water Plan of Slovakia¹⁹²</p>

¹⁹² https://www.minzp.sk/files/sekcia-vod/kvps2030_web.pdf and <https://www.minzp.sk/voda/vodny-plan-slovenska/>.

					standards after interventions	
<p>Description of the Action:</p> <ul style="list-style-type: none"> • Revise the current requirements for building and renovating water and wastewater infrastructure to align with new needs stemming from climate change. • Increase the flexibility and efficiency of water management systems and the integrated use of water resources (e.g., reusing grey water - wastewater from sinks, showers, washing machines, and kitchens – to significantly reduce freshwater consumption). • Increase the efficient use of water by promoting the use of equipment and technologies with low water consumption, new requirements to ensure a higher level of water recycling according to local water availability, or by measures to reduce water losses in distribution systems. This could include making use of key technical options such as filtration & treatment systems and introducing separate plumbing systems (e.g., for toilet flush and laundry). • Construction, expansion and increase in the capacity of sewage networks, construction, expansion and increase in the capacity of wastewater treatment plants and removal of nutrients in agglomerations over 2,000 inhabitants. • Improve and expand financial tools¹⁹³ for building and renovating water and wastewater infrastructure, including wastewater treatment plants such as direct transfers from state budget, innovative sources of funding and involvement of other state organs and municipalities. • Reduction of contaminants in water bodies in accordance with the Water Framework Directive to ensure increased status of the water bodies but also to secure long term drinking water supply. 						
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ¹⁹⁴		
Ensures safe and reliable access to clean drinking water, protecting public health - especially during heatwaves, droughts, or flood-related contamination Improves sanitation and hygiene services, particularly in growing or	Protects investments and extends the lifespan of costly infrastructure (e.g., treatment plants, distribution networks) by climate-proofing systems Reduces economic losses from service interruptions due to extreme weather or infrastructure failure	Supports the sustainable management of freshwater resources under shifting climate conditions (droughts, heavy rainfall, water scarcity) Reduces nutrient pollution and contaminant loads in rivers and aquifers, improving aquatic ecosystem health	Short-term: 1–3 years for risk assessments, policy revisions, and pilot infrastructure upgrades Medium-term: 4–7 years for infrastructure expansion, increased water efficiency, and widespread adoption of reuse technologies Long-term: 8–15 years for systemic modernization of water infrastructure and full climate resilience	Investing only in hard infrastructure without addressing demand-side measures (e.g., efficiency, reuse) may result in unsustainable water use Over-engineering solutions (e.g., oversized or inflexible infrastructure) may lock in high costs and limit future adaptability Failure to integrate decentralized and nature-based solutions (e.g., small-scale		

¹⁹³ There are two financial tools used today (European funds from Programme Slovakia and programs from Environmental Fund replenished from the EU ETS auction revenues). The water and wastewater infrastructure penetration in most of the EU countries is higher than in Slovakia. It is expected that the physical infrastructure should be in place (in compliance with Urban Waste Water Treatment Directive), therefore the political priorities for the following Multiannual Financial Frameworks will not be focused on expanding and building this infrastructure. Rather the priority will be to make this existing infrastructure more resilient to climate change. Therefore, the allocation of European funds into building and expanding this infrastructure will not be as big as today. Similarly, the use of the EU ETS auction revenues for funding these types of projects might be more difficult in the future, because with progressing decarbonisation in Slovakia the amount of EU ETS allowances and respective revenues from them will be decreasing. Investment gap in this infrastructure is still huge (5,7 billion EUR; <https://www.nku.gov.sk/-/nku-organizuje-workshop-o-vodarenstve-investicny-dlh-dosahuje-10-miliard>) and with current pace of investment will remain huge in foreseeable future.

¹⁹⁴ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

<p>underserved urban and rural populations</p> <p>Builds resilience of critical services in hospitals, schools, and public facilities by strengthening infrastructure performance under climate stress</p> <p>Reduces social inequalities by extending water and sewage infrastructure to marginalized communities</p>	<p>Stimulates green job creation and local economic development through infrastructure upgrades and innovation in water technology</p> <p>Improves cost-efficiency in water resource use (e.g., through greywater reuse, water-efficient appliances, leakage reduction), lowering utility bills and long-term operating costs</p>	<p>Helps achieve good ecological status of water bodies in line with the EU Water Framework Directive</p> <p>Encourages circular economy practices through water reuse, recycling, and nutrient recovery</p>		<p>treatment, rainwater harvesting) may miss opportunities for local resilience</p> <p>Ignoring the risks of nutrient overloading or treatment plant failures under extreme events could increase downstream pollution</p>
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4.2. Cluster Economy

This cluster focuses on economic resilience and sectoral sustainability under climate pressure. Proposed adaptation actions were developed from the 2018 NAS, 2021 NAP, national strategies (e.g., NECP, Just Transition Plan, National Tourism Strategy), stakeholder consultation, and aligned with EU databases (e.g. Climate-ADAPT, EU Mission Portal).

The total number of actions in this cluster is seven, distributed across four sectors as follows: three actions in the Economy & Industry sector, one in Energy, two in the Financial and Insurance System, and one in the Tourism sector. These actions encompass a wide range of themes. In the Economy & Industry sector, actions focus on supporting climate-resilient industrial transformation, fostering regional value chains, promoting circular economy practices, and strengthening workforce capacity through upskilling and retraining for climate adaptation. In Energy, measures aim to diversify the energy supply through renewables, low-carbon hydrogen, nuclear fuel, and small modular reactor technologies, while ensuring climate-proofing of electricity and gas infrastructure, energy storage systems, and transmission networks. The Financial and Insurance System actions aim to integrate climate risks into fiscal planning, develop domestic risk pools and reinsurance schemes, reform insurance frameworks, and improve coverage for vulnerable groups. Tourism activities focus on sustainable transformation through diversification of tourism offers, climate-resilient infrastructure, digitalization, biodiversity protection, and adoption of low-carbon energy and transport practices.

Implementation responsibilities are shared across national ministries, including the Ministry of Economy, Ministry of Environment, Ministry of Finance, and Ministry of Investments, Regional Development, and Informatization, along with regulatory authorities, financial institutions such as the National Bank of Slovakia, insurance providers,

regional and local tourism boards, business associations, and private sector stakeholders. Public administration bodies overseeing taxation, investment policies, infrastructure, and human capital development shall provide enabling support, while EU funding and sustainable finance mechanisms strengthen implementation capacity.

The proposed activities span short-, medium-, and long-term timeframes. Short-term actions include awareness-raising campaigns, climate risk audits, methodological guidance for businesses, and financial sector reviews. Medium-term priorities involve insurance framework reforms, workforce retraining in climate-relevant skills, and early steps in energy system adaptation. Long-term actions aim to embed resilience into core of economic governance, promote green innovation, support fully climate-adapted industrial and energy systems, and secure sustainable and resilient tourism and financial sectors.

While the geographical scope is national, certain activities target industrial hubs, energy-sensitive communities, regions with high climate vulnerability, and tourist destinations with seasonal pressures, reflecting spatial variability in climate risk and adaptive capacity.

4.2.1. Economy and Industry

Following the sectorial definition used by the International Energy Agency, the Economy and Industry sector encompasses heavy industries such as steel, aluminium, paper, chemicals, and cement, as well as light industry¹⁹⁵. In this context, light industry includes a diverse range of sub-sectors including food processing, textiles, and the manufacturing of consumer goods, vehicles, and machinery¹⁹⁶. In this section, the Economy & Industry sector excludes agricultural (including aquacultural) activities, tourism, and services related to the Information and Communication Technology (ICT) industry, as these are covered by other specific sectors detailed in chapters 5.1.1, 5.2.4 and 5.3.3.).

Impacts and Risks

Slovakia's economy is heavily industrialised, with industry contributing 22.2% to GDP in 2021, surpassing the EU average of 18%¹⁹⁷. Notably, the production of means of transport stands out, generating 34.7% of total revenues from industry production in 2021.

However, Slovak industry is susceptible to increased floods and low water availability for industrial processes, especially during the summer months. Extreme weather conditions are likely to impact both physical assets such as machinery, buildings, and other infrastructure and employee working conditions, such as work hours and additional measures to ensure the safety and preparedness of personnel. The rise in extreme events and exposure to natural hazards underscores the importance of existing strict regulations that enforce preventive measures for businesses. Consideration must also be given to decarbonisation efforts which will lead to changes in electricity and power demand, requiring the energy sector to adapt to new demands and integrate renewable energy sources.

¹⁹⁵ IEA (2023a). Industry - Energy System. <https://www.iea.org/energy-system/industry>.

¹⁹⁶ IEA (2023b). Light industry. <https://www.iea.org/energy-system/industry/light-industry>.

¹⁹⁷ Ministry of Environment of the Slovak Republic, 2023. National Communications (NC) NC 8. Biennial Reports (BR). BR5. <https://unfccc.int/documents/626514>.

In total, the assessment revealed three key risks to be addressed in the economy and industry sector. Extreme events such as floods and droughts are expected to pose high risks to business and industries in the far future (KR-EI-1). Medium levels of risks are expected for the risk of missed opportunities and unutilised innovation potential (KR-EI-2) and the risk of loss of jobs and lack of skilled workers (KR-EI-3).

Actions

The actions presented below are sourced from various existing national activities due to multiple strategic documents or regulations targeting individual aspects of the identified risks in the industry sector. Presently, sectoral guidance on industry's adaptation to climate change does not exist, therefore, relevant strategic actions fall under the auspices of multiple national actors. The Ministry of Environment is active in the sphere of setting targets and updating existing regulations and frameworks to ensure there are existing measures to prevent and protect from extreme weather events. The Slovak Environment Agency performs, among others, a knowledge-sharing role in assessing impacts on the environment and climate adaptation. To the end of enabling individual businesses and organisations to conduct their own risk assessments, the agency released methodological guidance.

The Ministry of Economy and Ministry of Environment are the most important drivers of energy transformation of industry towards more decarbonised and more resilient business model based on local energy production and, more circular economy principles, shorter supply chains and more local production and consumption of resources and products. This includes fostering climate-resilient regional industrial clusters, decentralized warehousing and logistics solutions, and supporting circular economy initiatives to reduce dependence on vulnerable international supply chains. The main tools are strategic documents, and national and European legislation with set targets for waste, energy efficiency, renewable energy. This effort is supported by several national and European funding instruments implemented by both ministries (in some cases also jointly coordinated), e.g. European Structural and Investment Funds, RRP, Modernisation Fund, Environmental Fund.

This whole transformation is supported by the European framework for sustainable finance, including ESG (environmental, social and governance) reporting requirement which formally falls under competence of the Ministry of Finance. This framework does not just encourage companies to look at the adaptation measures along with mitigation and energy measures, but most importantly, it is shifting the financial market into more sustainable and green investments which are driven by the European Investment Bank and national banks. In this regard, training and awareness on EU Taxonomy requirements are essential to ensure that companies and public institutions can access and benefit from sustainable finance mechanisms.

With the aim of increasing domestic and regional production and consumption of goods, support has been targeted toward fostering new business models and the coordination of regional supply chains by the Ministry of Investments, Regional Development and Informatisation and the Ministry of Economy. Strengthening the role of SMEs through targeted financial support, preferential procurement, and business-to-business networking platforms is a key part of building resilient regional value chains. The development of human capital, application of technical skills in practice, and matching the expectations of the current and evolving labour market is aligned with the Ministry of Economy's Vision and development strategy of Slovakia until 2030 with the support of the Ministry of Education and Ministry of Finance. The overarching aim is to foster a domestic labour force that will be prepared to technically manage industry's climate adaptation effort. In this context, retraining and upskilling programmes in

climate-relevant professions, support for R&D and innovation in adaptation technologies, and financial incentives for green skills development represent crucial steps to ensure that Slovakia's workforce is fully prepared to technically manage industry's climate adaptation effort and seize opportunities from the green transition.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-EI-1: Existing regulations and frameworks enforcing protective measures in companies against extreme events like floods and droughts and businesses are continuously adapted to changing climate risks and altered empirical values. 							
Action	Reinforcing existing flood protection measures						New
Aim of the action: Adapt and enhance flood protection measures							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)¹⁹⁸	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Slovak Water Management Authority	National	2026-2040	High	National (Public Budget, Municipalities), EU funds (ESIF), Private	<p>Number of industrial sites, logistics hubs, or utilities retrofitted or constructed with flood-resilient infrastructure, including nature-based solutions (e.g., green roofs, retention ponds, raised structures, improved drainage).</p> <p>Number of industrial zones equipped with IoT flood sensors and AI-based predictive flood management tools.</p>	Flood Protection Act 7/2010 Coll. Implementation of the WFD

¹⁹⁸ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						Number of businesses adopting flood-resilient measures through insurance, tax incentives, or compliance with updated flood-resilience standards.	
<p>Description of the Action: The Flood Protection Act 7/2010 Coll. has been amended and adapted most recently in 2024. The aim of the act is to set out what constitutes flood protection measures, which areas are vulnerable to floods, management and organisation of flood protection measures, responsibilities of other parties, and flood protection expenditure. One output based on the Flood Protection Act was the mapping of areas at risk of floods in the form of an interactive map created by the Slovak Water Management Authority.¹⁹⁹</p> <p>Based on this risk map, the following activities are suggested:</p> <p><u>Strengthening Flood-Resilient Infrastructure for Industries:</u></p> <ul style="list-style-type: none"> • Flood-Resistant Industrial Zones: Retrofitting existing industrial areas with improved drainage systems, waterproof barriers, and elevated structures to minimize flood damage. • Water-Resilient Logistics Hubs: Enhancing road and rail networks in flood-prone regions with permeable surfaces, raised transport corridors, and smart stormwater management. • Secure Power and Utility Systems: Installing flood-proof substations, backup energy sources, and water treatment facilities to ensure continuous industrial operations during extreme weather events. <p><u>Business-Oriented Nature-Based Solutions (NbS):</u></p> <ul style="list-style-type: none"> • Green Roofs & Rainwater Harvesting for Factories: Encouraging industries to integrate rooftop vegetation and rainwater collection systems to reduce surface runoff and lower flood risks. • Sustainable Industrial Parks: Designing business zones with retention ponds, buffer wetlands, and tree-lined perimeters to enhance natural water absorption. <p><u>Smart Monitoring and Early Warning Systems for Industrial Operations:</u></p> <ul style="list-style-type: none"> • IoT-Based Flood Sensors in Industrial Zones: Deploying sensor networks that provide real-time flood alerts to factories, warehouses, and commercial hubs. • Business Continuity Planning with AI Modelling: Using predictive analytics and GIS-based flood mapping to help companies adjust logistics, production cycles, and workforce safety measures in flood-prone periods. <p><u>Economic Incentives and Policy Support for Flood Resilience:</u></p> <ul style="list-style-type: none"> • Insurance & Risk Transfer Mechanisms: Encouraging businesses to adopt flood insurance schemes, subsidized by government adaptation funds, to mitigate financial losses. • Tax Breaks for Flood-Resilient Investments: Offering incentives for companies investing in flood-protection upgrades, such as flood-resistant materials and adaptive infrastructure. • Mandatory Flood-Resilience Standards for New Industrial Developments: Updating zoning laws and building codes to require flood protection in business districts. 							

¹⁹⁹ The interactive map can be found here: https://mpt.svp.sk/svp_vmapportal/?basemap=orto2023&zoom=0&lat=48.778724&lng=19.032391. Accompanying documents include a user manual (https://mpt.svp.sk/svp_vmapportal/manual_TIS.pdf) and legend (https://mpt.svp.sk/svp_vmapportal/legend_TIS.pdf).

Workforce and Supply Chain Adaptation Strategies:				
<ul style="list-style-type: none"> • Flood-Resilient Transport & Logistics: Strengthening inland waterway transport, rail freight, and emergency delivery routes to reduce supply chain disruptions. • Workforce Safety & Adaptation Training: Conducting preparedness training for employees in flood-prone manufacturing hubs and business districts. 				
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks²⁰⁰
<p>Enhances worker safety and health by preparing industrial zones and staff for flood emergencies, reducing injuries and fatalities during extreme events</p> <p>Builds public trust in local governance and businesses by proactively managing climate-related risks and protecting surrounding communities</p> <p>Supports the continuity of essential services and industrial employment in vulnerable regions, preventing climate-driven economic and social dislocation</p> <p>Reduces the risk of cascading social disruptions from industrial spills or power outages caused by flooding</p>	<p>Reduces direct economic losses from flood-related damage to industrial facilities, equipment, and infrastructure</p> <p>Minimizes business downtime, supply chain disruptions, and loss of productivity during extreme weather events</p> <p>Increases economic resilience of logistics and energy sectors critical to the broader economy</p> <p>Unlocks co-benefits from insurance incentives, tax breaks, and reduced long-term maintenance costs through smart, resilient design</p> <p>Encourages innovation and green investment in sustainable industrial infrastructure and nature-based solutions</p>	<p>Supports urban water cycle regulation by integrating green infrastructure (e.g., green roofs, wetlands, permeable surfaces) that absorb stormwater and reduce runoff</p> <p>Reduces pollution risk from flooded industrial facilities, preventing chemical spills into watercourses and ecosystems</p> <p>Enhances biodiversity and ecosystem services in and around industrial zones through nature-based design elements (e.g., buffer wetlands, tree-lined perimeters)</p> <p>Aligns industrial development with climate-resilient land-use planning and sustainable spatial management</p>	<p>Short-term: 1–3 years for risk mapping updates, pilot projects, and initial training programs</p> <p>Medium-term: 4–7 years for widespread deployment of flood-resilient infrastructure and smart monitoring systems</p> <p>Long-term: 8–15 years for systemic integration of flood resilience in industrial development and supply chain adaptation</p>	<p>Overreliance on hard infrastructure (e.g., concrete barriers, elevated zones) without integrating nature-based solutions may lead to ecological degradation and increased runoff downstream</p> <p>Failure to account for changing climate extremes may result in outdated flood defences that underperform during future events</p> <p>Inadequate attention to small and medium-sized enterprises (SMEs) could leave large parts of the industrial base unprotected</p> <p>Without proper incentives or enforcement, businesses may delay or avoid investing in resilience upgrades, creating uneven protection across sectors</p> <p>Displacing risks to nearby residential or natural areas if industrial defences are implemented in isolation, rather than through integrated watershed planning</p>

²⁰⁰ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-EI-1: Existing regulations and frameworks enforcing protective measures in companies against extreme events like floods and droughts and businesses are continuously adapted to changing climate risks and altered empirical values. 							
Action	Establish industry-specific drought prevention measures						New
Aim of the action: Develop drought protection measures for industry							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁰¹	Funding line	Output indicator	Link to other national activities
Ministry of Environment		National, Regional	2026-2040	Medium	National (Public Budget, Municipalities), EU funds (ESIF), Private	Number of industries implementing water-saving technologies, alternative water sources, or drought resilience strategies	Water policy concept and Water Plan ²⁰² Water management plan of Slovakia (The value is water: An action plan to address the impacts of drought and water scarcity
Description of the Action:							
Establishing industry-specific drought prevention measures requires targeted actions to reduce water consumption, enhance water efficiency, and secure long-term water availability.							
Key activities tailored to this sector include:							
<u>Water Efficiency and Conservation in Industrial Processes (see also chapter 4.1.5):</u>							
<ul style="list-style-type: none"> Implementation of Water Recycling & Reuse Systems: Encouraging industries (e.g., manufacturing, food processing) to adopt closed-loop water systems, where wastewater is treated and reused for production. Installation of Water-Efficient Technologies: Encouraging industry to upgrade industrial equipment to use less water (e.g., dry cooling systems in power plants, low-water textile dyeing). Leak Detection and Repair Programs: Establishing mandatory leak detection and maintenance systems to prevent unnecessary water losses in industrial pipelines. 							
<u>Diversification of Water Sources:</u>							
<ul style="list-style-type: none"> Rainwater Harvesting for Industrial Use: Encouraging companies to install large-scale rainwater collection systems for non-potable industrial applications. 							

²⁰¹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁰² https://www.minzp.sk/files/sekcia-vod/kvps2030_web.pdf and <https://www.minzp.sk/voda/vodny-plan-slovenska/>

- Use of Alternative Water Sources: Promoting the use of treated wastewater or desalinated water for industrial cooling and processing.
- Regional Water-Sharing Agreements: Establishing water allocation policies to ensure equitable distribution of water resources during droughts.

Industry-Specific Adaptation Strategies:

Energy Sector

- Switching to Low-Water Energy Production: Encouraging the use of renewable energy sources (solar, wind) that require minimal water compared to thermal power plants.
- Waste Heat Recovery for Water Conservation: encourage the implementation of systems that capture and reuse heat from industrial processes to reduce water demand.

Manufacturing & Heavy Industry

- Adoption of Waterless Manufacturing Technologies: Encouraging industries to shift to dry processing techniques where possible.
- Optimization of Cooling Systems: Promoting air-cooled or hybrid) cooling technologies in factories and power plants.

Risk Management and Policy Support (see also chapter 4.3.1):

- Drought Early Warning Systems for Industries: Developing real-time monitoring tools to provide drought alerts to businesses, allowing them to adjust operations accordingly.
- Incentives for Water-Saving Technologies: Providing financial incentives (grants, tax breaks) for companies that invest in water-efficient equipment.
- Mandatory Water Management Plans: Requiring industries to develop drought contingency plans as part of their environmental compliance.

Public-Private Collaboration and Capacity Building:

- Industry-Government Partnerships for Drought Resilience: Encouraging collaboration between public institutions and businesses to co-develop water sustainability initiatives.
- Training Programs for Industrial Water Management: Educating businesses on best practices for reducing water use and increasing resilience to droughts.
- Public Awareness Campaigns on Sustainable Industrial Water Use: Promoting corporate responsibility and consumer awareness of water-efficient products.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁰³
<p>Supports long-term job security and operational continuity in drought-prone areas by reducing industry’s dependency on scarce water supplies</p> <p>Promotes equitable water distribution by helping prevent industrial overuse during drought periods, protecting access for households and agriculture</p>	<p>Reduces water-related production costs and long-term operational risks for industries, especially in energy, manufacturing, and food sectors</p> <p>Avoids costly shutdowns during droughts by diversifying water sources and improving system redundancy</p> <p>Stimulates growth in green technology sectors</p>	<p>Reduces extraction pressure on freshwater ecosystems, helping maintain environmental flow requirements and aquatic biodiversity during droughts</p> <p>Promotes circular water use, reducing pollution discharges and minimizing untreated industrial wastewater release</p> <p>Encourages transition to cleaner, low-water energy sources like solar and wind, reducing industry’s overall environmental footprint</p>	<p>Short-term: 1–3 years for awareness campaigns, pilot projects, and early-stage policy implementation</p> <p>Medium-term: 4–7 years for scaling up water-efficient technologies and early warning systems</p> <p>Long-term: 8–15 years for full integration of drought-resilient practices across industries and sustained public-private collaboration</p>	<p>Relying solely on alternative water sources without efficiency gains may lead to high energy use and ecological impacts</p> <p>Inadequate monitoring and regulation could lead to overuse of reused or alternative water sources, stressing ecosystems or causing contamination</p> <p>Without inclusive planning, smaller businesses may lack resources to implement costly efficiency upgrades, increasing inequity</p> <p>Policies that prioritize industrial water supply without safeguards may reduce</p>

²⁰³ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Improves public trust in industries by demonstrating environmental responsibility and leadership in water stewardship	through demand for water-efficient systems, leak detection tech, and water recycling infrastructure	Mitigates risks of environmental degradation in water-stressed areas by integrating sustainable water use into industrial planning		availability for critical community or agricultural needs
Strengthens collaboration between government, industry, and the public, fostering shared ownership of drought resilience goals	Opens access to climate adaptation funds, tax incentives, and international financing for resilient infrastructure upgrades			Lack of integrated basin-wide planning may cause downstream impacts, such as water quality deterioration or conflict over shared water resources
	Supports sustainable industrial growth by ensuring long-term water availability in key economic zones			

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-EI-2: Industries are aware of relevant climate impacts that affect them and have the capabilities to manage them effectively, including enhanced resilience of supply chains. Further support to businesses such as additional financial resources or relevant information to assess their individual risk due to climate change is provided. 							
Action	Strengthening regional value chains within Slovakia						New
Aim of the action: Support business development to enhance regional value chains							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁰⁴	Funding line	Output indicator	Link to other national activities
Ministry of Investments, Regional Development and Informatisation	Ministry of Economy	National	2026-2040	Low to Medium	National (Public Budget), EU funds (ESIF), Private	Number of industries and businesses integrating regional suppliers,	Vision and development strategy of Slovakia until 2030

²⁰⁴ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						<p>localized production, or climate-resilient logistics into their value chains.</p> <p>Number of SMEs supported (through grants, credit lines, procurement, or capacity-building) to adopt climate-adaptive practices and integrate into regional value chains.</p>	
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Description of the Action:

Actively support business development to increase the added value of products, strengthen local and regional value chains, and enhance climate resilience of industrial operations.

The following activities are suggested:

Localizing Raw Material Sourcing and Industrial Production:

- Encouraging Local Supply Networks: Promote partnerships between industries and domestic raw material suppliers to reduce reliance on international imports vulnerable to climate shocks. (e.g., extreme weather, supply chain disruptions).
- Developing Climate-Resilient Industrial Clusters: Establish specialized regional manufacturing hubs (e.g., automotive, electronics, food processing) to boost intra-regional trade and innovation, focussing on enhancing resilience (e.g. for flood protection, drought-resistant water supply, and energy efficiency).
- Supporting Circular Economy Initiatives: Encourage industries to use locally recycled materials, reducing waste, dependency on global raw resources, and exposure to climate-related supply disruptions.

Improving Industrial Infrastructure and Logistics for Climate Resilience:

- Smart Supply Chain Technologies: Implement AI-based forecasting, digital monitoring, and blockchain tools to manage climate-related disruptions in supply chains and optimize regional logistics.
- Decentralized Warehousing and Storage Facilities: Establish strategically located storage hubs with flood-proofing, drought-resistant water systems, and backup energy to maintain supply continuity during climate-related transport disruptions.
- Climate-Resilient Transport Networks: Invest in robust road, rail, and inland waterway infrastructure designed to withstand extreme weather and floods, ensuring reliable regional trade flows and strengthen industrial connectivity across regions.
- Smart Supply Chain Technologies: Implement digital platforms, AI-based demand forecasting, and blockchain solutions to manage climate-related disruptions in supply chains and optimize regional logistics.

Enhancing Regional Manufacturing Capacity:

- Incentives for Localized Production: Provide tax benefits and subsidies to businesses investing in regional manufacturing and processing plants that. promote drought- and heat-resilient water management systems, energy efficiency, and local renewable energy integration to reduce vulnerability to climate extremes
- Reshoring and Nearshoring of Key Industries: Support industries in relocating production closer to consumption hubs to reduce risks from global climate risks affecting transport and supply chains.

Strengthening Business and SME Participation in Regional Markets:

- Financial Support for SMEs in adaptive Supply Chains: Provide grants, credit lines, and capacity-building programs to strengthen small businesses' role in climate resilient industrial value chains.
- Public Procurement Preferences for Local and Climate-Adapted Suppliers: Encourage government agencies and large corporations to source from regional businesses implementing climate-resilient practices.
- Business-to-Business (B2B) Networking and Collaboration: Establish platforms where local industries can share adaptive strategies, resources, and risk management solutions to reduce vulnerability to climate shocks.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁰⁵
<p>Enhances job creation and stability within communities by supporting locally-rooted industries and SMEs</p> <p>Builds regional economic identity and pride by promoting locally made products and services</p> <p>Increases social cohesion and inclusivity by empowering small businesses and fostering community-based value chains</p> <p>Strengthens the adaptive capacity of vulnerable regions by reducing dependency on volatile global supply chains</p>	<p>Boosts economic resilience by localizing production and reducing exposure to international supply chain disruptions caused by climate-related events</p> <p>Improves competitiveness of domestic industries through regional specialization, innovation, and circular economy models</p> <p>Attracts investment in infrastructure, logistics, and technology by developing industrial clusters and value-added processing hubs</p>	<p>Encourages use of recycled and renewable local materials, reducing resource extraction and minimizing waste</p> <p>Supports shorter supply chains, decreasing greenhouse gas emissions associated with long-distance transportation</p> <p>Promotes decentralized, climate-resilient infrastructure (e.g., warehousing, water management, and energy systems), reducing environmental risks</p> <p>Strengthens the environmental sustainability of industrial operations through adoption of green technologies and circular models</p>	<p>Short-term: 1–3 years for awareness, training, and pilot programs</p> <p>Medium-term: 4–7 years for widespread adoption and measurable improvements in regional supply resilience</p> <p>Long-term: 8–15 years for systemic change in industrial ecosystems and regional economic resilience</p>	<p>Over-subsidizing inefficient or high-emission local industries without sustainability standards may entrench environmentally harmful practices</p> <p>Focusing only on local sourcing without diversification could create new vulnerabilities in case of regional disasters or resource depletion</p> <p>Infrastructure investments that do not consider future climate scenarios (e.g., flood-prone logistics hubs) could lead to stranded assets</p> <p>Unequal distribution of financial support may exclude marginalized SMEs or rural businesses, exacerbating regional disparities</p> <p>Inadequate integration of environmental safeguards may result in local pollution</p>

²⁰⁵ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Facilitates skill development and vocational training aligned with local industrial opportunities	Reduces transportation costs and logistics delays, improving overall supply chain efficiency and carbon footprint Supports SMEs with targeted financial tools, increasing their capacity to grow and innovate within regional economies	Reduces pressure on global ecosystems and resource frontiers by reshoring production and emphasizing local reuse		hotspots or unsustainable land use if industrial expansion is unchecked
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Strategic direction addressed:							
<ul style="list-style-type: none"> SD-EI-3: Innovative concepts and niche business developments supporting climate change adaptation objectives are supported financially and through enabling policies. 							
Action	Continue to support human capital and business development initiatives						Existing
Aim of the action: Target human capital and business development support to complement the needs of the labour market							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁰⁶	Funding line	Output indicator	Link to other national activities
Ministry of Education, Research, Development and Youth	Ministry of Economy, Ministry of Finance Ministry of Labour	National	2026-2040	Low to Medium	National (Public Budget), EU funds (ESIF), Private	Number of workers trained or retrained in climate adaptation–relevant professions (e.g., water management, renewable energy, sustainable construction,	Economic Policy Strategy of the Slovak Republic until 2030 First action plan of the Economic Policy Strategy of the Slovak Republic until 2030

²⁰⁶ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						<p>disaster risk management)</p> <p>Number of businesses investing in research, development, or innovation projects focused on climate adaptation technologies (e.g., water-efficient systems, flood protection, nature-based solutions)</p> <p>Number of seminars, training modules, or capacity-building events delivered to businesses and public institutions on EU Taxonomy adaptation criteria and sustainable finance</p>	
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Description of the Action:

This action targets the development of human capital and skills in technical professions that are directly relevant to climate change adaptation and the green transition. The aim is to ensure that the Slovak labour market has the capacity to meet the needs of industries and public institutions in adapting to climate risks and advancing sustainable development.

Activities to be Completed:

- Retraining and Upskilling for Climate Adaptation Professions: Strengthen public-private cooperation in retraining programmes focused on climate-relevant sectors (e.g., water management, renewable energy, sustainable construction, disaster risk management).
- R&D and Innovation for Adaptation Technologies: Support businesses in increasing investment in research, development, and innovation related to climate resilience, such as water-efficient technologies, flood protection systems, and nature-based solutions.

<ul style="list-style-type: none"> • EU Taxonomy Alignment for Climate Adaptation: Provide training and seminars for businesses and public institutions on EU Taxonomy requirements, with a focus on adaptation-related activities and sustainable finance mechanisms. • Financial Incentives for Green Skills and Adaptation Innovation: Explore financial support and incentives (including through Slovak Investment Holding²⁰⁷.) to encourage companies to develop workforce skills and technologies that directly contribute to climate adaptation. 				
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁰⁸
<p>Addresses skills mismatch and supports future-ready workforce</p> <p>Promotes inclusion in emerging job markets through retraining</p> <p>Strengthens collaboration between education, government, and industry</p>	<p>Boosts productivity through innovation and R&D capacity</p> <p>Aligns labour force development with green and digital transitions</p> <p>Supports sustainable industry growth in line with EU Taxonomy</p>	<p>Encourages innovation in green technologies</p> <p>Builds administrative and technical capacity for implementing environmental standards</p> <p>Facilitates compliance with sustainable investment criteria</p>	<p>Short-term: 1–3 years for initiating regular labour market reviews, launching public-private retraining partnerships, and conducting initial training sessions on the EU Taxonomy for both industry and public sector actors.</p> <p>Medium-term: 4–6 years for expanding retraining and upskilling programmes, increasing R&D incentives within businesses, and establishing systems to monitor economic alignment with EU Taxonomy objectives.</p> <p>Long-term: 7–10 years for full integration of innovation and technological development into the economy, achieving a substantial increase in R&D investment by businesses, and embedding labour market adaptability into national employment and education systems.</p>	<p>Low, if programs remain aligned with market and environmental needs</p> <p>Risk may emerge if retraining does not keep pace with evolving technologies or if innovation support favours carbon-intensive industries</p>

4.2.2. Energy

The Energy sector is responsible for providing many of our basic needs, such as electricity for lighting, heating that keeps homes warm and the fuel that powers transportation. Generally, the Energy sector is involved in the extraction, production, refining and distribution of primary energy sources. The Energy sector comprises major energy demand

²⁰⁷ <https://www.sih.sk/en/>.

²⁰⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

sub-sectors, including industry, residential, commercial, transport and agriculture, and the energy supply sub-sectors, including resource extraction, conversion and delivery of energy products²⁰⁹.

Impacts and Risks

The Slovak Republic maintains a balanced energy mix, with its primary energy consumption in 2023 comprising natural gas (22.5 %), nuclear energy (24.5 %), oil (27 %), coal (14.37 %), and renewable sources (104.7 %) ²¹⁰.

The climate impacts assessment indicated that, while a number of climate impacts can be identified for the energy sector, five of these were rated as high priority. The priority impacts include both biophysical and socio-economic impacts. Heat during summers months is a key climate impact, and relevant for the energy sector as it is expected that cooling demand and requirements for electricity grids will increase, leading to increased energy demand during summer months. Climate impacts may lead to impairment of the energy supply, through potential damage to infrastructure; increased damage to high-voltage lines in particular is considered as a high priority impact. Climate impacts such as the increase in the number of flood events may further affect energy infrastructure, with particular impacts depending on the specific energy facility. Additional biophysical impacts, such as increase in bed load of watercourses, may affect energy supply, given the hydropower share in gross energy consumption. Lastly, a high priority impact is the change in seasonal distribution of precipitation, which may also affect the energy supply.

Given the high priority climate impacts, two key risks have been identified in the energy sector. The first is the risk of failure and impairment of energy production, supply and disruption of infrastructure due to extreme events (KR-E-1), which concerns the impact of extreme events, such as floods, on the production and supply of energy as infrastructure is vulnerable to such events. The second is the risk of fluctuations in energy production (KR-E-2), which is closely linked to the expected changes in weather patterns. Whereas the first one (KR-E-1) is expected to be very high in the far future under a pessimistic scenario (RCP8.5), the second one (KR-E-2) shows a medium level of risk according to the assessment.

Actions

Overall adaptation measures should be aimed at diversifying the energy mix, including an expansion of renewable energy sources, which would inadvertently allow to ensure security of energy supply, as well as contribute to ensuring sufficient energy capacity, as energy demand is likely to fluctuate in the future, impacted by altered weather patterns. This diversification should also include nuclear fuel supply, development of small modular reactor (SMR) technologies with climate-resilient siting standards, and promotion of renewable and low-carbon hydrogen, ensuring that site planning reflects water availability and biodiversity sensitivities.

²⁰⁹ European Climate Risk Assessment. Edited by European Environment Agency (EEA). Copenhagen (EEA report, 01/2024). Available online at <https://www.eea.europa.eu/publications/european-climate-risk-assessment>, checked on 3/11/2024.

²¹⁰ UNFCCC (2023). Slovakia. National Communication (NC). NC 8. Biennial Reports (BR). BR 5. <https://unfccc.int/documents/626514>.

Additionally, the energy and electricity infrastructure must be adapted to withstand the impacts of climate change. This requires construction of new transmission lines and renovation of existing ones to climate-resilient standards, phasing out outdated 220 kV systems in favour of more resilient 400 kV lines, upgrading substations to remote-control mode, and expanding interconnection capacity with neighbouring countries. Climate-resilient gas distribution systems are also needed, including replacement of outdated boilers, deployment of smart metering, and optimisation of compressors and network pressure. Energy storage capacity (batteries, hydrogen electrolysis, pumped hydro) must be expanded under technical standards that ensure safe operation during heatwaves, droughts and floods, while hydropower and pumped-storage plants must integrate climate projections for precipitation and biodiversity impacts. These measures should be embedded into national planning and permitting processes and aligned with the Directive (EU) 2022/2557 on the resilience of critical entities (CER Directive).

Lastly, raising public awareness about energy supply and demand is crucial for ensuring energy sufficiency and promoting energy efficiency. Through energy efficiency programmes, support for energy communities and decentralised production, and targeted awareness campaigns, Slovakia can build a more resilient and sustainable energy future.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-E-1: Security of supply from an optimally structured energy and electricity system is ensured, including an expansion of PV-, solar-, wind- and water-based sources, and considering the role of energy supply at the interface of climate mitigation and adaptation. 							
Action	Security of energy supply						New
Aim of the action: Ensure security of energy and electricity supply, including RES expansion							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²¹¹	Funding line	Output indicator	Link to other national activities
Ministry of Economy	Ministry of Environment Authority for Spatial Planning and Construction of the Slovak Republic (ASPC SR) Slovak Energy Regulatory Office Slovak Environmental Inspection Slovak National Grid Renewable Energy Producers and Developers Energy Storage Companies	National	2026-2040	High	National (Public Budget), EU funds (ESIF), Private	Number of new or upgraded interconnectors, SMRs, or major energy facilities designed or retrofitted with climate-resilience standards (e.g., flood safety, heatwave tolerance). Share of new RES (solar, wind, biomass, district heating) projects incorporating adaptation requirements (e.g., site selection considering climate projections and biodiversity impacts, extreme	(Draft) Updated National Energy and Climate Plan; Slovak Recovery and Resilience Plan

²¹¹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						<p>weather protection).</p> <p>Number of hydropower and storage projects (battery, hydrogen, pumped hydro) designed or upgraded to ensure reliable performance under projected climate conditions (drought, storms, floods).</p> <p>Number of legislative updates, planning guidelines, or training events incorporating climate change projections into energy infrastructure planning and permitting.</p>	
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Description of the Action:

Climate-Resilient Interconnectors and Supply Diversification:

- Build new interconnectors with neighbouring countries (e.g. Hungary) and maintain existing ones (e.g. Ukraine and Poland) while ensuring that design and maintenance standards take into account climate projections (e.g., extreme heat, floods, storms).
- Diversify nuclear fuel supply and participate in small modular reactor (SMR) exploration projects, ensuring that siting and safety standards reflect changing climate risks (e.g., cooling water availability during droughts, flood safety).

Renewable Energy Sources (RES) Adapted to Climate Conditions:

- Support small-scale electricity and heat generation installations in buildings, with requirements for resilience to extreme weather (e.g., high temperatures, hail, flooding).
- Develop district heating systems with a focus on climate adaptation - integrating RES and waste heat but also ensuring resilience against heatwaves and droughts.
- Promote renewable and low-carbon hydrogen with site planning that considers water availability and biodiversity sensitivities.

- Encourage energy communities and self-consumers to integrate RES with storage solutions designed to perform reliably under extreme weather conditions.

Energy Storage and Hydropower Adaptation:

- Expand electricity storage (batteries, hydrogen electrolysis, pumped hydro) with standards ensuring reliable operation under heatwaves and storm events.
- For hydropower and pumped-storage plants, consider climate projections for precipitation, drought risk, and biodiversity impacts when planning new installations or upgrading existing ones.

Legislative and Institutional Framework for Resilience:

- Ensure a stable legislative framework and sufficient incentives for energy communities and electricity sharing, with a focus on promoting decentralised, climate-resilient energy systems.
- Incorporate climate change projections into energy planning and permitting processes, particularly for new infrastructure.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²¹²
<p>Empowers communities through energy self-sufficiency and participation in energy production</p> <p>Supports energy affordability and access, especially in residential heating and electricity</p> <p>Enhances public awareness and involvement in renewable energy initiatives</p>	<p>Strengthens national energy security and reduces dependence on imported fuels</p> <p>Stimulates green innovation, infrastructure investment, and job creation in the energy sector</p> <p>Boosts competitiveness through energy cost stability and diversified supply</p>	<p>Accelerates decarbonization and reduces emissions from fossil-based energy systems</p> <p>Supports the integration of renewable hydrogen and clean heating solutions</p> <p>Promotes circular energy flows, including use of waste heat and cogeneration</p>	<p>Short-term: 1–3 years for initiating interconnector projects, exploring SMR opportunities, and establishing support mechanisms for RES in the heating sector.</p> <p>Medium-term: 4–6 years for expanding RES infrastructure (solar, wind, hydrogen) and battery storage systems, as well as developing legislative frameworks for energy communities and electricity sharing.</p> <p>Long-term: 7–15 years for full integration of RES into district heating systems, completion of SMR installations, and widespread adoption of energy storage solutions across the grid.</p>	<p>Technological Lock-in: Over-reliance on transitional fossil-based energy infrastructure or imported nuclear fuel could delay full decarbonization.</p> <p>Inequitable Access: Energy communities and RES self-generation support may benefit mainly wealthier regions or households unless equity measures are embedded.</p> <p>Resource Stress: Large-scale hydrogen or battery production could increase pressure on water and mineral resources if not sustainably managed.</p> <p>Underutilization of Infrastructure: Without effective planning, new interconnectors or district heating upgrades may not be fully utilized, leading to inefficiencies.</p> <p>Over-reliance on specific energy sources (e.g., hydrogen or SMRs) without a comprehensive diversification plan could lead to vulnerabilities if those</p>

²¹² Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

				<p>technologies fail to meet expected capacities or face delays.</p> <p>Exclusion of vulnerable groups in energy community initiatives could exacerbate social inequalities, with some communities facing barriers to accessing new energy solutions.</p>
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Strategic direction addressed:							
<ul style="list-style-type: none"> SD-E-2: Energy and electricity infrastructure (from production to distribution to the end-user) is adapted to changing climatic conditions, e.g. increased risk of grid failure. SD-E-3: The capacity of the energy and electricity system is sufficient to meet potentially changing demands (e. g. increased cooling requirements). Technical innovations ensure that these demands are covered as efficiently as possible. 							
Action	Climate proofing energy and electricity infrastructure						New
Aim of the action: Safeguard energy and electricity infrastructure from climate impacts							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²¹³	Funding line	Output indicator	Link to other national activities
Ministry of Economy	Ministry of Environment Slovak Energy Regulatory Office Slovak Environmental Inspection Transmission and Distribution System Operators Energy Companies and Industry Partners	National	2026-2040	High	National (Public Budget), EU funds (ESIF), Private	Percentage increase in capacity and completion of climate-resilient energy transmission, gas distribution, and energy storage infrastructure projects	Ten Year Transmission System Development Plan 2020-2029 Ten-Year Network Development Plan (Draft) Updated National Energy and Climate Plan Directive (EU) 2022/2557 on the resilience of critical entities (CER Directive)
Description of the Action:							
<p>This action aims to ensure that the Slovak transmission, gas, and electricity systems are developed and modernised in ways that strengthen their resilience to climate change impacts. Infrastructure development and upgrades will integrate climate-proofing and risk assessments, in line with Directive (EU) 2022/2557 on the resilience of critical entities (CER Directive).</p> <p>This consists of: <u>Climate-Resilient Transmission and Distribution Systems:</u></p>							

²¹³ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

- Construct new transmission lines and renovate older ones with technical standards that account for projected climate risks (e.g., heatwaves reducing line efficiency, storm and flood damage).
- Phase out outdated 220 kV lines and replace them with modern, more resilient 400 kV systems.
- Upgrade substations from local/manual to remote control mode, ensuring redundancy and resilience against extreme weather disruptions.
- Expand interconnection capacity (e.g., SK-HU 400 kV) with climate-adaptive design, to secure supply during cross-border disruptions caused by climate events.

Climate-Resilient Gas Distribution:

- Reduce vulnerability of gas distribution networks by replacing outdated boilers with efficient, low-emission, and climate-resilient alternatives.
- Deploy intelligent metering systems and optimise compressors and network pressure to enhance flexibility and reliability during climate-related disruptions.

Storage and Flexibility for Adaptation:

- Increase capacity of energy storage systems (batteries, hydrogen electrolysis, pumped hydro) with technical standards ensuring safe and reliable operation under extreme temperatures, drought conditions, and flooding risks.

Critical Infrastructure Resilience:

- Fully transpose and enforce Directive (EU) 2022/2557 (CER Directive) to enhance the resilience of critical entities in the energy sector, explicitly integrating climate change projections and natural hazard risks into planning, operation, and maintenance.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²¹⁴
<p>Improved energy reliability and resilience enhance public safety and energy security.</p> <p>Job creation through infrastructure upgrades and technological advancements.</p> <p>Enhanced public awareness of energy efficiency and smart grid systems.</p>	<p>Increased transmission capacity supports energy market stability and reduces transmission costs.</p> <p>Investment in energy storage and infrastructure fosters economic growth in the energy sector.</p> <p>Reduced gas distribution intensity and energy efficiency measures cut operational costs for consumers and businesses.</p>	<p>Reduced carbon emissions by optimizing gas distribution and transitioning to cleaner energy sources.</p> <p>Increased energy efficiency and smarter infrastructure minimize environmental impact.</p> <p>Expansion of renewable energy sources and integration of storage facilities contribute to sustainable energy systems.</p>	<p>Short-term: 1–3 years for planning, feasibility studies, and initiation of climate-resilient upgrades to existing transmission lines, substations, and gas distribution systems.</p> <p>Medium-term: 4–7 years for implementation of new interconnections, energy storage installations, and major transmission system upgrades designed for climate resilience.</p> <p>Long-term: 8–15 years for Full operationalization of climate-resilient energy networks, integration of advanced storage solutions, and verification of resilience measures under projected climate conditions.</p>	<p>Delayed adaptation of energy infrastructure could exacerbate vulnerabilities during extreme climate events.</p> <p>Insufficient integration of renewable energy sources into grid expansion may lead to continued dependency on fossil fuels.</p> <p>Failing to update regulatory frameworks could slow down the implementation of new technologies and energy innovations.</p>

Strategic direction addressed:

²¹⁴ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

- SD-E-4 : Awareness raising of the Slovak society with respect to the supply with and demand of energy in the context of climate change ensures energy sufficiency as crucial pillar next to efficiency.

Action Inform the general public about individual measures to be taken with regards to both supply and demand of energy **New**

Aim of the action: The adaptation measure of awareness raising focuses on informing and educating Slovak society about energy supply and demand, specifically in the context of climate change. This action seeks to build resilience against climate-related energy disruptions by ensuring that citizens understand their role in both managing energy demand and supporting a diverse and sustainable energy supply system. This is a crucial component in securing energy sufficiency, alongside improving energy efficiency and promoting renewable energy.

Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²¹⁵	Funding line	Output indicator	Link to other national activities
Ministry of Economy	Ministry of Environment Slovak Energy Regulatory Office Slovak Environmental Inspection Non-Governmental Organizations (NGOs) and Civil Society Groups Slovak Academy of Sciences Industry Associations and Professional Bodies	National, Regional, Local	2026-2040	Low	National (Public Budget), EU funds (ESIF), Private	Number of awareness-raising activities	(Draft) Updated National Energy and Climate Plan

Description of the Action:

²¹⁵ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

The below measures would target multiple facets of public engagement and action, ensuring the broader societal transition toward a climate-resilient energy system. These initiatives should aim to empower individuals, communities, and industries to understand their energy needs, the implications of climate change on energy systems, and how they can contribute through responsible energy use and consumption practices.

Key activities include:

Public Information Campaigns on Energy Supply and Demand:

- Media campaigns (TV, radio, print, and online) that highlight the importance of reducing energy demand and shifting to renewable energy.
- Social media engagement promoting energy-saving tips and actions individuals can take to reduce their consumption.
- Public service announcements (PSAs) on the benefits of energy-efficient appliances, smart meters, and home insulation.

Promotion of Energy Efficiency in Households and Businesses:

- Campaigns focused on the benefits of energy-efficient appliances (e.g., LED lighting, energy-efficient heating systems, and insulation).
- Encouraging businesses to adopt energy management systems and reduce energy use in production processes, transportation, and logistics.
- Information on financial incentives for home energy improvements, such as insulation, new heating systems, or smart home technologies that monitor and reduce energy use.

Strengthening Public Understanding of Renewable Energy Systems:

- Local campaigns to promote the installation of solar panels, wind turbines, and biomass heating systems in households, small businesses, and local communities.
- Information on the benefits of decentralized energy production, such as community-owned renewable energy projects, and how these can help secure energy supply at the local level.

Strengthening Energy Resilience in Communities and Industries:

- Workshops and consultations with local governments and industry representatives on how to implement energy resilience strategies (e.g., backup energy systems, energy storage, and decentralized energy production).
- Pilot projects on microgrids, battery storage systems, and other innovations that enhance energy resilience and help buffer against grid failures or disruptions caused by extreme weather events.
- Promoting the concept of energy communities, where local entities generate, store, and manage energy collectively, reducing overall dependence on central power sources and enhancing local energy resilience.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²¹⁶
Empowerment of individuals and communities to take responsibility for their energy use. Increased public awareness and participation in energy	Growth of local businesses and industries adopting energy-efficient technologies and systems. Cost savings for households and businesses through energy efficiency measures and incentives.	Reduced energy consumption through efficiency measures, lowering carbon emissions. Increased adoption of renewable energy sources, contributing to a cleaner energy mix. Strengthened community resilience to climate impacts by	Short-term: 1–3 years for public campaigns, awareness programs, and pilot projects. Medium-term: 4–7 years for widespread adoption of energy-efficient practices and the installation of renewable energy systems. Long-term: 8–15 years for widespread energy resilience in communities and	Overemphasis on individual actions (e.g., home improvements) may overlook the need for systemic energy infrastructure changes. Insufficient access to financial incentives or information could limit participation in energy efficiency and renewable energy programs.

²¹⁶ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>efficiency and renewable energy initiatives.</p> <p>Building stronger community engagement through energy resilience programs and local energy projects.</p>	<p>Creation of green jobs through the promotion of renewable energy systems and energy management services.</p>	<p>fostering decentralized and renewable energy systems.</p>	<p>industries, with decentralized energy systems fully integrated into the national grid.</p>	<p>Lack of coordination between local, regional, and national energy policies may slow down the transition to a more resilient energy system.</p> <p>Ignoring the diverse needs of vulnerable communities may exacerbate energy inequalities, leaving some groups unable to fully engage with new technologies.</p>
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4.2.3. Financial and Insurance System

The **financial sector** is part of the economy, including firms and institutions that provide financial services to commercial and retail customers. This sector comprises a broad range of industries such as banks, investment companies, insurance companies, and real estate firms²¹⁷. The public sector institutions, such as central banks and financial regulators, oversee the financial system to ensure stability and prevent crises.

The financial system channels funds from those who are net savers (i.e. who spend less than their income) to those who are net spenders (who spend more than their income)²¹⁸.

The **insurance sector** involves companies offering risk management utilising insurance contracts. The basic concept of insurance is that one party, the insurer, guarantees payment for an uncertain future event. Meanwhile, another party, the insured or the policyholder, pays a smaller premium to the insurer in exchange for protection on the uncertain future occurrence²¹⁹.

²¹⁷ Kenton, W. (2021). Financial Sector: Definition, Examples, Importance to Economy. https://www.investopedia.com/terms/f/financial_sector.asp. Accessed 6 June 2024.

²¹⁸ European Central Bank (n.d.). Managing climate-related risks. https://www.ecb.europa.eu/ecb/climate/managing_mitigating_climatel_risk/html/index.en.html. Accessed 6 June 2024.

²¹⁹ <https://www.investopedia.com/ask/answers/051915/how-does-insurance-sector-work.asp>.

Impacts and Risks

Financial systems are severely at risk due to climate change impacts; whereby current risk assessments tend to underestimate the associated adverse effects²²⁰. In Slovakia, financial institutions such as the National Bank of Slovakia are aware of these risks and are taking first steps to deepen the understanding of the consequences that climate change has on financial stability and economy and to raise awareness among other financial institutions²²¹.

Among the most relevant climate impacts is the increase in extreme events. These are strongly linked to the insurance system that is of particular relevance in Slovakia as inhabitants do not pay for technical risk insurance²²². Likewise, property insurance is not mandatory and rising insurance premiums might result in the fact that individuals do not get insurances anymore. In particular against the background of unprecedented levels of global warming, the question arises whether associated climate-related risks will be at all insurable. Furthermore, insurance policies might not have a national focus, given that branches of insurance companies in Slovakia are subsidiaries of multinational corporations. In terms of financial resources, it should be noted that there is an increasing need for adaptation and mitigation. The urgency to act is already at high levels for addressing extreme events, increasing insurance costs as well as for making sufficient financial resources available to invest in mitigation and adaptation.

Three key risks were identified, including the risk of fiscal and individual financial instability and instability of bank portfolios due to climate-related events, in particular extreme weather events (KR-FI-1). There is also a risk of increasing insurance costs and uninsurable climate impacts potentially leading to a loss of risk transfer possibilities (KR-FI-2), expected to reach very high levels in the far future. Likewise, insufficient mitigation and adaptation to climate change is associated with rising costs for society due to inaction.

Actions

Slovakia should adopt a proactive investment strategy, using stress tests and updated risk models with climate projections to better prepare for future risks. Adaptation must be integrated into all policies, supported by sufficient domestic funding, additional EU resources, and financial incentives such as subsidies or tax breaks for climate-resilient investments. At the EU level, Slovakia needs to play an active role in shaping solidarity mechanisms while also developing domestic risk pools and reinsurance schemes. Public finances should be managed prudently, with climate risks incorporated into fiscal planning, full compliance with EU sustainability regulations, and regular impact assessments by public and financial institutions. Awareness campaigns, training for local governments and insurers, and stronger dialogue with the insurance sector will be necessary to expand coverage, update legislation, and adapt insurance schemes to new climate challenges. Finally, mapping and addressing social risks linked to changing insurance policies will help protect vulnerable groups and reduce fiscal pressures on the state.

²²⁰ EEA, 2024. European Climate Risk Assessment. EEA report 01/2024, Kopenhagen. <https://www.eea.europa.eu/publications/european-climate-risk-assessment>. Accessed 11 March 2024.

²²¹ Národná Banka Slovenska, 2021. Climate Pledge of the National Bank of Slovakia: Information for Public. <https://nbs.sk/en/news/climate-pledge-of-the-national-bank-of-slovakia/>. Accessed 6 June 2024.

²²² Technical risk insurance refers to insurance related to technical equipment/machinery.

Strategic directions addressed:							
<ul style="list-style-type: none"> SD-FI-1: Sufficient funding of adaptation and mitigation measures ensures a climate-resilient Slovak society. Climate adaptation-related financial needs in other government sectors/ministries are known, and funding is allocated appropriately. The governmental body is aware of the resulting effects like reduced availability of funds in other fields of action. Funding opportunities from competitive EU programs available to support climate change adaptation efforts at all levels are additionally used. SD-FI-2: Public finances allocation is prudent and under transparent public scrutiny. In their operations, public and financial institutions take into account climate change related risks such as the potential lack of risk transfer (uninsurable climate impacts), have sufficient knowledge concerning climate change related impacts on the financial sector and act accordingly. EU-level obligations are implemented. 							
Action	Mainstream adaptation into public administration budgets						New
Aim of the action: Climate adaptation-related financial needs in other government sectors/ministries are known and funding is allocated appropriately							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²²³	Funding line	Output indicator	Link to other national activities
Ministry of Finance	All Ministries	National	2026-2040	Low	National (Public Budget)	Amount and percentage of budget dedicated to adaptation	
Description of the Action:							
<p>Mainstreaming adaptation into national public administration budgets involves integrating climate change adaptation considerations into the core government budgeting process. This ensures that climate resilience is a priority across all sectors and that adequate resources are allocated to address climate risks. In the first steps the results of the Climate Risk and Vulnerability Assessment are used to prioritise adaptation actions: based on their potential to reduce climate risks, enhance resilience, and achieve cost-effectiveness.</p> <p>In a second step, the budgetary integration should be done along the following elements:</p> <p><u>Baseline Budgeting:</u></p> <ul style="list-style-type: none"> Incorporate climate change considerations into existing budget lines to identify potential synergies and trade-offs. <p><u>Dedicated Climate Budgets:</u></p> <ul style="list-style-type: none"> Allocate specific funds for climate adaptation measures, either as a separate line item or within existing budgets. <p><u>Climate-Proofing Existing Investments:</u></p> <ul style="list-style-type: none"> Ensure that new investments are designed to be resilient to climate change, such as by using climate-resilient infrastructure and technologies. <p><u>Change towards a Climate-Responsive /green Tax Policy:</u></p> <ul style="list-style-type: none"> Consider tax incentives or disincentives to encourage climate-friendly behaviours and investments. This can include taxes on energy, transport, pollution and resources. Taxing sources of environmental pollution and greenhouse gas emissions is an efficient and effective way to combat and adapt to climate change, biodiversity loss and pollution. Revenues generated could be allocated towards Nature-based Solutions (NbS) and other types of adaptation. 							

²²³ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Explore new innovative financial tools, such as green bonds, nature credits, carbon offsetting mechanism and new carbon pricing mechanisms besides ETS to either reduce greenhouse gas emissions and generate revenue for climate adaptation or directly contribute to adaptation.
Provide training to budget officials, planners, and technical staff on climate change concepts, risk assessment, and adaptation strategies.
 Further, Slovakia will actively contribute to the next EU MFF discussion, ensuring that sufficient spendings are linked to adaptation.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²²⁴
<p>Strengthening institutional knowledge and capacity on climate change adaptation across government departments.</p> <p>Promoting accountability and transparency in how adaptation funds are allocated and used.</p> <p>Empowering public administrators with the skills to integrate climate resilience into decision-making processes.</p>	<p>Optimizing government spending by prioritizing cost-effective climate adaptation measures.</p> <p>Stimulating green investment through tax incentives and innovative financial tools like green bonds and carbon offset mechanisms.</p> <p>Leveraging financial resources for nature-based solutions and other sustainable adaptation measures.</p>	<p>Encouraging the use of climate-resilient infrastructure and technologies in public investments.</p> <p>Ensuring that national development projects are designed to withstand climate risks, reducing long-term environmental damage.</p> <p>Channelling revenue from green taxes into funding adaptation measures that improve natural ecosystems and biodiversity.</p>	<p>Short-term: 1–3 years for incorporating climate change considerations into budgeting processes and initial training programs for budget officials.</p> <p>Medium-term: 4–7 years for dedicated climate budgets, climate-proofed investments, and the implementation of tax policies that support adaptation.</p> <p>Long-term: 8–15 years for systemic integration of climate resilience into national public administration budgets, with a sustainable, fully operational climate adaptation financing system.</p>	<p>Focusing too heavily on financial incentives or innovative mechanisms could lead to uneven distribution of resources, with vulnerable populations missing out on necessary support.</p> <p>Failure to assess the full scope of potential climate risks could result in inadequate or misguided investments in adaptation infrastructure.</p> <p>Overreliance on market-driven solutions (e.g., carbon pricing) may not fully address the needs of sectors or regions that are hardest hit by climate impacts.</p> <p>Insufficient coordination between departments could result in fragmented or redundant adaptation efforts, leading to inefficiencies.</p>

Strategic objective addressed:

- SD-FI-3: Schemes and obligations for technical and property insurance are enforced and adapted to climate change and potentially unprecedented climate-related impacts.

Action

Strengthen the insurance scheme

Aim of the action: Strengthen insurance schemes and adapt them to emerging challenges

²²⁴ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²²⁵	Funding line	Output indicator	Link to other national activities
<p>Ministry of Finance of the Slovak Republic (for regulating insurance and financial markets)</p> <p>Slovak Insurance Association (for collaborating with insurance companies on policy adaptation)</p> <p>Ministry of Environment of the Slovak Republic (for coordinating climate-related risk assessments and providing data)</p> <p>Slovak National Bank (for integrating climate risks into financial oversight)</p> <p>Slovak Institute of Hydrology (for providing up-to-date flood and climate data)</p>	<p>Local Governments and Municipalities (for regional implementation and awareness-raising)</p> <p>Insurance Companies (for integrating climate risk into their models and product offerings)</p> <p>Building and Infrastructure Associations (for encouraging resilient infrastructure in insurance requirements)</p> <p>Climate Science and Research Institutions (for providing scientific data and projections)</p> <p>Civil Society Organizations (for engaging the public and increasing climate risk awareness)</p>	National, Local	2026-2040	Medium to High	National (Public Budget), EU funds (Climate and Disaster Risk Reduction Funds), Private	<p>Number of insurance companies complying with climate risk disclosure</p> <p>Percentage of policies covering climate-related damages</p> <p>Percentage of public funding allocated for climate-resilient infrastructure incentives</p> <p>Number of public awareness and capacity-building activities conducted.</p>	<p>National Risk Assessment and Management Plans: Incorporating climate risks into national disaster risk management frameworks.</p> <p>National Financial Instruments for Climate Resilience: Linking financial mechanisms and adaptation subsidies to insurance incentives.</p> <p>EU Regulations on Insurance: Harmonizing with EU legislation on climate adaptation in insurance.</p>
Description of the Action:							

²²⁵ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

This action involves the development and implementation of insurance frameworks that take into account the increasing frequency and severity of climate-related impacts, such as flooding, droughts, heatwaves, and storms. The goal is to ensure that insurance schemes (including both property and technical insurance) adapt to these new risks and that both policyholders and insurance providers are equipped to manage climate-related damages effectively. The action will focus on:

Public Sector-Led Risk Assessment Adaptation:

- Government agencies (e.g., ministries of finance, environment, or disaster management authorities) collaborate with insurers to update risk assessment models to account for projected climate impacts, including extreme weather events and long-term climate trends. This includes integrating climate projections and extreme weather data into national actuarial frameworks, insurance regulation and risk pricing.

Public Policy and Regulatory Measures:

- Revise insurance regulations to require coverage for climate-related damages, including flooding, extreme heat, and storms.
- Revise insurance regulations to require coverage for climate-related damages, such as from flooding, extreme heat, and storms.
- Set standards for climate-resilient retrofitting measures and infrastructure upgrades to qualify for insurance.
- Establish mandatory climate risk disclosure rules for insurance providers, enforced by public authorities, to ensure transparency in pricing, underwriting, and claims management.

Public Awareness and Capacity Building:

- Run public awareness campaigns to educate property owners and business operators on climate risks and the importance of having appropriate insurance coverage that includes climate adaptation measures.
- Provide training for local governments and insurers on integrating climate adaptation into risk management strategies.

Financial Mechanisms:

- Create incentives, such as subsidies or tax breaks, for property owners or businesses that invest in climate-resilient infrastructure, such as flood barriers or heat-resistant roofing, as part of their insurance coverage.
- Support development of publicly backed risk pools or reinsurance mechanisms to manage systemic climate risks.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²²⁶
Increases awareness of climate risks and resilience measures among property owners and businesses.	Potentially increases insurance premiums due to the integration of climate risks into policies.	Improves management of climate-induced damage to infrastructure, thus reducing long-term environmental degradation.	Short-term: 1–3 years for updating risk assessment models to include projected climate impacts, revising insurance policies to cover climate-related risks, and launching public awareness and capacity-building campaigns.	Failure to update risk models could lead to insufficient insurance coverage, leaving individuals and businesses exposed to climate-related losses.
Improves access to climate-resilient insurance coverage for vulnerable populations.	Saves long-term costs through prevention of climate-related damages via resilience measures. Provides economic incentives for	Promotes climate-resilient construction techniques that help mitigate urban heat islands and water runoff.	Medium-term: 4–6 years for implementing mandatory climate risk disclosure for insurance companies, achieve widespread revision of insurance terms, and introduce financial incentives for climate-resilient infrastructure investments.	Overemphasis on financial incentives may neglect the need for deeper systemic changes in infrastructure resilience. Inadequate public awareness could result in property owners neglecting to adapt their infrastructure to future climate risks. Disparities in access to climate-resilient insurance may exacerbate inequalities, leaving vulnerable populations under protected.

²²⁶ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>Strengthens capacity to handle climate-related financial losses and damages.</p> <p>Enhances public understanding of the importance of insurance in climate adaptation.</p>	<p>businesses and homeowners to invest in climate adaptation.</p> <p>Provides potential market opportunities for insurance providers offering climate-resilient products.</p> <p>Offers cost-sharing between public and private sectors for climate-related damage mitigation.</p>	<p>Promotes natural climate solutions within insurance policies, such as floodplain restoration and green infrastructure.</p> <p>Encourages sustainable land use practices through insurance incentives for climate-resilient infrastructure.</p>	<p>Long-term: 7–10 years for the integration of climate-resilient insurance practices across the sector, ensuring nationwide adoption of climate adaptation measures in insurance coverage, and strengthening systemic resilience to climate risks.</p>	
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4.2.4. Tourism

Tourism includes all activities of incoming travellers who visit a place for less than one year for leisure, business or other personal purposes. This includes tourism behaviour and patterns, tourist activities and the use of local infrastructure (e. g. recreational areas and parks, beaches, etc.) by daily visitors and overnight guests. Furthermore, it encompasses the recreation activities of local inhabitants. The sector is highly interconnected with and dependent on the development of many other fields of action and the state of natural areas.

Impacts and Risks

Climate impacts such as decrease in snow precipitation and snow reliability during winter are associated with threatening winter tourism, including its revenue and employment. The lack of snow could lead to fewer winter holiday tourists, who may prefer destinations like the Alps, Dolomites, or Bulgarian mountains, forcing Slovak winter recreation centres to diversify their offers to remain competitive. To adapt, tourism services must focus on alternative activities and services that cater to visitors, leveraging existing infrastructure, entrepreneurial innovation, financial resources and subsidies, highlighting the need for investments. Additional financial resources are also relevant due to adverse impacts of climate extremes as such events may lead to damages of infrastructure and costly repairs and rebuilding. Besides, it might be necessary to restrict visitor movements to ensure visitors safety and heat related extremes lead to an increasing need for sufficient cooling solutions, particularly in urban areas. Conflicts over water use have to be taken into account, particularly water-dependent tourism providers, wellness centres and other water-dependent activities will be affected. Increasing risks of forest and wildfires require respective measures to raise awareness and to ensure wildfire prevention.

These climate impacts are mirrored in three key risks, including a risk of decreasing tourism competitiveness due to increasing costs for tourism providers (KR-T-1). Besides, Slovakian tourist destinations might have to deal with newly emerging competing destinations at national and international level (KR-T-2). Climate impacts such as in extreme events, increase in heat waves, increase in urban heat island effect, decrease in water quality, increase in negative impacts on safety of tourists are associated with the risk of loss of touristic attractiveness, key sources & limited accessibility of tourist attractions. Except for KR-T-2 (low for all time horizons), the associated risks are expected to become more severe throughout the century for both scenarios.

Actions

To increase the resilience of Slovakia’s tourism sector, EU methodological recommendations and climate risk assessments should be incorporated into strategic and environmental planning. Tourism offers must be diversified, with a shift toward wellness, eco-, agro-, gastro- and geo-tourism, supported by green and blue measures in development strategies. Investments in digital technologies are needed to improve visitor experience, marketing, and partnerships with local communities.

Sustainable tourism management should be strengthened through biodiversity protection, better visitor flow management, and preparedness for natural hazards, including interconnected early-warning and information systems. Regular monitoring and evaluation of tourism impacts are essential. Financial incentives and flexible tax schemes should be developed to support businesses that adopt climate-friendly measures, such as ecological tourism and sustainable transport.

Finally, adopting sustainable practices - renewable energy, energy efficiency, and low-carbon transport - will help preserve natural and cultural heritage, strengthen local economies, and ensure long-term competitiveness of Slovakia’s tourism industry.

Strategic directions addressed:							
<ul style="list-style-type: none"> • SD-T-1: Tourism offers are diversified to meet emerging markets and demands and to ensure competitiveness of destinations. • SD-T-2: Tourism is effectively managed based on partnership and data to support sustainability by key resources, including measures in visitor management, adaptation to changing climatic conditions (e. g. cool attractions for extreme heat) and implementation of preventive measures against natural hazards. • SD-T-3: Tourism is sustainable, adapted to climate change and contributes to high quality, climate-friendly life in destinations and supports resilience in changing conditions. 							
Action	Update the national tourism strategy						Existing
Aim of the action: Attract more tourists and promising ventures to Slovakia and ensure sector resilience							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²²⁷	Funding line	Output indicator	Link to other national activities

²²⁷ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Ministry of Tourism and Sports	Local and regional destination management organisations (DMOs)	National	2026-2040	Low	National (Public Budget)	National strategy adopted	
<p>Description of the Action: The National Sustainable Tourism Strategy and action plans for 2030 is currently under development. Current works should set priorities and goals for the climate resilience and sustainable use of the potential of the tourism sector in Slovakia. Mainstreaming climate change adaptation in the revision of the Tourism Strategy shall consider measures such as:</p> <p><u>Diversification of Tourism Offerings:</u></p> <ul style="list-style-type: none"> • Broaden the portfolio of offers to other kinds of tourism to take into account climate change (e.g. decrease in the number of days with snow cover in certain regions and altitudes, limited water availability in the event of long-term drought, etc.), inter alia: <ul style="list-style-type: none"> ○ Promote all-season tourism by developing hiking, cycling, and wellness tourism to compensate for declining winter sports activities. Expand cultural and heritage tourism to attract visitors beyond nature-based attractions ○ Support agritourism and ecotourism to encourage sustainable rural tourism and preserve local traditions ○ Develop spa and wellness tourism using Slovakia’s natural thermal springs as a climate-independent attraction ○ Offer complementary interior activities around noon during hot summer days and limit certain outdoor activities (e.g., barbecue) to reduce risks of wildfires. ○ Strengthen partnerships with local communities to develop authentic and culturally sensitive tourism experiences <p><u>Sustainable Natural Resource Management:</u></p> <ul style="list-style-type: none"> • Implement visitor management strategies in national parks to prevent environmental degradation and overcrowding • Encourage the use of sustainable transport options (e.g., electric buses, cycling infrastructure) for tourist travel • Promote water conservation in tourist facilities, especially in areas prone to drought <p><u>Education and investment:</u></p> <ul style="list-style-type: none"> • Offer awareness raising and training events for tourism actors on climate change adaptation, subsequently raising the environmental awareness of employees and customers. • Incorporation of the Slovak methodological recommendations number 2 and partially 5, 9, 10 for assessment of investment risks linked to negative consequences of climate change developed by the Slovak Environmental Agency in 2023²²⁸ into processes at the level of strategic and environmental assessment (SEA and EIA) <p><u>Implement a tourist tax for paying for adaptation measures in the sector Information services for tourists:</u></p> <ul style="list-style-type: none"> • Aligned with disaster risk reduction management, ensure that information services for visitors in case of natural catastrophes are set up and available to tourist accommodation, Destination Management Organisations (DMOs), and tourist attraction providers. This includes timely warning and necessary information on how to behave in the event of emergencies. Digital solutions should be prioritised. • Improve information services on tourist health, including necessary vaccinations, preventive measures against ticks and mosquitoes, pollen warning service and advice for allergy sufferers. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective		Systemic risks²²⁹		

²²⁸ <https://metodiky.sazp.sk/>.

²²⁹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>Engaging local communities in the development of sustainable and culturally sensitive tourism offerings.</p> <p>Promoting public awareness of climate change impacts on tourism, fostering responsible behaviour among tourists and operators.</p> <p>Encouraging a shift in consumer behaviour towards more sustainable and climate-resilient tourism options.</p>	<p>Diversifying tourism offerings to adapt to climate change, ensuring that Slovakia remains an attractive destination in all seasons.</p> <p>Supporting local businesses through agritourism and ecotourism to preserve local traditions while promoting sustainable economic growth.</p> <p>Investing in climate-resilient infrastructure and services (e.g., water conservation measures, electric transport) to enhance the sustainability of the tourism sector.</p>	<p>Mitigating climate impacts on tourism by promoting sustainable practices, such as eco-friendly transport options and responsible resource management.</p> <p>Protecting natural resources and reducing environmental degradation through sustainable visitor management in national parks and other protected areas.</p> <p>Encouraging tourism that aligns with conservation goals, such as wellness tourism utilizing Slovakia's thermal springs.</p>	<p>Short-term: 1–3 years for revising the Tourism Strategy, developing a diverse tourism portfolio, and launching awareness campaigns for stakeholders.</p> <p>Medium-term: 4–7 years for the implementation of visitor management strategies, the introduction of sustainable transport options, and the integration of climate change adaptation in strategic and environmental assessments.</p> <p>Long-term: 8–15 years for a fully climate-resilient tourism sector with widespread adoption of sustainable practices, the operationalization of tourist taxes for adaptation, and successful mainstreaming of climate resilience across the sector.</p>	<p>Focusing too much on diversifying tourism offerings without proper environmental safeguards could lead to overdevelopment/overtourism and environmental degradation.</p> <p>Promotion of all-season tourism may place additional pressure on natural areas, leading to overcrowding and loss of biodiversity.</p> <p>Insufficient planning for water conservation in tourist facilities could exacerbate water scarcity in vulnerable areas during droughts.</p> <p>Lack of coordination with local communities in the development of tourism may result in cultural insensitivity and erosion of local traditions.</p>
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4.3. Cluster Safety and Well-being

This cluster addresses the physical safety, health, and digital resilience of Slovak society in the face of accelerating climate impacts. The adaptation actions within this group are built upon a wide array of national and international sources, including the 2018 NAS and 2021 NAP, the National Environmental Health Action Plan (NEHAP V), civil protection frameworks, EU-level ICT security directives (e.g. Directive 2022/2555), and global best practices from the WHO and European Civil Protection Mechanism. Additionally, stakeholder recommendations and scenario-based expert input helped shape a set of practical and scalable interventions.

Altogether, the cluster comprises 7 adaptation actions: four actions in the Disaster Risk Management & Civil Protection sector, one in the Health sector, and two in the Information and Communication Technology (ICT) sector. These actions are designed to ensure climate-resilient infrastructure and services, reduce loss of life and property from climate-induced disasters, and strengthen public health systems and digital networks to withstand heatwaves, floods, disease outbreaks, and service disruptions.

Responsibility for implementation is shared across a broad institutional landscape. Key actors include the Ministry of the Interior (responsible for civil protection), the Ministry of Health, the Ministry of Investment and Regional Development, and the Ministry of Environment. Civil protection units, local governments, public health authorities, ICT regulators, private telecom providers, and emergency response services all play essential operational roles. In the health and digital sectors, universities and specialized agencies also support research, preparedness, and system upgrades.

Implementation timeframes span all levels of urgency. Several actions - such as updating risk and vulnerability assessments, improving early warning systems, and strengthening community emergency planning - can and should be initiated immediately. Medium-term activities include upgrading ICT infrastructure for climate resilience and investing in mobile public health units. Long-term goals include systemic transformation in how disaster risk is managed across sectors and levels of government, the full digitization and decentralization of risk response systems, and the mainstreaming of climate resilience in the national healthcare system. Geographically, these actions apply across the entire Slovak territory but are particularly crucial in high-risk zones exposed to floods, landslides, extreme heat, or where digital and healthcare access is limited.

4.3.1. Disaster risk management, Civil protection and critical infrastructure

Disaster Risk Management (DRM) is defined as “processes for designing, implementing and evaluating strategies, policies and measures to improve the understanding of current and future disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, prevention and protection, response and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life and sustainable development”²³⁰.

²³⁰ IPCC, 2022d. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

While there is no official definition of **Civil Protection**, it can be understood as the protection of people, the environment and property against both natural and man-made disasters. This involves planning, preparation and response activities, including deployment of forces and equipment as appropriate.

In Europe, **Critical Infrastructure** is defined by the European Union legislation²³¹ as “an asset, a facility, equipment, a network or a system, or a part of an asset, a facility, equipment, a network or a system, which is necessary for the provision of an essential service”.

Impacts and Risks

Significant climate impacts for Slovakia’s Disaster Risk Management, Civil Protection, and Critical Infrastructure (DRM) sector refer to the increase of frequent extreme weather events, such as floods (45% of natural events), landslides and mudslides, severely affecting low-lying and critical infrastructure. Prevention measures are assessed as inadequate, especially for landslides and mudslides, leading to prolonged recovery times. Key risks identified include widespread disruptions from floods, wildfires and extreme weather, causing infrastructure damage and accessibility issues (KR-DRM-1), increased costs for maintenance and emergency response due to climate change impacts (KR-DRM-2), and vulnerable groups disproportionately affected by intensifying climate extremes (KR-DRM-3). The urgency for action varies from medium to high, with risks rated as very high under pessimistic future scenarios.

Actions

Overall adaptation measures for disaster risk management (DRM) should aim to build a resilient society that effectively anticipates, mitigates, and responds to the growing risks posed by climate change and natural disasters. This involves integrating climate risk assessments into all levels of planning, enhancing early warning systems, and ensuring that critical infrastructure and communities are prepared for extreme events. Measures should focus on preventive actions, such as land-use planning, nature-based solutions, and retrofitting existing infrastructure, while strengthening emergency response capabilities through improved coordination, technical resources, and community engagement. The ultimate goal is to safeguard lives, property, and ecosystems while ensuring compliance with EU directives and fostering long-term resilience.

Strategic direction addressed:

- SD-DRM-1: Critical infrastructure, civil protection and disaster risk management are in place, reflecting relevant laws of the European Union and account for climate change impacts and associated risks to ensure a resilient Slovak Republic.

²³¹ European Commission (2022b). Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the resilience of critical entities and repealing Council Directive 2008/114/EC (Text with EEA relevance). 2022/2557.

Action	Strengthening Climate-Resilient Critical Infrastructure and Disaster Preparedness						Existing
Aim of the action: To enhance the resilience of critical infrastructure and improve civil protection systems by duly considering climate-related risks into disaster risk management practices for disaster prevention and preparedness and ensuring compliance with EU regulations.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²³²	Funding line	Output indicators	Link to other national activities
Ministry of Interior	Ministry of Environment Slovak Hydrometeorological Institute Ministry of Finance	National	2026-2040	Low to Medium	National (Public Budget), EU (ESIF)	Number of climate risk and vulnerability analyses conducted for critical infrastructure sectors, including hazard mapping, identification of high-risk nodes, and nature-based solutions Percentage of critical infrastructure retrofitted or newly designed to withstand climate change impacts, including public buildings and essential facilities Number of national adaptation guidelines	Implementation of the Critical Entities Resilience Directive (EU) 2022/2557 National Strategy for Risk Management of Security Threats of the Slovak Republic ²³³

²³² Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²³³ <https://www.minv.sk/?tlacove-spravy&sprava=vlada-schvalila-narodnu-strategiu-riadenia-rizik-bezpecnostnych-hrozieb-slovenskej-republiky>.

						<p>published and adopted.</p> <p>Climate resilience fund established to finance infrastructure adaptation and disaster preparedness projects</p> <p>Percentage of DRM program costs covered by external funding sources (EU, PPPs, etc.) and leveraged for policy implementation, spatial planning, and monitoring activities.</p>	
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Description of the Action:

Develop and implement a climate robust and comprehensive disaster risk management (DRM) system including the following activities:

Risk and Vulnerability Assessment:

- Conduct climate risk and vulnerability analyses for all critical infrastructure sectors (energy, transportation, water, telecommunications).
- Develop detailed hazard maps, including flood, drought, geological and heatwave risks, using updated climate projections.
- Identify infrastructure nodes with the highest risk of cascading failures (e.g., energy grid dependencies on water systems).

Climate-Resilient Infrastructure Planning:

- Integrate climate resilience criteria into the design and construction of new infrastructure projects, following EU standards and good practices.
- Retrofit existing critical infrastructure to withstand climate change impacts, including the reinforcement of bridges, levees, and electrical grids.
- Introduce climate-proofing guidelines for public buildings and facilities used in disaster response (e.g., hospitals, fire stations).

Risk-Informed Spatial Planning:

- Integrate Hazard Maps into Planning Processes and request municipalities and regional authorities to incorporate updated flood, drought, and landslide risk maps into land-use plans, ensuring development avoids high-risk areas.
- Establish and enforce no-build zones in areas prone to severe flooding, erosion, or landslides to minimize exposure of critical infrastructure.
- Create buffer zones around essential infrastructure (e.g., energy plants, hospitals) to reduce risk from natural hazards.

- Limit urbanisation and industrial development in areas susceptible to climate risks, such as floodplains and steep slopes.
- Promote clustering of infrastructure in areas with low climate risk to optimise land use and reduce costs for protective measures.
- Encourage permeable land use by prioritising green infrastructure, such as wetlands and urban forests, to enhance water retention and reduce flood risks in urban areas.
- Promote and implement nature-based solutions such as wetland conservation and restoration to act as natural buffers against flooding and water scarcity or afforestation and soil stabilisation measures on degraded lands near infrastructure sites to prevent landslides and soil erosion.

Policy and Legislative Alignment:

- Update Slovakia’s critical infrastructure and disaster risk management frameworks to align with EU directives, including the EU Floods Directive for water-related infrastructure; the Critical Infrastructure Protection Directive for safeguarding essential systems; the European Civil Protection Mechanism for coordinated disaster response.
- Develop national adaptation guidelines for sectors essential to disaster resilience, such as health care, transportation, and energy.

Financial and Resource Mobilization:

- Create a dedicated climate resilience fund to finance infrastructure adaptation and disaster preparedness projects.
- Leverage EU funding mechanisms, such as the Cohesion Fund and the European Regional Development Fund (ERDF), for climate adaptation initiatives.
- Incentivise public-private partnerships (PPPs) to bring innovation and investment into resilient infrastructure development.

Monitoring and Evaluation:

- Develop a national resilience scorecard²³⁴ to measure progress in critical infrastructure adaptation and disaster readiness. The purpose of such as Scorecard would be:
 - Benchmarking resilience: Establish a standardized way to evaluate the readiness of critical infrastructure (e.g., transportation, energy, healthcare, water systems) against natural disasters, climate change, cyber threats, and other risks.
 - Tracking progress: Identify improvements over time and highlight gaps in adaptation and emergency preparedness.
 - Guiding policy and investment: Inform government agencies, industries, and communities on where resources and funding should be allocated.
 - Enhancing coordination: Foster collaboration between federal, state, and local authorities, as well as private sector stakeholders, to improve resilience.
- Regularly review and update risk assessments and disaster management plans based on evolving climate data and lessons learned from previous incidents.
- Engage independent experts to conduct audits of adaptation measures to ensure accountability and effectiveness.

²³⁴ A National Resilience Scorecard is a structured assessment tool designed to measure a country's progress in critical infrastructure adaptation and disaster readiness.

A comprehensive scorecard would assess resilience across multiple dimensions, including:

Category	Metrics/Indicators
Infrastructure Readiness	Condition of roads, bridges, energy grids, water treatment plants, etc.
Disaster Preparedness	Emergency response plans, training programs, and drills for various hazards.
Climate Adaptation	Measures taken to protect against extreme weather (e.g., flood defences, fire prevention).
Cybersecurity	Protection of digital infrastructure from cyber threats and data breaches.
Community & Social Resilience	Public awareness programs, evacuation procedures, and support systems.
Economic Resilience	Business continuity planning, insurance coverage, and financial preparedness.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²³⁵
<p>Protecting vulnerable populations by reducing exposure to climate-related disasters.</p> <p>Increasing public safety through resilient infrastructure and emergency preparedness.</p> <p>Enhancing local governance capacity and community participation in disaster planning.</p>	<p>Reducing economic losses from climate-related disruptions to critical infrastructure.</p> <p>Attracting investment through stable and climate-resilient infrastructure systems.</p> <p>Mobilizing funding and incentivizing innovation via public-private partnerships (PPPs).</p>	<p>Promoting nature-based solutions (e.g., wetland restoration, afforestation) to complement grey infrastructure.</p> <p>Minimizing development in ecologically sensitive and high-risk areas.</p> <p>Enhancing land and water resource sustainability through integrated risk-informed planning.</p>	<p>Short-term: 1–3 years for updating building codes and technical guidelines, piloting climate-resilient materials, and initiating early warning system upgrades.</p> <p>Medium-term: 4–7 years for scaling up use of reflective and flood-resilient materials, implementing green infrastructure and smart monitoring across priority areas, and retrofitting vulnerable infrastructure.</p> <p>Long-term: 8–15 years for full integration of climate-resilient technologies and nature-based solutions across all infrastructure sectors, supported by ongoing monitoring, adaptive management, and maintenance strategies.</p>	<p>Relying solely on grey infrastructure without integrating nature-based solutions may increase environmental degradation.</p> <p>Poorly planned spatial restrictions could hinder socioeconomic development if not balanced with local needs.</p> <p>Failure to update hazard maps and climate projections may result in underprepared infrastructure.</p> <p>Over-concentration of infrastructure in designated “safe” zones without adequate resilience planning could lead to bottlenecks or systemic vulnerabilities.</p>

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-DRM-2: Effective preventive and emergency measures are implemented at all levels of governance to ensure resilience of communities, settlements and critical infrastructure against natural disasters. Current emergency response systems are evaluated and adapted where necessary to ensure readiness in extreme events even under altered conditions, including ensuring sufficient funding and provision of technical sources. 							
Action	Development of a Comprehensive Multi-Level Emergency Preparedness and Response Program						Existing
Aim of the action: To enhance the resilience of communities, settlements, and critical infrastructure by implementing robust, climate-adapted preventive and emergency response measures across all levels of governance, ensuring effective readiness for natural disasters.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs	Funding line	Output indicators	Link to other national activities

²³⁵ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

				(high-medium-low) ²³⁶			
Ministry of Interior	Ministry of Environment Slovak Hydrometeorological Institute Ministry of Finance	National, Local	2026-2040	Low to Medium	National (Public Budget), EU (ESIF)	Number of emergency response systems updated that integrate preventive measures and address altered climatic conditions Number of personnel trained in emergency preparedness and response (by level: local, regional, national). Number of public awareness campaigns conducted.	National Strategy for Risk Management of Security Threats of the Slovak Republic ²³⁷
<p>Description of the Action:</p> <p><u>Evaluation and Modernisation of Emergency Response Systems:</u></p> <ul style="list-style-type: none"> • Conduct a nationwide assessment of existing emergency response protocols and infrastructure to identify gaps and inefficiencies. • Update response systems to reflect risks associated with altered climatic conditions, such as identified in the climate impact and risk assessment <p><u>Capacity Building for Emergency Services:</u></p> <ul style="list-style-type: none"> • Train emergency response personnel on new and emerging risks, including the use of advanced technologies like drones and geographic information systems (GIS) for real-time monitoring and response. • Organise regular multi-stakeholder disaster simulation exercises at local, regional, and national levels to test readiness and coordination. • Strengthening Early Warning Systems (EWS) <p><u>Community-Based Disaster Risk Reduction (CBDRR):</u></p>							

²³⁶ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²³⁷ <https://www.minv.sk/?tlacove-spravy&sprava=vlada-schvalila-narodnu-strategiu-riadenia-rizik-bezpecnostnych-hrozieb-slovenskej-republikym>.

- Empower communities to develop localised disaster response plans, ensuring alignment with national and regional frameworks.
- Provide training and resources to local governments and community groups to enhance grassroots preparedness and recovery efforts.

Strengthen Civil Protection Systems:

- Expand EWS to cover a broader range of climate risks, leveraging real-time monitoring technologies, geospatial data and AI-based risk prediction models.
- Ensure EWS reaches all communities, including vulnerable and remote areas, through multiple communication channels (e.g., mobile alerts, sirens, social media).
- Develop public education campaigns to increase community preparedness for climate-induced disasters, such as flash floods or extreme heat events.
- Conduct regular drills and training exercises for emergency response teams, simulating scenarios linked to climate change.

Emergency Response Enhancements:

- Establish regional hubs for disaster response with pre-positioned supplies and mobile infrastructure to ensure rapid deployment during emergencies.
- Create a centralised national disaster database for tracking incidents, assessing risks, and guiding resource allocation.
- Strengthen cross-border cooperation with neighbouring EU countries to address transboundary climate risks and align disaster response protocols.

Monitoring and Continuous Improvement:

- Develop a real-time incident reporting and data analysis platform to monitor emergency responses and identify lessons learned after each event.
- Periodically review and adapt response plans based on evolving climate projections, disaster experiences, and technological advancements.

Provision of Sufficient Resources:

- Secure dedicated funding for preventive and emergency measures, prioritising investment in resilient infrastructure, emergency equipment, and reserve supplies.
- Establish resource-sharing agreements between local and regional governments to optimise the use of technical equipment and expertise during crises

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²³⁸
Enhances safety and preparedness of local communities, especially vulnerable groups. Empowers citizens and local authorities through training and community-based disaster planning. Builds public trust through transparent risk communication and inclusive participation.	Reduces economic disruption and recovery costs by improving rapid disaster response. Stimulates innovation and investment in risk monitoring technologies and emergency infrastructure. Promotes cost-efficiency through regional cooperation and resource-sharing.	Integrates climate risk data into emergency planning to better protect natural assets. Supports ecosystem preservation by mitigating secondary environmental damage during disasters. Encourages sustainable disaster preparedness that accounts for long-term climate trends.	Short-term: 1–2 years for assessment of current systems, training of personnel, and initial EWS expansion. Medium-term: 3–5 years for community-based planning, technology upgrades, and regional coordination mechanisms. Long-term: 6–10 years for full institutional integration, cross-border protocols, and ongoing adaptive system reviews.	Overreliance on high-tech systems (e.g., AI, drones) without community training may create operational gaps during outages. Inadequate outreach to remote or disadvantaged areas could lead to unequal access to early warnings. Excessive centralisation of response hubs may reduce flexibility and delay interventions in peripheral regions. Neglecting regular updates and scenario testing may result in outdated or

²³⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

				ineffective emergency plans as climate risks evolve.
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4.3.2. Health care

Health is defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” by the World Health Organization²³⁹. Thus, the three components of ‘health’ evaluated to assess climate risks and vulnerabilities are physical health, mental health and general well-being. Key predictors of well-being used by the IPCC include annual income, access to food and water, a healthy environment and access to green spaces²⁴⁰. Although usually assessed separately, physical health, mental health and well-being are inter-connected – any type of health problem can reduce overall well-being and vice versa.

Impacts and Risks

Significant health concerns and changes in health conditions are associated with climate change. The rise in temperatures and extreme heat conditions is associated with a rise in illnesses, mortality, and morbidity during heat waves, resulting particularly in increased numbers of heat strokes, heart attacks and collapses due to heat. There is also an increase in newly emerging diseases. Vector-borne diseases are on the rise, with 10 out of 60 mosquito species in Slovakia now being invasive and transmitting such diseases. Similarly, the number of cases of tick-borne encephalitis and waterborne diseases (including hepatitis and diarrhoea) in Slovakia is expected to increase as a result of climate change.²⁴¹ Another indirect consequence of climate change on health originates from potentially changing ultraviolet radiation which plays an important role in the development of skin cancer, cataracts and other eye diseases, and suppresses the immune system²⁴². A reduction in work performance is also linked to increasing numbers of summer and tropical days and nights, affecting physical health, psychological well-being, and productivity. Mental health issues, including anxiety and depression, are rising, particularly among younger generations, due to concerns about climate change and inadequate solutions.

Additionally, the spread of invasive plants and animals also contributes to health risks, with invasive vegetation increasing allergen concentrations and insects posing threats as disease vectors. Due to changes in pollination, pollen load, and allergenicity, exacerbated by the extended pollen season and shorter and milder winters, allergies are

²³⁹ IPCC, 2022d. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

²⁴⁰ IPCC (2022). Chapter 6: Cities, Settlements and Key Infrastructure. In: IPCC (Ed.) Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of working group 2 to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, New York.

²⁴¹ Ticks in Slovakia are spreading to higher altitudes and are active for longer periods due to milder winters, increasing the risk of tick-borne encephalitis outbreaks (World Health Organization (WHO), 2022. Health and climate change: country profile 2021: Slovakia. <https://www.who.int/publications/i/item/WHO-HEP-ECH-CCH-21.01.11>).

²⁴² Government of the Slovak Republic (2019): New action plan for the environment and health of the inhabitants of the Slovak Republic, NEHAP V. Online available under: <https://www.uvzsr.sk/web/uvz/akcny-plan-pre-zivotne-prostredie-a-zdravie-obyvatelov>.

increasing. Extreme weather events affect groundwater levels, leading to fluctuations impacting the availability and quality of drinking water, especially during floods. This issue is particularly severe in villages where households use questionable well water to save money and/due to a lack of sufficient infrastructure²⁴³. Marginalised Roma communities are particularly at risk due to lower water network connections.

As a result, four key risks have been identified, addressing the risk to human health from extreme heat events and overall increase in heat (KR-H-1), increasing in air-, insect-, water-and food-borne diseases, pathogens and allergens (KR-H-2), lacking access to public water infrastructure (KR-H-3) as well as health-related increases in economic losses and burdens (KR-H-4). These risks are expected to reach high to very high levels in the far future under both an optimistic (RCP4.5) and pessimistic scenario (RCP8.5).

Actions

The actions presented below fall under the auspices of several authorities, however, all follow the conceptions first set out in the Fifth Slovak National Environmental Health Action Plan V (NEHAP V) from 2019. The primary objective of NEHAP V is to minimize risks from the environment that may harm and endanger human health through the proposed activities of each priority area, which includes climate change. NEHAP V is further recognized as an effort to integrate climate change adaptation into health sectoral policies, plans and programmes. The Vision and development strategy of Slovakia until 2030 and Water policy concept of the Slovak republic until 2030 with a view to 2050 further build upon the NEHAP V to set out improvements in wastewater treatment and sanitation systems by incorporating climate proofing practices, adaptive wastewater treatment technologies, hydraulic capacity upgrades, as well as prioritising the remediation of environmental burdens in the catchment areas of water bodies in poor condition or causing a risk of failure to achieve good status of water bodies. Governance frameworks, legislative support, and financial incentives are emphasized to enable municipalities and private actors to invest in climate-resilient water infrastructure, ensuring social inclusion and access for vulnerable communities.

To increase awareness on concrete health measures individuals can take during extreme environmental conditions, specific campaigns are recommended following the topics and recommendations outlined in the document on environmental emergencies (*Mimoriadne environmentálne situácie*)²⁴⁴:

- Floods
 - Health risks, their causes and (in)direct health consequences of floods
 - Basic hygiene requirements for the protection of health after floods
 - The risk of transmittable diseases as a result of floods and the principles for preventing their occurrence
- Excessive mosquitoes
 - The lifecycle of mosquitoes
 - Health risks

²⁴³ <https://spravy.stvr.sk/2024/04/na-slovensku-stale-existuju-stovky-obci-bez-pitnej-vody-sposob-zivota-tam-prirovnali-k-afrike/>

²⁴⁴ <https://www.uvzsr.sk/documents/d/uvz/portal-mimoriadne-environmentalne-situacie-1->

- Principles of protection against mosquitoes
- “Calamitous” mosquitoes²⁴⁵
- Mosquito control principles and measures to prevent calamitous mosquito breeding
- Extreme heat
 - Health risks connected to extreme heat
 - Recommended guidelines during extreme heat

Strategic direction addressed:							
<ul style="list-style-type: none"> ● SD-H-1: Slovak healthcare infrastructure is adapted to changing demands and climate risks resulting from heat waves and diseases. Sufficient capacities are available, i.e. training, infrastructure, energy, human and financial resources, complemented by available information for the general public and sufficient accessibility to healthcare infrastructure, both specifically for vulnerable groups and including mental health. Protection through state and emergency mechanisms are ensured. 							
Action	Develop and implement a National Heat-Resilient Healthcare Infrastructure Program						New
Aim of the action: The National Heat-Resilient Healthcare Infrastructure Program aims to enhance Slovakia’s healthcare system’s ability to withstand heat waves and climate-related health risks by strengthening hospital infrastructure, increasing workforce capacity, improving accessibility for vulnerable populations, and integrating early warning systems. This ensures that healthcare services remain effective, accessible, and well-prepared to address both physical and mental health challenges caused by climate change.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁴⁶	Funding line	Output indicator	Link to other national activities
Ministry of Investments, Regional Development and Informatisation	Ministry of Health, Office of the Deputy Prime Minister of the Slovak Republic for the Recovery Plan and the Knowledge Economy	National, Local	2026-2040	Medium	National (Public Budget), EU (ESIF)	Number of healthcare facilities upgraded with heat-resilient infrastructure and emergency preparedness measures	National Environmental Health Action Plan V (NEHAP V) Vision and development strategy of Slovakia until 2030

²⁴⁵ A calamity is an occurrence of mosquitoes when several dozen – a weak calamity, or several hundred – a strong calamity, attacks on one person can be recorded in one minute.

²⁴⁶ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

							Water policy concept and Water Plan ²⁴⁷
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Description of the Action:

The program focuses on adapting Slovakia’s healthcare infrastructure to climate risks, particularly extreme heat and related health challenges and includes the following activities:

Climate-Resilient Hospital Infrastructure:

- Retrofit hospitals and healthcare centres with heat-resistant materials, cooling systems, and green infrastructure (e.g., rooftop gardens, shaded areas).
- Establish backup energy sources (solar panels, microgrids) to ensure operations during heat waves and extreme weather events.

Expansion of Healthcare Workforce & Training:

- Increase specialized training for healthcare professionals on heat-related illnesses (e.g., dehydration, heatstroke, cardiovascular stress).
- Recruit additional medical personnel in high-risk regions to prevent capacity overload during climate-induced health crises.

Targeted Support for Vulnerable Populations:

- Implement mobile healthcare units to reach remote and elderly populations during extreme heat.
- Provide mental health support services addressing heat stress and climate anxiety.

Public Awareness & Preparedness:

- Run public education campaigns on hydration, recognizing heat-related symptoms, and emergency response steps.

Integrated Emergency Response & Policy Coordination:

- Strengthen coordination between health authorities, emergency responders, and municipalities to ensure rapid response.
- Increase funding for climate adaptation in healthcare (especially after the end of the funding from Recovery and Resilience Plan in 2026), including EU funding mechanisms for resilient healthcare infrastructure.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁴⁸
Protects vulnerable populations, including elderly and remote communities, from heat-related health risks. Improves healthcare accessibility during climate-induced crises through mobile units and outreach.	Prevents economic losses by reducing healthcare system overload during extreme weather events. Encourages investment in resilient infrastructure, boosting innovation in green and energy-efficient technologies. Secures continued service delivery, protecting	Promotes green hospital design using heat-mitigating features like rooftop gardens and natural shading. Encourages sustainable energy use through solar panels and microgrids in healthcare facilities. Supports environmentally conscious health adaptation measures that align with broader climate goals.	Short-term: 1–2 years for workforce training, awareness campaigns, and mobile healthcare deployment. Medium-term: 3–5 years for retrofitting healthcare facilities and installing renewable backup systems. Long-term: 6–10 years for full integration into national healthcare strategy and securing sustained funding.	Retrofitting without proper ventilation or urban planning may increase energy demand and urban heat effects. Focusing only on infrastructure could neglect necessary behavioural and policy changes for long-term resilience. Inadequate rural coverage may widen the urban–rural healthcare gap during climate emergencies.

²⁴⁷ https://www.minzp.sk/files/sekcia-vod/kvps2030_web.pdf and <https://www.minzp.sk/voda/vodny-plan-slovenska/>.

²⁴⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

Enhances public awareness of heat-related health threats and response strategies.	workforce productivity and reducing long-term public health costs.			Relying solely on temporary funding (e.g., RRP) without a long-term financing strategy could limit sustainability.
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Strategic objective addressed:							
<ul style="list-style-type: none"> SD-H-2: The resilience of the population (especially disadvantaged groups) is strongly supported. People are aware of health risks, including mental health, due to heat and risks resulting from air-, food-, water- or vector-borne diseases. 							
Action	Inform the general public about individual measures to be taken in environmental emergencies						Existing
Aim of the action: Increase the scale of awareness-raising campaign about health risks and adaptation measures to environmental emergencies							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁴⁹	Funding line	Output indicator	Link to other national activities
Public Health Office of the Slovak Republic		National	2026-2040	Low	National (Public Budget), EU (ESIF) I	<p>Number of individuals reached through awareness-raising campaigns on environmental emergencies.</p> <p>Number and type of awareness-raising campaigns on environmental emergencies per year.</p>	<p>Healthy summer: the big manual for the summer heat (<i>Zdravé leto: Veľký manuál letných horúčav</i>)</p> <p>Environmental emergencies (<i>Mimoriadne environmentálne situácie</i>)</p>
Description of the Action:							
<u>Awareness raising:</u>							
The document on environmental emergencies (<i>Mimoriadne environmentálne situácie</i>) ²⁵⁰ details emergency situations and provides measures for individuals to either help prevent them or take appropriate action following exposure to environmental emergencies. The aim of this action is to raise awareness of measures individuals can take to prevent or adapt to the impacts of climate change, especially during periods when such environmental emergencies are likely to occur. Those awareness raising campaigns could additionally be based on the manual ²⁵¹ of							

²⁴⁹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁵⁰ <https://www.uvzsr.sk/documents/d/uvz/portal-mimoriadne-environmentalne-situacie-1->

²⁵¹ https://www.uvzsr.sk/web/uvz/home/-/asset_publisher/lgb/content/zdrave-let-2023-velky-manual-letnych-horucav.

actions and recommended measures (published by the Public Health Office) for all age groups to ensure safe handling and storing of food and water, hydration best practices, safe practices indoors and outdoors (including swimming best practices), extreme events as a result of extreme heat such as storms and torrential rain. All recommendations emphasise the need to ensure vulnerable groups such as children, seniors and those with pre-existing health conditions.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁵²
<p>Increases public understanding of climate-related health and safety practices.</p> <p>Supports vulnerable groups (e.g., children, elderly, people with health conditions) during environmental emergencies.</p> <p>Promotes safe behaviours during extreme weather events like heatwaves and storms.</p>	<p>Reduces healthcare costs by promoting preventive measures and early risk awareness.</p> <p>Minimizes disruption to daily life and labour productivity during extreme climate events.</p> <p>Low-cost investment with high return in public safety and resilience.</p>	<p>Encourages individual behaviours that help prevent environmental emergencies (e.g., proper waste handling, water conservation).</p> <p>Reduces pressure on emergency services and infrastructure during extreme weather.</p> <p>Supports overall climate adaptation by fostering a culture of preparedness.</p>	<p>Short-term: 0–1 year for campaign design, pilot testing, and initial rollout.</p> <p>Medium-term: 2–3 years for scaling nationwide, integrating into school and community programs.</p> <p>Long-term: 4–5+ years for behavioural change and integration into national resilience culture.</p>	<p>Messaging that excludes marginalized or digitally disconnected groups may increase inequities.</p> <p>Over-reliance on awareness alone without accompanying infrastructure or services could reduce effectiveness.</p> <p>Inconsistent or unclear communication may cause confusion or panic during emergencies.</p> <p>Campaign fatigue could occur if efforts are not regularly refreshed or updated with new risks.</p>

²⁵² Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-H-2: The resilience of the population (especially disadvantaged groups) is strongly supported. People are aware of health risks, including mental health, due to heat and risks resulting from air-, food-, water- or vector-borne diseases. 							
Action	Specific Healthcare Measures for Minority Groups						Existing
Aim of the action: Increase the promotion campaign of measures to ensure optimal health conditions for the population in extreme heat							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁵³	Funding line	Output indicators	Link to other national activities
Public Health Office of the Slovak Republic	-	National	2026-2040	Low	National (Public Budget)	Number of temporary cooling centres established in minority-populated areas during heatwaves. Number of mobile healthcare team deployments per summer season. Number of heat-related health screenings conducted among vulnerable populations. Number of multilingual educational materials produced and distributed	National Health Strategy Roma Inclusion Strategy Public Health Preparedness Plans Disaster Risk Reduction Framework

²⁵⁴ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

						(including Romani and Hungarian). Reach and engagement metrics for awareness campaigns (e.g., radio broadcasts, social media reach, community engagement sessions).	
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Description of the Action:

Minority groups, including Roma communities, older adults, and socio-economically disadvantaged populations, may face increased vulnerability during extreme heat due to poor housing conditions, limited healthcare access, and existing health disparities. To address these challenges, the following targeted healthcare activities are suggested:

During heat waves:

- Establish temporary cooling centres in areas with high minority populations (e.g., Roma settlements) to provide a safe refuge from extreme heat (utilize existing community spaces (schools, cultural centres, religious institutions) for these services).
- Deploy mobile healthcare teams to visit minority communities during heatwaves, conducting health check-ups, distributing rehydration salts, and identifying individuals at risk.
- Provide free heat-related health screenings (for dehydration, heatstroke, cardiovascular stress).

Targeted Awareness Campaigns in Native Languages

- Develop multilingual educational materials on heatwave safety, hydration, and first aid for heatstroke, including in Romani and Hungarian languages.
- Use radio broadcasts, community leaders, and social media to spread awareness in minority communities.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁵⁴
Protects high-risk groups like Roma, older adults, and socio-economically disadvantaged communities. Reduces health disparities by improving	Low-cost interventions (e.g., mobile teams, cooling centres) prevent costly hospitalizations. Minimizes productivity loss and long-term health costs in vulnerable populations.	Improves community-level climate resilience through local infrastructure use (e.g., schools, cultural centres). Encourages adaptation in areas most exposed to extreme heat.	Short-term: 0–1 year for campaign materials, cooling centre identification, and mobile team coordination. Medium-term: 2–3 years to embed these measures in local health systems and expand coverage.	Failure to tailor materials and services linguistically/culturally may reduce uptake. Risk of creating dependency on temporary services if not integrated into broader health systems.

²⁵⁴ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

<p>access to emergency care and information.</p> <p>Builds trust through culturally sensitive outreach and community involvement.</p>	<p>Supports equity in public health investment.</p>	<p>Enhances climate justice by aligning adaptation efforts with environmental equity.</p>	<p>Long-term: 4–5+ years for sustained reduction in climate-related health disparities.</p>	<p>Inadequate coordination with local leaders may limit effectiveness or lead to mistrust.</p> <p>Infrastructure strain if cooling centres are not properly maintained or scaled.</p>
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Strategic direction addressed:							
<ul style="list-style-type: none"> SD-H-3: The sanitation system is adapted to changing water availability and demand and increasing climate risks such as extreme events. 							
Action	Improve water management practices accounting for climate risks						Existing
Aim of the action: Increase the share of connections to public sanitation systems and improve wastewater treatment facilities and practices							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁵⁵	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Municipalities and regional administrations	National, Municipalities	2026- 2040 ²⁵⁶	High	National (Public Budget, Municipalities), EU (ESIF), Private (water fee)	<p>Percentage of municipalities with climate-resilient sewerage and wastewater systems</p> <p>Number of wastewater treatment plants implementing adaptive and energy-efficient technologies</p> <p>Number of incentive-supported connections of residents, including socially excluded communities, to upgraded public sewerage systems</p>	Water policy concept of the Slovak republic until 2030 with a view to 2050
Description of the Action:							

²⁵⁵ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁵⁶ For the detailed deadlines as set out in Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast) please see Art 32, <https://eur-lex.europa.eu/eli/dir/2024/3019/oj/eng>.

This action focuses on strengthening water management infrastructure and practices to account for climate risks, including increased flooding, droughts, and extreme precipitation events. It aims to ensure the resilience of municipal sewerage and wastewater systems while maintaining water quality and ecosystem services.

Key activities include:

Climate-Resilient Infrastructure Expansion:

- Increase the share of municipalities connected to public sewerage in lagging regions, with upgrades to hydraulic capacity in agglomerations over 2,000 equivalent inhabitants to withstand extreme weather events.
- Construct sewer networks and wastewater treatment plants in smaller agglomerations (up to 2,000 equivalent inhabitants) in protected water management areas, ensuring state-of-the-art climate-resilient systems and comply with the requirements of the recasted Urban Waste Water Directive.

Risk-Informed Planning & Operation:

- Introduce adaptive wastewater treatment practices to manage hazardous substances and emerging contaminants under changing climate conditions. (comply with the requirements of the recasted Urban Waste Water Directive)
- Implement control mechanisms for monitoring and managing sewage effluent, with enhanced capacity to handle extreme events such as heavy rainfall or flooding.

Energy Efficiency and Climate Neutrality:

- Promote energy-efficient and low-carbon wastewater treatment technologies to reduce emissions and increase system resilience.

Ecosystem-Based Adaptation:

- Prioritize measures that preserve ecosystem services and buffer climate impacts (e.g., wetlands for flood mitigation, natural retention areas), ensuring continued functionality under new climate scenarios to ensure sufficient and high-quality drinking water.

Governance, Incentives, and Funding:

- Develop legislative frameworks and financial mechanisms to enable adaptive water management practices.
- Establish incentives for municipalities and private actors to invest in climate-resilient wastewater infrastructure, including social inclusion for vulnerable communities.
- Consider the development of water protection areas for future demands

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁵⁷
<p>Enhances public health by improving sanitation, especially in lagging and socially excluded communities.</p> <p>Increases access to safe water and sanitation in rural and vulnerable regions.</p>	<p>Supports compliance with EU wastewater standards, reducing penalties and enabling funding.</p> <p>Encourages innovation in treatment technologies, fostering green economic development.</p> <p>Mitigates long-term infrastructure and health</p>	<p>Improves water quality and ecosystem health, particularly in protected areas.</p> <p>Reduces pollution and hazardous substances in wastewater discharge.</p> <p>Promotes energy-efficient, climate-neutral wastewater treatment processes.</p>	<p>Short-term: 1–2 years for financial mechanisms, incentives, and pilot systems.</p> <p>Medium-term: 3–5 years to expand networks and treatment capacity in priority agglomerations.</p> <p>Long-term: 6–10 years for widespread infrastructure upgrade and environmental benefits.</p>	<p>Improper design or placement of sewer systems may harm protected ecosystems.</p> <p>Failure to ensure affordability may exclude vulnerable households from connection.</p> <p>Over-reliance on high-tech solutions without capacity-building may reduce effectiveness in small municipalities.</p>

²⁵⁷ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Promotes equity through inclusive connection incentives and services.	costs by modernising systems now.			Climate impacts (e.g., extreme rainfall) could overwhelm systems if not properly future-proofed.
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Strategic direction addressed:							
<ul style="list-style-type: none"> SD-H-4: Safe water supply is ensured and water networks are further expanded. 							
Action	Safeguarding climate-resilient drinking water supply						Existing
Aim of the action: To ensure the safe supply of drinking water and apply practices for freshwater treatment							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²⁵⁸	Funding line	Output indicator	Link to other national activities
Ministry of Health, Ministry of Environment	Regional administrations	National, Regional	2026-2040	High	National (Public Budget, Municipalities), EU (ESIF), Private (water fee)	National (Public Budget, Municipalities), EU (ESIF), Private (water fee) Percentage of drinking water sources assessed and managed for climate and health risks. Number of facilities implementing Legionella and water safety measures. Number of priority environmental burdens remediated, and surface water pollution reduced.	NEHAP V Water policy concept of the Slovak republic until 2030 with a view to 2050
Description of the Action: <p>The action will apply risk-based approaches to ensure the health safety of drinking water supplies, including individual sources such as wells, while promoting the value of safe drinking water and encouraging responsible water use among the public. It will also aim to reduce the risk of Legionella and other waterborne illnesses in facilities housing vulnerable populations, such as hospitals.</p>							

²⁵⁸ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

<p>The action is also focused on updating freshwater treatment practices, specifically in areas that are most susceptible to pollution or effects that lead to decreased quality of drinking water. The action sets out to:</p> <ul style="list-style-type: none"> • update the State Programme for the Remediation of Environmental Burdens and give priority to the remediation of environmental burdens in the catchment areas of water bodies in poor condition or causing a risk of failure to achieve good status of water bodies, which may adversely affect the quality of drinking water sources and water in protected water management areas, military districts and protected areas, with special attention to those environmental burdens, which contain substances with demonstrably negative effects on human health. • take measures to reduce the pollution of surface waters by floating waste, in particular plastics. • minimise the use of substances that may pose a threat when removing invasive and other unwanted organisms or damage ecosystems, pose a potential risk of pollution to groundwater and/or surface water. 				
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁵⁹
<p>Protects public health by reducing exposure to waterborne diseases (e.g. Legionella).</p> <p>Enhances public trust in and use of safe tap water.</p> <p>Safeguards vulnerable populations in hospitals and facilities for the immunocompromised.</p> <p>Raises community awareness of drinking water safety and value.</p>	<p>Reduces healthcare costs related to waterborne illnesses.</p> <p>Minimizes long-term environmental liability through prioritized remediation of polluted areas.</p> <p>Supports cost-effective management of drinking water quality through risk-based approaches.</p>	<p>Improves the ecological status of catchment areas and protected water zones.</p> <p>Reduces pollution of surface waters by plastic and hazardous substances.</p> <p>Promotes sustainable freshwater treatment and safer chemical use.</p>	<p>Short-term: 1–2 years for awareness campaigns and Legionella risk mitigation in priority facilities.</p> <p>Medium-term: 3–5 years to implement risk-based water safety plans and update treatment protocols.</p> <p>Long-term: 5–10 years to complete remediation of environmental burdens in water catchments.</p>	<p>Overuse of certain chemicals in water treatment could harm ecosystems or contaminate groundwater.</p> <p>Neglecting smaller or individual water sources (e.g., wells) may leave rural communities at risk.</p> <p>Insufficient funding for remediation could delay action and lead to worsening water quality.</p> <p>Focus on technical fixes without public engagement may reduce effectiveness and local compliance.</p>

4.3.3. Information and Communication Technology

An information and communication technology (ICT) system comprises integrated networks, systems and components that enable the transmission, receipt, capture, storage and manipulation of information by users on and across electronic devices²⁶⁰.

²⁵⁹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

²⁶⁰ Fu, G., Horrocks, L., Winne, S. (2016). Exploring impacts of climate change on UK's ICT infrastructure. Infrastructure Asset Management 3 (1), 42–52.

Impacts and Risks

A relevant aspect to be highlighted in ICT is that the state's crisis management of the Slovak Republic in this sector is rather weak, indicating a need for improvement, including the implementation of respective governance frameworks. Climate impacts of high priority for Slovakia include an increase in extreme events, forest and wildfires, heat load as well as erosion. Infrastructure can be damaged and directly or indirectly disrupted due to climate extremes. Against this background, there is an increasing demand to implement adaptation measures concerning ICT services in order to ensure an adequate response to climate change induced adverse effects and risks.

The need for adaptation in the ICT sector due to various climate change impacts is covered in the identified key risk, i.e. risk of damage to ICT infrastructure and widespread disruptions of ICT services e.g. due to extreme events (KR-ICT-1). This risk is expected to increase, reaching a very high level by the end of the century under a pessimistic scenario (RCP8.5).

Actions

Activities proposed focus on integrating climate adaptation into frameworks and planning to ensure a smart, resilient, and energy-efficient ICT infrastructure. A clear governance framework must be established for crisis management, defining roles for public and private actors, backed by robust emergency response plans, effective communication channels, regular stress tests, and regulations for private ICT infrastructure. To reduce risks from extreme weather and power outages, both public and private ICT systems, including data centres, must be adapted to changing climate conditions. Finally, awareness-raising and education for policymakers, industry, and the public are needed to strengthen preparedness and foster a culture of resilience in the ICT sector.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-ICT-1: Sufficient governance frameworks are implemented on a national scale to ensure state-wide effective crisis management, i.e. ICT infrastructure break-downs, including regulations for privately owned ICT infrastructure. 							
Action	Implement Commission Delegated Regulation (EU) 2024/1774 supplementing Regulation (EU) 2022/2554 of the European Parliament and of the Council with regard to regulatory technical standards specifying ICT risk management tools, methods, processes, and policies and the simplified ICT risk management framework						New
Aim of the action: Achieve a high common level of digital operational resilience.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁶¹	Funding line	Output indicator	Link to other national activities
National Bank of Slovakia	Commercial banks	National	2026-2040	High	National (Public Budget), EU (ESIF), Private, Investment Loans (EIB)	Number of ICT response and recovery plans developed and tested, including scenarios addressing climate-related and environmental disruption risks.	
Description of the Action:							
Develop ICT response and recovery plans, in line with Commission Delegated Regulation 2024/1774, identifying relevant scenarios, including scenarios of severe business disruptions and likelihood of occurrence of business disruptions, based on current information on threats and on lessons learned from previous occurrences. Financial entities shall duly take into account, among others, the impact of climate change and environment degradation related events, natural disasters.							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective		Systemic risks²⁶²		
Enhances public trust in financial institutions through improved stability and business continuity.	Increases the resilience of financial markets and institutions against climate-induced and digital disruptions.	Promotes the integration of environmental and climate risk factors into financial ICT systems. Facilitates proactive planning for disruptions linked to natural	Short-term: 1–2 years for full legal transposition and initial capacity building within financial institutions. Medium-term: 3–5 years for development and testing of robust ICT response and		Overly complex or costly compliance requirements could burden smaller financial entities.		

²⁶¹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁶² Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Protects citizens' access to essential financial services during climate-related or natural disasters. Ensures a safer digital financial environment for all user groups, including vulnerable populations.	Reduces financial losses due to unplanned outages, data breaches, or climate-related damage to infrastructure. Supports compliance with EU regulations, strengthening Slovakia's competitiveness and alignment with EU standards.	disasters, extreme weather, and environmental degradation. Contributes indirectly to climate adaptation by supporting robust and climate-aware financial governance.	recovery plans, including climate-linked scenarios. Long-term: Ongoing adaptation of risk frameworks in response to evolving environmental threats and cyber risks.	Failure to update climate-related threat scenarios regularly may reduce effectiveness. Excessive reliance on digital tools without physical redundancies might increase systemic vulnerabilities. Lack of coordination between ICT and environmental risk experts may limit the relevance of adaptation scenarios.
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Strategic objective addressed:							
<ul style="list-style-type: none"> SD-ICT-2: ICT infrastructure is adapted to climate-related impacts, taking into account the need for a green transformation. SD-ICT-3: Sufficient and effective awareness raising measures are implemented with respect to climate-related impacts on the ICT sector, in particular on IT infrastructure. 							
Action	Develop and Implement a Green ICT Resilience and Awareness Program						Existing
Aim of the action: The aim of this action is to adapt Slovakia's ICT infrastructure through the development of climate-resilient, energy-efficient ICT systems, the promotion of green technologies, and the implementation of nationwide awareness-raising campaigns on the climate impacts of the ICT sector.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²⁶³	Funding line	Output indicator	Link to other national activities
Ministry of Investments, Regional Development, and Informatization	Ministry of Environment Slovak Environment Agency Private Sector & ICT Industry Leaders (e.g., Slovak Telekom, Orange Slovakia, ESET, cloud service providers)	National	2026-2040	Medium	National (Public Budget), EU (ESIF)	Percentage of data centres retrofitted with climate-resilient designs (target: 60% by 2030). Integration of ICT infrastructure into the national flood risk map (target: 100% of critical	National Energy and Climate Plan (NECP) 2021-2030 Slovakia's Digital Transformation Strategy 2030 National Cybersecurity Strategy

²⁶³ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						ICT sites mapped by 2030). Increase in renewable energy usage in ICT infrastructure (target: 50% of data centres powered by green energy by 2030).	EU Green Digital Strategy & European Data Strategy
<p>Description of the Action: <u>Upgrade Data Centres and IT Infrastructure</u></p> <ul style="list-style-type: none"> Retrofit and build climate-resilient data centres and ICT infrastructure (e.g., cloud storage systems, communication networks) with enhanced cooling mechanisms, energy-efficient designs, and green energy solutions (solar, wind, geothermal). Ensure that critical ICT infrastructure is protected against extreme weather events (flooding, heatwaves, storms) by implementing flood barriers, backup power sources (e.g., renewable energy), and robust disaster recovery plans. Integrate ICT in the interactive map created by the Slovak Water Management Authority.²⁶⁴ for better visualisation of potential flood risks under the Flood Protection Act 7/2010 Coll. Invest in edge computing and distributed systems to reduce data traffic congestion and minimize the strain on centralized data centres during climate-induced disruptions. <p><u>Public Education and Engagement</u></p> <ul style="list-style-type: none"> Launch nationwide campaigns to raise awareness about the climate-related risks to the ICT sector and how individuals, businesses, and public institutions can minimize their environmental impact. This could include online courses, webinars, infographics, and social media outreach targeting both the general public and ICT professionals. <p><u>Partnerships with Industry Leaders</u></p> <ul style="list-style-type: none"> Foster collaboration with ICT industry leaders, universities, and tech companies to research, develop, and deploy green ICT innovations that align with climate goals. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective		Systemic risks ²⁶⁵		
Ensures continuity of essential digital services for citizens during extreme weather events. Raises public awareness about climate impacts on	Reduces long-term operational costs through energy-efficient and resilient infrastructure. Supports innovation and job creation in the green tech and ICT sectors.	Decreases the carbon footprint of digital infrastructure through green energy solutions and energy-efficient cooling. Promotes sustainable ICT practices and contributes to national climate mitigation and adaptation goals.	Short-term: 1–2 years for climate risk assessments of existing ICT infrastructure and design of upgrade plans. Medium-term: 3–5 years for retrofitting major data centres, implementing distributed systems, and deploying public education campaigns.		Overreliance on centralised digital infrastructure could lead to single points of failure during extreme events. Inadequate planning for future energy demand could undermine sustainability efforts.		

²⁶⁴ The interactive map can be found here: https://mpt.svp.sk/svp_vmapportal/?basemap=orto2023&zoom=0&lat=48.778724&lng=19.032391. Accompanying documents include a user manual (https://mpt.svp.sk/svp_vmapportal/manual_TIS.pdf) and legend (https://mpt.svp.sk/svp_vmapportal/legend_TIS.pdf).

²⁶⁵ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

digital infrastructure and responsible ICT use. Empowers communities and professionals through accessible educational resources on green digital practices.	Enhances business continuity and digital security, increasing economic stability in climate crisis scenarios.	Integrates ICT infrastructure planning with environmental data tools (e.g., flood risk maps) for proactive climate adaptation.	Long-term: 5–10 years for full integration of green energy solutions and national-level resilience in the ICT sector.	If public outreach doesn't reach vulnerable or remote groups, digital inequalities could widen. Risk of "greenwashing" if ICT upgrades are labelled sustainable without full lifecycle environmental assessment.
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4.4. Cluster Built environment and spatial planning

This cluster focuses on the adaptation of Slovakia's physical spaces - its buildings, infrastructure, cultural assets, and land-use systems - to the growing impacts of climate change. It recognizes that climate-resilient spatial planning and construction are essential to protecting people, property, and heritage, while ensuring sustainable development across urban and rural areas. The adaptation actions within this group draw on a comprehensive range of national frameworks and international guidance, including the 2018 NAS and 2021 NAP, the Concept of Spatial Development of the Slovak Republic, the Cultural Heritage Protection Act, EU directives on energy performance and construction, and best practices from neighbouring countries with comparable risk profiles. The actions are further grounded in expert and stakeholder input collected through workshops and scenario-based planning exercises conducted during the project's analytical phases (notably D2.2 and D2.3 and stakeholder consultation on a draft final version of this report).

The cluster includes eight adaptation actions: two in the Cultural Heritage sector, two in Spatial Planning, and four in Transport, Infrastructure and Buildings. These actions aim to enhance the climate resilience of both new and existing physical structures, promote heat- and flood-adapted urban planning, protect Slovak cultural assets from climate-related hazards, and foster integrated land-use policies that reduce long-term exposure to environmental risks.

Implementation responsibility is distributed among several key institutions. The Ministry of Environment leads national spatial planning policy and climate mainstreaming, while the Ministry of Transport and Construction oversees technical building standards, infrastructure resilience, and transport adaptation. The Monuments Board of the Slovak Republic plays a central role in safeguarding cultural heritage, and the Ministry of Culture supports related policy and funding. Local and regional governments are pivotal in land-use implementation, zoning, and permit decisions. Other essential actors include urban planners, construction industry stakeholders, cultural and academic institutions, and engineering experts involved in adaptation design and retrofitting.

The timeframe for these actions spans immediate, medium, and long-term horizons. Short-term efforts include the development of updated guidelines for climate-resilient construction, the integration of adaptation measures in local spatial plans, and enhanced data collection on vulnerable heritage sites. Medium-term priorities involve modernizing transport infrastructure to withstand heat and flooding, retrofitting buildings with passive cooling and water management systems, and piloting nature-based solutions in urban development. Long-term objectives include the institutionalization of climate-smart planning principles across sectors, the revitalization of urban spaces to improve liveability under future climate conditions, and the permanent integration of risk and resilience metrics in spatial planning tools and permitting processes.

While these actions are applicable nationwide, they hold particular relevance for rapidly urbanizing areas, floodplains, historically significant sites, and regions experiencing increasing heat stress or landslide risks. The cluster's interventions aim not only to safeguard the built environment but also to reinforce the social, cultural, and economic fabric of Slovak communities in a changing climate.

4.4.1. Cultural heritage

The sector **Cultural Heritage** includes two types of artefacts, 1) physical or tangible artefacts, assets and spaces like architecture, monuments, sites, landscapes, parks, gardens, artwork, other archives and 2) other expressions of human creativity that are intangible like traditions, practices and knowledge. Cultural heritage can be public or private as well as digitised and analogue. Both tangible and intangible cultural heritage may hold the potential to support the implementation of adaptation measures^{266 267}

Impacts and Risks

Slovakia has a rich and extensive cultural heritage, including six recognised UNESCO World Cultural Heritage sites²⁶⁸. This underscores the importance of addressing climate related impacts in this sector²⁶⁹. Among the most relevant climate impacts is the increasing need for maintenance, whereby several aspects have to be considered. Firstly, permanent maintenance, including the conduction of care and implementation of respective monitoring measures, is crucial for the appropriate prevention of climate-related threats. For instance, irreversible damage can be avoided by the timely detection and repair of malfunctions, damage to human-made or natural objects. Besides that, the necessity for conducting maintenance and evaluation work for each monument or building must be taken into account. Already established risk assessments such as heritage value assessments can serve as a foundation for assessing historical buildings/objects accordingly. Secondly, with respect to extreme weather events such as floods, landslides, or fires, a functioning infrastructure with sufficient capacity is important (e.g. water drainage, availability of rescue equipment, fire extinguishing). Most importantly, the urgency to take action for climate impacts as aforementioned is high.

In course of the assessment, one key risk was identified, also comprising impacts on natural heritage sites. The risk loss of historical, archaeological, cultural and natural sites, landscapes values, traditional practices and authenticity is expected to reach high levels in the far future (KR-CH-1).

²⁶⁶ European Commission (2024b). EU Policy for cultural heritage. <https://culture.ec.europa.eu/cultural-heritage/eu-policy-for-cultural-heritage><https://culture.ec.europa.eu/cultural-heritage/eu-policy-for-cultural-heritage>. Accessed 15 April 2024.

²⁶⁷ UNESCO Institute of Statistics (2024). Cultural heritage: Definition. <https://uis.unesco.org/en/glossary-term/cultural-heritage>. Accessed 15 April 2024.

²⁶⁸ Besides, Slovakia has two Natural World Heritage Sites. <https://whc.unesco.org/en/statesparties/sk>.

²⁶⁹ UNESCO Institute of Statistics (2024). Cultural heritage: Definition. <https://uis.unesco.org/en/glossary-term/cultural-heritage>. Accessed 15 April 2024.

Actions

A proactive approach shall be adopted to preserve cultural heritage by ensuring regular maintenance, climate-adapted servicing, preventive measures such as climate-controlled storage, and investment in research to advance conservation techniques. Intangible heritage must be safeguarded through documentation, promotion, revitalisation, and support for cultural festivals, workshops, and educational programs, while digital technologies should be used to preserve and disseminate traditions more widely.

Legal frameworks and policy alignment with EU Directives, UNESCO standards, and international frameworks, clear responsibilities, and adequate resources are necessary for climate-proofing, retrofitting, and reinforcing cultural sites. Finally, strengthening international cooperation will allow Slovakia to share expertise, address transboundary risks, and contribute to global efforts to safeguard cultural heritage for future generations.

Strategic directions addressed:							
<ul style="list-style-type: none"> SD-CH-1: Tangible cultural goods like buildings, museums, archives, etc. are protected and preserved through regular, preventive maintenance and climate-adapted servicing ensuring a sufficient level of resilience. 							
Action	Implement a national preventive maintenance program for cultural heritage sites, integrating climate-adaptive measures						New
Aim of the action: Strengthen the resilience of Slovakia’s cultural heritage assets by reducing climate-related risks (e.g., extreme weather, humidity, temperature fluctuations) through preventive conservation, adaptive maintenance, and sustainable restoration practices.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²⁷⁰	Funding line	Output indicator	Link to other national activities
Ministry of Culture	Ministry of Environment Monuments Board of the Slovak Republic State Nature Conservancy of the Slovak Republic (SNC)	National	2026-2030	Medium to High	National (Public Budget, Municipalities), EU (ESIF), Private	Percentage of cultural heritage sites with implemented climate-adaptive maintenance plans	UNESCO Convention for the Safeguarding of Intangible Cultural Heritage (Ratified by Slovakia in 2006) Program for the Protection and Development of Intangible Cultural Heritage (Ministry of Culture Initiative)

²⁷⁰ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

	UNESCO National Committee Slovakia ²⁷¹						Care programs of National parks with UNESCO sites ²⁷²
	Municipalities and regional governments						
	NGOs						
Description of the Action:							
Set up a preventive maintenance program that allows the performance of the following steps:							
<u>Risk Assessment & Monitoring:</u>							
<ul style="list-style-type: none"> • Conduct detailed assessments to identify vulnerabilities of natural heritage sites to climate change impacts like extreme weather events, temperature fluctuations, and increased humidity. • Make use of tools such as heritage value assessments – for example UNESCO’s World Heritage List²⁷³ and International Council on Monuments and Sites. (ICOMOS)²⁷⁴ – will be used to support climate adaptation and make people aware of the potential loss of such prestigious assets • Establish robust monitoring systems to track changes in natural heritage sites using digital tools (e.g., remote sensors, climate impact modelling) to monitor environmental conditions in heritage sites. 							
<u>Preventive Maintenance:</u>							
<ul style="list-style-type: none"> • Conduct regular inspections of historical buildings, museums, and archives to identify vulnerabilities (e.g., moisture infiltration, structural weaknesses). • Apply climate-adaptive materials (e.g., breathable coatings, flood-resistant barriers) to protect structures from weather extremes. • Upgrade HVAC (heating, ventilation, air conditioning) and dehumidification systems in archives and museums to maintain stable conditions. 							
<u>Capacity Building & Training:</u>							
<ul style="list-style-type: none"> • Provide specialized training for conservation professionals in climate-adaptive restoration techniques. • Raise awareness among local communities and stakeholders on the importance of protecting cultural heritage from climate change. 							
<u>Emergency Preparedness & Response:</u>							
<ul style="list-style-type: none"> • Develop site-specific disaster risk management plans for cultural heritage sites. • Strengthen collaboration between cultural heritage authorities, meteorological services, and disaster response agencies. • Ensure compliance with the EU Floods Directive by securing reporting (every 6 years) on how many cultural heritage sites might be affected by flooding (see also chapter 4.1.5) 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective			Systemic risks²⁷⁵	

²⁷¹ <http://www.unesco.sk/>.

²⁷² <https://www.npslovenskykras.sk/wp-content/uploads/2024/01/Program-starostlivosti-o-NP-Slovensky-kras-OP-CHVU-UEV-2024.pdf> and <https://nppoloniny.sopsr.sk/wp-content/uploads/2022/12/Program-starostlivosti-o-Narodny-park-Poloniny-a-jeho-ochranne-pasmo-na-roky-2023-2032.pdf>.

²⁷³ <https://whc.unesco.org/en/list/>.

²⁷⁴ <https://www.icomos.org/en>.

²⁷⁵ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>Preserves national identity and cultural continuity by safeguarding historical and natural heritage.</p> <p>Engages communities in valuing and protecting shared cultural assets.</p> <p>Builds local capacity and public awareness around heritage conservation in a changing climate.</p>	<p>Protects revenue streams from cultural tourism by maintaining the integrity of heritage sites.</p> <p>Avoids high restoration costs by investing in preventive maintenance and risk reduction.</p> <p>Creates skilled job opportunities in climate-adaptive restoration and heritage conservation.</p>	<p>Minimizes damage to heritage sites from climate-driven threats like flooding, heatwaves, and humidity.</p> <p>Promotes sustainable use of materials and infrastructure adapted to local environmental changes.</p> <p>Strengthens disaster risk management around environmentally sensitive heritage zones.</p>	<p>Short-term: 1–2 years for conducting risk assessments, training staff, and installing basic monitoring systems.</p> <p>Medium-term: 3–5 years for implementing full preventive maintenance and emergency response protocols.</p> <p>Long-term: 5–10 years for full site resilience, integration into national climate reporting, and adaptive material use across protected assets.</p>	<p>Using non-climate-resilient materials could lead to faster degradation under new environmental conditions.</p> <p>Insufficient collaboration between climate experts and cultural authorities may result in misaligned priorities.</p> <p>Failure to involve local communities could reduce buy-in or lead to ineffective protection strategies.</p> <p>Over-tourism as a response to renewed interest in preserved sites could undermine environmental sustainability.</p>
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Strategic direction addressed:							
<ul style="list-style-type: none"> SD-CH-2: Intangible cultural heritage and associated practices and traditions are secured and well promoted to support local identity. 							
Action	Safeguard and promote intangible cultural heritage for cultural continuity and local identity						New
Aim of the action: Ensure that Slovakia’s rich intangible cultural heritage - such as folklore, traditional crafts, languages, rituals, and festivals - is preserved, adapted, and actively practiced, fostering a strong sense of local identity and cultural continuity							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁷⁶	Funding line	Output indicator	Link to other national activities
Ministry of Culture	Slovak National Museum and Slovak National Library Centre for Traditional Folk Culture (CTFC) Matica slovenská Local governments and municipalities UNESCO National Committee Slovakia NGOs and Cultural Associations	National	2026-2040	Medium	National (Public Budget, Municipalities), EU (ESIF), Private	Number of intangible cultural heritage elements actively practiced and documented	UNESCO Convention for the Safeguarding of Intangible Cultural Heritage (Ratified by Slovakia in 2006) Program for the Protection and Development of Intangible Cultural Heritage (Ministry of Culture Initiative)
Description of the Action:							
To address the preservation and promotion of intangible cultural heritage in the face of climate change, the following actions are recommended:							
<u>Documentation and Digitalization:</u>							
<ul style="list-style-type: none"> Create a national digital archive for traditional practices, oral histories, rituals and folk traditions. Digitise relevant materials, such as audio recordings, videos, and photographs, to ensure long-term preservation. Encourage the use of digital platforms (e.g., websites, apps, and virtual museums) to showcase intangible cultural elements. 							
<u>Education and Community Involvement:</u>							
<ul style="list-style-type: none"> Integrate ICH into school curricula to encourage youth participation in traditional crafts, dance, music, and storytelling. Develop community-led heritage festivals and workshops to engage different generations in cultural practices. 							

²⁷⁶ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Tourism and Economic Development:				
<ul style="list-style-type: none"> Promote intangible heritage as part of sustainable tourism strategies (e.g., heritage trails, cultural experience tours). Support local businesses that produce traditional handicrafts and regional cuisine. 				
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks²⁷⁷
<p>Preserves cultural diversity and local traditions, fostering a sense of identity and belonging within communities.</p> <p>Strengthens intergenerational knowledge transfer by involving youth and elders in cultural practices.</p> <p>Enhances cultural exchange through digital platforms, promoting shared heritage across generations and regions.</p>	<p>Boosts sustainable tourism by incorporating intangible cultural heritage into travel experiences, which attracts eco-conscious tourists.</p> <p>Supports local economies through the promotion of traditional crafts, arts, and cuisine, leading to business growth.</p> <p>Opens new revenue streams by encouraging digital innovation, such as virtual heritage tours and online platforms for traditional practices.</p>	<p>Reduces the environmental impact of physical preservation by digitizing cultural elements and maintaining virtual archives.</p> <p>Promotes sustainable cultural tourism practices that minimize ecological footprints while supporting local communities.</p> <p>Encourages the sustainable use of local resources for traditional crafts, reducing reliance on imported goods and fostering local material economies.</p>	<p>Short-term: 1–2 years for establishing the digital archive, integrating cultural heritage into school curricula, and launching initial community workshops.</p> <p>Medium-term: 3–5 years for expanding digital platforms, developing heritage festivals, and promoting intangible heritage through tourism.</p> <p>Long-term: 5–10 years for widespread incorporation of intangible heritage in national cultural policy and for tangible economic benefits to local businesses.</p>	<p>Over-commercializing intangible heritage could lead to cultural dilution and loss of authenticity.</p> <p>Technological barriers or a lack of digital literacy could limit the effectiveness of online platforms for cultural preservation.</p> <p>Insufficient support for local communities in maintaining traditional crafts could undermine economic sustainability and heritage integrity.</p> <p>Climate change could impact traditional practices (e.g., agriculture, crafts, or festivals) that rely on specific local environmental conditions.</p>

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-CH-4: Effective governance frameworks, aligned with propositions/policies by the European Union and international organisations like UNESCO, are implemented. 							
Action	Establish effective governance frameworks for the protection of cultural heritage						Existing
Aim of the action: Comply with cultural heritage relevant policies							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁷⁸	Funding line	Output indicator	Link to other national activities

²⁷⁷ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

²⁷⁸ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Ministry of Culture	Ministry of Environment Slovak National Commission for UNESCO Pamiatkový úrad SR European Union Delegation to Slovakia Local and Regional Governments NGOs and Heritage Networks –	National	2026-2040	Low	National (Public Budget, Monument fund of the Slovak Republic)	Number of heritage professionals trained in climate-resilient conservation practices. Number of cross-sector coordination mechanisms established for climate-resilient heritage governance.	National Strategy for Cultural Heritage Preservation
<p>Description of the Action: This action focuses on integrating climate adaptation into the protection and management of cultural heritage, including the following activities:</p> <p><u>Framework Development:</u></p> <ul style="list-style-type: none"> Regularly update and harmonize national cultural heritage policies with EU regulations and international frameworks such as the UNESCO World Heritage Convention, explicitly incorporating measures to address climate risks such as flooding, heatwaves, and erosion to promote climate-resilient conservation practices. <p><u>Institutional Strengthening:</u></p> <ul style="list-style-type: none"> Promote cross-sector collaboration between ministries (culture, environment, and education) and other stakeholders, including local governments and NGOs. to embed climate adaptation into heritage management strategies. Strengthen institutional capacities by providing training for heritage professionals on climate risk assessment, adaptation measures, and EU climate-resilient heritage recommendations²⁷⁹. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective		Systemic risks ²⁸⁰		
Enhances national cultural heritage policies to align with EU and international standards, reinforcing cultural	Harmonization with EU regulations can unlock access to EU funding and support for heritage preservation projects.	Ensures that cultural heritage policies reflect the Green Deal and international sustainability principles, mitigating environmental impacts and	Short-term: 1–2 years to develop frameworks and initiate cross-sector collaboration, including training programs for heritage professionals.		Slow adaptation to international frameworks may lead to missed opportunities for funding or collaboration, impeding effective heritage preservation.		

²⁷⁹ See e.g. European Commission. (2022). *Strengthening cultural heritage resilience for climate change: Where the European Green Deal meets cultural heritage*. Publications Office of the European Union. <https://www.frh-europe.org/eu-report-strengthening-cultural-heritage-resilience-for-climate-change/>

²⁸⁰ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>preservation and global cooperation.</p> <p>Promotes cross-sector collaboration, ensuring that cultural heritage is integrated into broader national and local development plans.</p> <p>Strengthens the role of local communities in heritage management, fostering inclusivity and broader stakeholder engagement.</p>	<p>Institutional strengthening enables more effective management of cultural heritage resources, optimizing economic outcomes from tourism and cultural industries.</p> <p>Encourages sustainable investment in heritage conservation, which can attract tourism and stimulate local economies.</p>	<p>climate change associated with heritage management.</p> <p>Encourages environmentally responsible practices in the preservation of cultural assets, especially those that are vulnerable to climate change.</p> <p>Supports the adaptation of heritage sites and practices to the effects of climate change, promoting climate resilience in cultural heritage conservation.</p>	<p>Medium-term: 3–5 years for fully implementing policies and strategies, integrating them into national and local governance systems.</p> <p>Long-term: 5–10 years for fully harmonized national and EU cultural heritage legislation, with strong institutional capacities in place for ongoing heritage management and sustainability.</p>	<p>Lack of cross-sector cooperation could result in fragmented cultural heritage policies that don't adequately address climate risks or community needs.</p> <p>Insufficient training and capacity-building for heritage professionals could undermine the effective implementation of EU and international agreements.</p>
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4.4.2. Spatial planning

Spatial Planning is understood as the public task of coordinating the demands for the use of space, with the view of influencing the future distribution of activities^{281 282}. It aims to create a rational territorial organisation, that balances demand for development with the need to protect the environment and achieve development objectives. Thus, an interdisciplinary approach is required to balance the competing demands. Structures created through spatial planning transcend political and administrative boundaries.

Impacts and Risks

Local governments have the main competence over spatial planning, while the Slovak government, through the Authority for Spatial Planning and Construction, is revising and updating planning rules, as well as reviewing spatial planning methodologies.

Spatial Planning is very cross-cutting in its nature, and thus key priorities and concerns come not just from within the sector, but other sectors beyond it. Both biophysical and socio-economic impacts can be found in the Spatial Planning sector. Given that just over half of Slovakia's population lives in cities, the primary concerns are the impacts there. These include an increase in summer and tropical days and nights, the intensification of urban heat island (UHI) effects. From these impacts, based on a climate risk

²⁸¹ Danielzyk, R., Münter, A., 2018. Spatial planning. https://www.arl-international.com/sites/default/files/dictionary/2021-09/spatial_planning_raumplanung.pdf.

²⁸² UNECE, 2008. Spatial Planning: Key Instrument for Development and Effective Governance with Special Reference to Countries in Transition. https://unece.org/fileadmin/DAM/hlm/documents/Publications/spatial_planning.e.pdf.

assessment, three key risks have been identified in the Spatial Planning sector. The first key risk is the risk to population and infrastructure in urban and rural areas from heat-, drought- and flood-related extreme events (KR-SP-1), which relate to climate impacts such as an increase in summer days and tropical nights, as well as heat waves and other extreme events, such as floods and landslides. The exposure risk is expected to increase throughout the century due to ongoing urbanisation as well as increases in heat and heat extremes exacerbating the risk. The second key risk is the risk of long-lasting maladaptation and lock-ins (KR-SP-2), as potential land-use conflicts crystallise the crucial role of spatial planning in risk reduction. If policy is not created that may aid in avoidance of maladaptation, risk is expected to increase. The third key risk is the risk of uncontrolled migration (urban/rural) (KR-SP-3), which considers the migration dynamics in the context of urbanisation.

Actions

Land use planning is identified as one of the most effective processes to facilitate local adaptation to climate change. To ensure the long-term sustainability of the environment, land use planning is crucial to protect ecologically relevant areas. In addition, decision-making processes should be informed by the latest relevant scientific data. Also, spatial development plans and land-use management instruments should be aligned with climate mitigation and adaptation goals. This means reviewing official plans, zoning, and/or development permits based on scientific data to minimise the municipal development risks. By integrating climate considerations into spatial planning, more resilient and sustainable communities can be created.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-SP-1: Ecologically relevant areas, land and soil reserves are used to ensure long-term sustainability and preservation and lower the vulnerability of the respective area. Relevant areas are connected to ensure suitable bio-corridors for species. 							
Action	Establish and enhance ecologically relevant areas and bio-corridors						New
Aim of the action: This action will focus on creating or reinforcing bio-corridors for species. These corridors will be used to ensure genetic diversity and reduce the vulnerability of species in the context of changing environmental conditions. The action also aims to integrate agricultural and forest landscapes with ecological preservation and ensure sustainable land use.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²⁸³	Funding line	Output indicator	Link to other national activities
Authority for Spatial Planning and Construction of the Slovak Republic (ASPC SR)	Ministry of the Environment Slovak Environmental Inspectorate	National	2026-2040	Low to Medium	National (Public Budget, Municipalities, EU (ESIF, CAP), Private	Length of Bio-Corridors Established Number of enforcement	Concept of Spatial Planning in Slovakia ²⁸⁴ National Spatial Development Plan

²⁸³ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁸⁴ <https://uupv.sk/aktuality/oznamenie-o-zacati-obstaravania-koncepcie-uzemneho-rozvoja-slovenska>.

						mechanisms established	
Description of the Action:							
<u>Design and Implementation of Bio-Corridors:</u>							
<ul style="list-style-type: none"> • Bio-Corridor Creation: Design and implement bio-corridors that connect fragmented ecosystems, facilitating species migration and reducing isolation. These corridors should be strategically located to maximize their potential to support wildlife and plant species. • Green Infrastructure: Integrate green infrastructure (e.g., tree lines, buffer zones along rivers, wildlife bridges) into existing landscapes to enhance connectivity between habitats. 							
<u>Design and Install Instruments to Prevent Unsustainable Land Management and Unauthorized Encroachment:</u>							
<ul style="list-style-type: none"> • Monitoring Systems: Establish remote sensing technologies, drones, and satellite monitoring to track land use changes and detect unauthorized encroachment or unsustainable practices (e.g., illegal logging, land grabs, deforestation). • Legal and Physical Barriers: Install physical barriers such as fences, signage, or buffer zones to protect sensitive areas from unauthorized activities. Develop legal instruments, such as zoning laws, land tenure regulations, and land use permits, to prevent unsustainable land management practices. • <u>Enforcement Mechanisms</u>: Strengthen law enforcement mechanisms to detect and prevent illegal land use and encroachment. This includes the use of surveillance systems, GPS tracking, and coordination with local authorities and law enforcement to ensure compliance. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁸⁵			
<p>Enhances biodiversity conservation and ecosystem connectivity, benefiting local communities dependent on natural resources.</p> <p>Encourages sustainable land use practices, reducing conflicts over land tenure and illegal land grabbing.</p> <p>Promotes environmental stewardship among local populations through awareness campaigns on the importance of bio-</p>	<p>Bio-corridors can improve agricultural productivity by maintaining ecosystem services (e.g., pollination, soil health).</p> <p>Reduces long-term costs associated with ecosystem degradation, such as soil erosion and loss of agricultural yields.</p> <p>Strengthens the sustainable tourism sector by preserving wildlife habitats and enabling ecotourism opportunities.</p>	<p>Bio-corridors enhance ecological resilience, enabling species to adapt to climate change by providing safe passage and access to new habitats.</p> <p>Green infrastructure supports the restoration of natural landscapes and mitigates negative impacts from fragmentation.</p> <p>Monitoring and enforcement mechanisms reduce environmental degradation and protect sensitive ecosystems from illegal activities.</p>	<p>Short-term: 1–2 years to design bio-corridors, implement initial green infrastructure, and set up monitoring systems.</p> <p>Medium-term: 3–5 years to establish legal and physical barriers, and to begin monitoring land use changes effectively using remote sensing technologies.</p> <p>Long-term: 5–10 years to fully integrate enforcement mechanisms, monitor ecosystems over time, and see the long-term benefits of connected landscapes and protected areas.</p>	<p>Insufficient coordination between stakeholders could result in fragmented or ineffective bio-corridors, reducing their impact on species migration.</p> <p>Over-reliance on technology (e.g., remote sensing, drones) without proper infrastructure could limit effectiveness in detecting and preventing land management violations.</p> <p>Legal and enforcement mechanisms may not be sufficiently robust or locally supported, allowing for continued illegal encroachment and unsustainable practices.</p> <p>Climate change could impact the efficacy of bio-corridors if the corridors are not</p>			

²⁸⁵ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

corridors and legal land management practices.	Protects land value by preventing illegal encroachment and ensuring sustainable land management.			designed to account for changing ecosystems and shifting species ranges.
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Strategic direction addressed:							
<ul style="list-style-type: none"> SD-SP-3: Decision-making systems take changes in empirical values regarding climate hazards and extreme events into account to secure reliable and accessible infrastructure. (NAP: 6.2, 6.3, 6.4, 7.2) 							
Action	Integrate latest climate impact and risk science into decisions on infrastructure						Existing
Aim of the action: To strengthen spatial planning processes by integrating empirical climate data, ensuring that land use decisions, infrastructure development are climate-resilient, minimizing vulnerability to extreme climate events and ensuring sustainable, accessible, and reliable infrastructure.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁸⁶	Funding line	Output indicator	Link to other national activities
Ministry of the Environment	Authority for Spatial Planning and Construction of the Slovak Republic (ASPC SR) Slovak Hydrometeorological Institute Ministry of Transport Ministry of Investments, Regional	National	2026-2040	Medium	National (Public Budget), EU (ESIF), Private	Number of Spatial Planning Policies updated for climate resilience	National Spatial Development Plan Acts on construction and spatial planning ²⁸⁷

²⁸⁶ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁸⁷ <https://www.slov-lex.sk/ezbierky/pravne-predpisy/SK/ZZ/2025/25/?ucinost=01.04.2025>.

<https://www.slov-lex.sk/ezbierky/pravne-predpisy/SK/ZZ/2022/200/?ucinost=01.04.2025>.

	Development, and Informatization							
<p>Description of the Action:</p> <p><u>Climate Risk Assessment and Data Integration into Spatial Planning:</u></p> <ul style="list-style-type: none"> • Collect and Analyse Climate Data: Use historical climate data, climate change projections, and real-time monitoring to assess current and future climate risks, including floods, heatwaves, storms, droughts, and land degradation. Integrate this data into spatial planning databases. • Climate Risk Mapping: Develop climate risk maps that identify vulnerable areas within urban and rural landscapes. Focus on areas susceptible to flooding, heat islands, droughts, landslides, and other climate-related hazards. These maps will serve as critical inputs in land use decisions, zoning, and infrastructure design. • Scenario Planning: Utilize climate modelling and forecasting tools to explore various climate scenarios and their potential impact on different regions. This will inform future spatial planning efforts and land use regulations. <p><u>Updating Spatial Planning Regulations to Reflect Climate Risks:</u></p> <ul style="list-style-type: none"> • Climate-Resilient Land Use Zoning: Revise zoning laws and regulations to ensure that land use decisions consider climate resilience. For example, restrict or prohibit development in flood-prone areas, establish buffer zones along rivers, and promote the use of green spaces in urban areas to combat heat islands. • Development Standards for Extreme Events: Introduce new building codes and development standards that take into account projected increases in extreme weather events such as flooding, storms, and heatwaves. This includes setting higher resilience thresholds for infrastructure in vulnerable areas. <p><u>Strengthening Infrastructure Design and Urban Planning:</u></p> <ul style="list-style-type: none"> • Climate-Adaptive Infrastructure Design: Integrate climate risk data into infrastructure design to ensure that roads, bridges, water systems, and other public utilities can withstand extreme weather events. For example, roads in flood-prone areas may need to be elevated, and drainage systems should be upgraded to handle increased rainfall. • Flood and Stormwater Management Systems: Incorporate advanced flood control and stormwater management systems into spatial planning to address increased rainfall and storm events. This could include rainwater harvesting systems, improved drainage infrastructure, and the restoration of wetlands to absorb excess water. <p><u>Decision Support Tools for Spatial Planning:</u></p> <ul style="list-style-type: none"> • Climate Risk Decision Support Systems (DSS): Develop or enhance GIS-based decision support tools that allow planners to visualize climate risks and evaluate the potential impact of various land use and infrastructure scenarios. These tools should incorporate up-to-date climate data, including the impact of climate change on existing and future infrastructure. • Stakeholder Engagement in Spatial Planning: Ensure that decision support tools and climate data are accessible to all relevant stakeholders (e.g., urban planners, engineers, local governments, and citizens) to promote transparent and informed decision-making. This can be achieved by creating user-friendly platforms for data access and visualization. <p><u>Adaptive Management in Spatial Planning:</u></p> <ul style="list-style-type: none"> • Adopt an adaptive management approach in spatial planning, where plans are periodically reviewed and updated based on new data and observations of climate impacts. Ensure that spatial planning is flexible and can be adjusted as climate conditions change. 								
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁸⁸				
Increases resilience for communities through the identification and	Reduces financial risk from climate-related damages to infrastructure	Preserves natural resources by integrating flood control, stormwater management, and	Short-term: 1–2 years for initial data collection, development of climate risk	Over-reliance on projections without continuous adaptation to the latest				

²⁸⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>prioritization of vulnerable areas, improving preparedness for extreme weather events and enhancing disaster response strategies.</p> <p>Promotes inclusive urban planning by ensuring all communities, especially those in high-risk areas, benefit from climate-resilient infrastructure and better land use practices.</p> <p>Encourages community awareness and participation through stakeholder engagement in spatial planning, ensuring that local knowledge and needs are incorporated into decision-making.</p>	<p>by proactively designing resilient buildings and infrastructure that can withstand extreme weather events.</p> <p>Strengthens local economies by reducing the long-term costs of disaster recovery and promoting sustainable urban and rural development.</p> <p>Encourages green infrastructure investments, such as sustainable drainage systems and flood control measures, which create new jobs and business opportunities in the construction and environmental sectors.</p> <p>Enhances the attractiveness of cities and regions by implementing climate-resilient urban designs, contributing to economic growth through eco-tourism and climate-conscious investment.</p>	<p>green space planning into spatial planning efforts, contributing to ecosystem health.</p> <p>Mitigates climate change impacts such as heat islands, flooding, and land degradation, through targeted land-use zoning and development standards.</p> <p>Supports the adaptation of urban landscapes, ensuring infrastructure and ecosystems are resilient to extreme weather conditions, promoting sustainability and reducing carbon footprints.</p>	<p>maps, and integration into spatial planning tools.</p> <p>Medium-term: 3–5 years for revising zoning laws, implementing climate-adaptive infrastructure designs, and introducing new development standards.</p> <p>Long-term: 5–10 years for establishing fully climate-resilient urban planning systems, adaptive management frameworks, and ensuring long-term monitoring and updates to planning regulations as climate conditions evolve.</p>	<p>climate data could lead to inadequate planning for unforeseen climate risks.</p> <p>Implementation delays in updating infrastructure and zoning regulations may result in vulnerable communities being left unprotected during critical climate events.</p> <p>Inadequate stakeholder engagement could lead to mismatches between the needs of local communities and the infrastructure solutions provided, especially in marginalized areas.</p> <p>Failure to adapt as climate conditions continue to change could lead to infrastructure that is no longer resilient to new or more extreme climate impacts, resulting in costly repairs or failures.</p>
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Strategic direction addressed:

- SD-SP-4: Spatial development plans and management instruments used to shape and regulate the use of land are in coherence with and support of climate mitigation and adaptation objectives. Maladaptation and lock-in effects are avoided, securing future availability of adaptation options. (NAP: 6.1, 6.2, 6.3, 6.4, 7.2)

Action	Integrate Climate Adaptation Strategies into Spatial Development Plans						New
Aim of the action: To ensure that spatial development plans, land use policies, and management instruments in Slovakia are aligned with climate adaptation objectives, minimizing vulnerability to climate impacts and avoiding maladaptation and lock-in effects that could restrict future adaptation options.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ²⁸⁹	Funding line	Output indicator	Link to other national activities
Authority for Spatial Planning and Construction of the Slovak Republic (ASPC SR)	Ministry of the Environment	National	2026-2040	Low	National (Public Budget)	Percentage of Spatial Plans incorporating climate adaptation goals	
Description of the Action:							
<u>Incorporate Climate Adaptation into Spatial Planning Frameworks:</u>							
<ul style="list-style-type: none"> Policy Integration for Climate Adaptation: Embed climate adaptation goals into national, regional, and local spatial planning policies. Every level of planning should include explicit adaptation objectives, such as improving infrastructure resilience, reducing exposure to climate risks, and maintaining flexibility in land use for future adaptation needs. Climate-Resilient Land Use Zoning: Update zoning laws and regulations to avoid development in high-risk areas (e.g., floodplains, coastal zones, or landslide-prone areas). Designate areas for ecosystem-based adaptation measures such as wetlands, forests, or green spaces, which provide natural climate buffers. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective		Systemic risks ²⁹⁰		
Enhances community well-being by creating safer environments through better zoning and land use planning that minimizes risks from climate change impacts like floods or heatwaves. Ensures equal access to climate-resilient spaces for all citizens by integrating green spaces, wetlands, and other	Saves cost through reducing damage to infrastructure and public services by avoiding development in high-risk areas and investing in resilient infrastructure. Stimulates green economy by promoting ecosystem-based solutions like green spaces and wetlands, which can also create job	Protects ecosystems by integrating nature-based solutions (e.g., wetlands, forests) into spatial planning to buffer against climate impacts like flooding and temperature extremes. Preserves biodiversity by reducing development in ecologically sensitive areas, maintaining natural habitats and promoting sustainable land management practices.	Short-term: 1–2 years to update spatial planning policies and integrate explicit climate adaptation goals at the national and local levels. Medium-term: 3–5 years for implementing updated zoning laws and regulations, including setting aside areas for natural climate buffers and ecosystem-based adaptation measures. Long-term: 5–10 years for complete integration of climate adaptation strategies into spatial planning frameworks across all		Failure to anticipate future risks could lead to continued development in areas that become more vulnerable to climate impacts over time, exacerbating risks. Overemphasis on nature-based solutions without sufficient consideration of infrastructure needs might lead to gaps in protection, leaving some areas inadequately defended against climate events. Conflicts with existing land use could arise if adaptation measures are not balanced		

²⁸⁹ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁹⁰ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>natural buffers into urban planning, which benefits public health and social inclusion.</p> <p>Promotes public awareness and involvement by embedding climate adaptation objectives in planning policies that affect everyone, ensuring transparency and fostering community resilience.</p>	<p>opportunities in conservation, landscaping, and sustainable development.</p> <p>Increases property value and attractiveness for investors due to the improved environmental resilience and sustainability of developed areas.</p> <p>Potential for long-term economic growth as areas become more climate-resilient, reducing the financial burden of disaster recovery and fostering sustainable urban development.</p> <p>Reduces the risk of economic losses due to proper risk zoning.</p>	<p>Enhances ecological services, such as water filtration, carbon sequestration, and flood regulation, by prioritizing ecosystem-based adaptation strategies in land use planning.</p> <p>Supports climate resilience by incorporating flexibility into land use planning, ensuring that urban and rural landscapes can adjust to evolving climate conditions.</p>	<p>levels, ensuring ongoing monitoring and adjustments as climate conditions evolve.</p>	<p>with the needs of urban growth, potentially leading to social tensions or unequal access to climate-resilient areas.</p> <p>Lack of flexibility in zoning laws may hinder the ability to adapt quickly to emerging risks or unforeseen changes in climate patterns.</p>
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4.4.3. Transport, infrastructure and buildings

The **infrastructure** sector is defined as the basic equipment, utilities, productive enterprises, installations and services essential for the development, operation and growth of a city or nation²⁹¹. It comprises public and private physical structures such as roads, railways, bridges, tunnels, water supply systems, sewers, electrical grids and

²⁹¹ IPCC (2023b). Transport. In: Change, I.P.o.C. (Ed.) Climate Change 2022 - Mitigation of Climate Change. Cambridge University Press, pp. 1049–1160.

telecommunications. Infrastructure also includes green and blue infrastructure, such as sports grounds, parks and water treatment facilities. It corresponds to the built environment, representing everything people live in and around. The transport and buildings sectors are subsystems of the infrastructure sector^{292 293 294}.

The **transport** sector represents companies that provide services to move people or goods and construct and maintain transportation infrastructure. It includes road, rail, and marine transport, logistics, airlines and the corresponding infrastructure²⁹⁵.

The **buildings** sector represents an industry associated with erecting, renovating, repairing, maintaining or altering and completing buildings. This includes residential, commercial, institutional and public buildings²⁹⁶.

Impacts and Risks

Several climate impacts are relevant concerning infrastructure with respect to mobility and transport. For instance, temperature increases and heat waves require the implementation of sufficient cooling systems in public transport. Due to the urban heat island effect, temperature related extremes, including an increase in summer as well as tropical days and nights, are of particular importance in cities and other rather urbanised areas. Additionally, the frequency of extreme weather events is leading to greater wind and water erosion, as well as an increase in land- and mudslides, which damage infrastructure and transport facilities.

As a result, two key climate risks have to be considered. Firstly, the risk of damage to infrastructure and buildings e.g. due to landslides/mudslides and pluvial floods potentially leading to loss of livelihoods (KR-TIB-1). And secondly, the risk to human comfort and health due to increased heat in urban centres as well as buildings (KR-TIB-2). According to the assessment, both risks reach very high levels in the far future under a pessimistic scenario (RCP8.5).

Actions

Actions proposed for the transport sector in Slovakia include investing in modern, climate-resilient infrastructure and integrating adaptation measures into construction and modernization processes. This involves adopting resilient design and construction practices, using sustainable materials and green infrastructure such as vegetation buffers and natural water retention areas, and updating building codes, technical norms, and maintenance strategies to reflect climate risks. EU methodological recommendations, including the Sustainable and Smart Mobility Strategy and national guidance, are to be applied in strategic and environmental assessments.

²⁹² Boyle, M.J. (2024). Infrastructure: Definition, Meaning, and Examples. <https://www.investopedia.com/terms/i/infrastructure.asp>. Accessed 10 June 2024.

²⁹³ EEA, 2024b. European Climate Risk Assessment. EEA report 01/2024, Copenhagen. <https://www.eea.europa.eu/publications/european-climate-risk-assessment>. Accessed 11 March 2024.

²⁹⁴ Markard, J. (2011). Infrastructure sector characteristics and implications for innovation and sectoral change. *Journal of Infrastructure Systems* (17(3)), 107–117.

²⁹⁵ Hayes, A. (2021). Transportation Sector and Transportation Industry Investments. <https://www.investopedia.com/terms/i/infrastructure.asp>. Accessed 10 June 2024.

²⁹⁷ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Actions also include fully implementing the Lower Danube Green Corridor Project and the EU Strategy for the Danube Region, ensuring sustainable development of the Danube River for freight transport. This requires sediment management, regular maintenance of waterworks, and, if necessary, adjustments to the riverbed or flood protection barriers. Support for municipalities is proposed to help them finance preventive measures and address damages to local roads and railways. Urban planning actions involve promoting compact development, applying transit-oriented design, and aligning transport infrastructure with public transport hubs to encourage sustainable and climate-adapted mobility.

Further actions include strengthening governance frameworks and funding schemes for resilient transport, while enhancing monitoring and early-warning systems through the Slovak Hydrometeorological Institute to reduce disruptions from floods, storms, and other extreme events.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-TIB-1: Effective governance frameworks are implemented, and sufficient funds are made available to ensure a climate-resilient adaptation of transport, infrastructure and buildings to climate change SD-TIB-2: Transport, infrastructure and buildings are adapted to climatic conditions such as increased heat and natural disasters such as floods, land- or mudslides (e.g. through used materials and technology). 							
Action	Develop and Implement Governance Frameworks for Climate-Resilient Transport, Infrastructure, and Buildings						Existing
Aim of the action: To establish robust governance frameworks and secure adequate financial resources to ensure the climate-resilient adaptation of Slovakia's transport, infrastructure, and buildings.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)²⁹⁷	Funding line	Output indicator	Link to other national activities
Ministry of Transport	Ministry of Environment Ministry of Finance National Transport Authority Aviation and Maritime	National	2026-2040	High	National (Public Budget), EU (ESIF)	Number of coordinating bodies established or strengthened for cross-sector governance in the transport/infrastructure/buildings sectors.	Strategic Transport Development Plan 2030 ²⁹⁸

²⁹⁷ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

²⁹⁸ The Strategic Transport Development Plan of the Slovak Republic up to 2030 is a long-term strategic document that guides effective development of the transport sector and determines the implementation of its development vision. It contains a list of measures that contribute to achieving the vision “A sustainable integrated multimodal transport system that meets society’s economic, social and environmental needs and contributes to the full integration of the Slovak Republic into the European Economic Area.” The list of measures proposed in there need to be crosschecked with the new CRVA and adjusted if needed.

	Investigation Authority					Number of climate-resilient standards and guidelines developed and implemented for transport, infrastructure, and buildings.	
	Private Sector (Construction, Engineering, and Transport Companies)					Amount of public and private funding mobilized	

Description of the Action:

The following activities are suggested for this action:

Governance and Coordinated Institutional Frameworks:

- Incorporate climate resilience into transport, infrastructure, and building regulations and policies at the national, regional, and local levels. This includes creating or updating laws that require climate risk assessments for new infrastructure projects and retrofitting existing assets.
- Establish or strengthen coordinating bodies that bring together government ministries (transport, construction, environment, finance) to ensure that adaptation measures are integrated across all relevant sectors.
- Clarify the roles and responsibilities of government agencies, local authorities, private sector entities, and NGOs in climate adaptation efforts related to transport, infrastructure, and buildings. Create clear lines of accountability to ensure effective implementation and monitoring.
- Develop and enforce standards and guidelines that incorporate climate resilience into the design, construction, operation, and maintenance of transport networks, infrastructure, and buildings. These should include specific adaptation measures for climate hazards such as flooding, heatwaves, and storms.

Secure Funding for Climate Resilient Adaptation Projects:

- Establish mechanisms to secure both public and private funding for climate adaptation projects. This could include national budgets, international climate funds (e.g., Green Climate Fund), and partnerships with private stakeholders or development banks.
- Create incentives for the private sector to invest in climate-resilient infrastructure through subsidies, tax credits, or public-private partnerships. This will encourage businesses to adopt climate adaptation strategies in building and infrastructure projects.
- Develop financial strategies for long-term investments in climate-resilient transport systems, infrastructure, and buildings. This includes prioritizing projects that protect vulnerable infrastructure, such as flood defences for transport corridors and retrofitting of buildings to withstand extreme weather events.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ²⁹⁹
Integrates climate resilience into national, regional, and local	Secures financial resources from public and	Mandates climate risk assessments for new infrastructure and building	Short-term: 1–2 years to establish governance frameworks, integrate climate resilience into national and local policies,	Failure to integrate climate resilience into infrastructure and building regulations may result in continued vulnerability to

²⁹⁹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

<p>policies to enhance community protection.</p> <p>Establishes coordinated institutional frameworks across ministries to ensure comprehensive adaptation actions.</p> <p>Clarifies roles and responsibilities for government agencies, local authorities, and the private sector in climate adaptation.</p> <p>Promotes accountability through clear lines of responsibility for effective implementation and monitoring.</p>	<p>private sectors for climate adaptation projects.</p> <p>Incentivizes private sector investment in climate-resilient infrastructure through financial incentives.</p> <p>Prioritizes long-term investments in resilient transport systems and infrastructure to protect vulnerable assets.</p> <p>Creates financial strategies to ensure sustainable funding for climate adaptation initiatives.</p>	<p>projects to ensure resilience to climate hazards.</p> <p>Retrofits existing infrastructure to improve climate resilience, including flood barriers and sustainable drainage systems.</p> <p>Enhances the climate resilience of transportation infrastructure to withstand flooding, heat stress, and extreme storms.</p>	<p>and secure initial financial resources for adaptation projects.</p> <p>Medium-term: 3–5 years to implement coordinated institutional frameworks, conduct climate risk assessments for new and existing infrastructure, and begin retrofitting existing assets.</p> <p>Long-term: 5–10 years for the full integration of climate adaptation measures into infrastructure and building design, ensuring transport systems and buildings are resilient to extreme weather events, with sustained funding and continuous monitoring.</p>	<p>climate hazards, such as flooding and heatwaves, especially in already at-risk areas.</p> <p>Insufficient coordination between sectors could create fragmented adaptation efforts, leading to inefficiencies and gaps in coverage, ultimately delaying or hindering the full implementation of climate adaptation measures.</p> <p>Overlooking the importance of financial mechanisms may limit the ability to secure long-term investments for adaptation projects, particularly in vulnerable infrastructure, risking the loss of assets due to climate impacts.</p> <p>Neglecting the retrofitting of existing infrastructure could expose transportation networks and buildings to extreme weather events, leaving them inadequate to withstand future climate challenges and potentially leading to higher costs for repairs and disaster recovery.</p>
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Strategic direction addressed:							
<ul style="list-style-type: none"> SD-TIB-2: Transport, infrastructure and buildings are adapted to climatic conditions such as increased heat and natural disasters such as floods, land- or mudslides (e.g. through used materials and technology). 							
Action: Enhance the Climate Resilience of Transport, Infrastructure, and Buildings through Materials, Technology, and Nature-Based Solutions							Existing
Aim of the action: Strengthen Slovakia’s transport, infrastructure, and building sectors against climate-related risks such as increased heat, floods, landslides, and mudslides by implementing climate-adaptive materials, innovative technologies, and nature-based solutions. This will ensure long-term functionality, safety, and sustainability while minimizing damage from extreme weather events.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ³⁰⁰	Funding line	Output indicator	Link to other national activities

³⁰⁰ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Ministry of Transport	Ministry of Environment National Transport Authority Aviation and Maritime Investigation Authority Ministry of Finance Slovak Hydrometeorological Institute	National	2026-2040	High	National (Public Budget), EU (ESIF), Private	Percentage of newly built or retrofitted transport infrastructure and buildings complying with climate-resilient standards. Total area (in hectares) of green infrastructure (e.g., permeable surfaces, retention basins, restored wetlands) developed to mitigate flood and heat risks Total funding allocated for climate-resilient infrastructure projects (in EUR).	
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Description of the Action:

Implement Climate-Resilient Materials and Technologies:

- Use Heat-Resistant and Reflective Materials: Promote the use of cool roofing, reflective pavements, and heat-resistant asphalt in urban areas to reduce the urban heat island effect and prevent infrastructure degradation due to high temperatures.
- Flood-Resilient Construction: Adopt water-resistant materials for transport infrastructure and buildings in flood-prone areas to minimize water damage and prolong structural integrity.
- Smart Infrastructure Monitoring: Deploy sensors and AI-driven monitoring systems to track climate-related stresses (e.g., temperature fluctuations, soil stability, flood levels) and enable proactive maintenance of roads, bridges, and buildings.

Enhance Flood and Landslide Protection Measures:

- Green Infrastructure and Nature-Based Solutions:
 - Implement permeable surfaces, rain gardens, and urban spaces and canopy cover to enhance water absorption and reduce surface runoff.
 - Design sustainable drainage system, both above and below ground – bioretention system, swales, soakaways and infiltration system – to manage and use rainwater close to where it falls, on the surface and incorporating vegetation.

- Restore wetlands and riparian zones to act as natural buffers against floods and mudslides.
 - Structural Adaptations:
 - Construct protective barriers and retaining walls in landslide-prone regions.
 - Early Warning Systems: Improve forecasting and real-time monitoring systems for floods and landslides to enable timely responses and infrastructure adjustments.
- Adapt Buildings for Climate Resilience:
- Heat-Resilient Urban Planning: Incorporate green roofs, vertical gardens, and enhanced ventilation in building designs to mitigate heat stress (see also chapter 4.5.1.)
 - Water-Resilient Building Standards: Strengthen building codes to require flood-proofing measures, such as raised foundations, improved stormwater drainage and capture and use of “grey” water and rainwater.
 - Passive Cooling and Energy Efficiency: Encourage the use of shading, natural as well as controlled ventilation with heat recovery, and thermal insulation to reduce energy consumption and increase resilience to temperature extremes.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ³⁰¹
<p>Reduces health risks from extreme heat, especially for vulnerable groups such as the elderly, children, and outdoor workers.</p> <p>Increases public safety by minimizing the likelihood of infrastructure failure during floods and landslides.</p> <p>Enhances quality of life and urban liveability through cooling features and green spaces.</p> <p>Promotes community awareness and preparedness via improved early warning and monitoring systems</p>	<p>Reduces long-term costs for repair, retrofitting, and maintenance of infrastructure impacted by climate hazards.</p> <p>Minimizes economic losses and service disruptions caused by infrastructure damage due to floods or heatwaves.</p> <p>Drives investment and job creation in climate-smart construction, green building materials, and monitoring technology sectors.</p> <p>Encourages private sector engagement and innovation through increased demand for</p>	<p>Mitigates the urban heat island effect and supports ecosystem health through reflective materials and green infrastructure.</p> <p>Reduces surface runoff and enhances water absorption with permeable surfaces and restored natural areas.</p> <p>Promotes sustainable water use and resource efficiency with rainwater harvesting and grey water systems.</p> <p>Supports biodiversity in urban environments and protects natural landscapes with nature-based solutions.</p>	<p>Short-term: 1–3 years for updating building codes and technical guidelines, piloting climate-resilient materials, and initiating early warning system upgrades.</p> <p>Medium-term: 4–7 years for scaling up use of reflective and flood-resilient materials, implementing green infrastructure and smart monitoring across priority areas, and retrofitting vulnerable infrastructure.</p> <p>Long-term: 8–15 years for full integration of climate-resilient technologies and nature-based solutions across all infrastructure sectors, supported by ongoing monitoring, adaptive management, and maintenance strategies.</p>	<p>Using non-locally adapted materials or technologies may result in increased maintenance needs or performance issues.</p> <p>Over-reliance on high-tech solutions without adequate maintenance frameworks may lead to system failures or gaps in resilience.</p> <p>Insufficient community engagement in design and implementation may reduce the effectiveness or social acceptance of interventions.</p> <p>Green infrastructure could be underutilized or degraded if not properly maintained or supported by long-term planning and funding mechanisms.</p>

³⁰¹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

	resilient building practices and technologies.			
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4.5. Cross-cutting aspects

This cluster encompasses the foundational enablers of adaptation across Slovak society, addressing systemic dimensions such as governance, education, research, regional cooperation, social equity, and urban resilience. Unlike the sector-specific clusters, Cross-Cutting Aspects provide the horizontal scaffolding that ensures adaptation efforts are inclusive, informed, coordinated, and scalable. The actions in this cluster are essential to empower institutions, mobilize communities, and ensure that no region or group is left behind in Slovakia’s climate transition.

The formulation of actions within this cluster draws from multiple national and EU-level strategies, including the 2018 NAS, 2021 NAP, the Environmental Strategy of the Slovak Republic 2030, the EU Strategy on Adaptation to Climate Change, and the EU Urban Agenda. The measures also reflect insights from key stakeholders engaged during D2.2 and D2.4 consultations, particularly around local governance challenges, educational gaps, and regional disparities in adaptation capacity.

In total, this cluster comprises nine adaptation actions, distributed across six thematic areas: Urban Areas (1), Social Issues (1), Education and Society (2), Research (1), Governance (2), and Regional and Cross-Border Cooperation (2). These actions are designed to strengthen Slovakia’s institutional readiness, enhance public awareness and adaptive behaviour, support climate science and innovation, and foster inter-municipal and cross-border partnerships for resilience-building.

Responsibility for implementing these measures is spread across a wide array of actors. The Ministry of Environment and its Working Group on Adaptation serve as overarching coordinators, while specific actions fall under the purview of the Ministry of Education, Ministry of Labour and Social Affairs, Ministry of Investment and Regional Development, and regional self-governments. Key partners also include academia and research institutions, urban planning bodies, civil society organizations, media, and international networks such as the Carpathian Convention or Interreg-funded platforms.

The implementation timeline spans across all temporal levels. Some actions - such as improving access to climate data, launching educational campaigns, and supporting vulnerable social groups - can begin immediately. Mid-term actions include strengthening regional governance capacities, expanding adaptation-related curricula and teacher training, and establishing incentives for city-to-city learning. Over the long term, the strategy envisions a systemic transformation: embedding adaptation in national education standards, creating robust networks of climate-resilient cities and regions, and integrating Slovakia more deeply into EU-wide and cross-border adaptation governance structures.

These actions apply to all regions of Slovakia but are especially important for urban centres under climate stress, socially disadvantaged areas, rural communities lacking institutional capacity, and border regions where cross-national cooperation is crucial to managing shared environmental risks.

4.5.1. Urban areas

Urban areas are densely populated regions that include cities and towns, where infrastructure, buildings, and public services are concentrated. The Organisation for Economic Co-operation and Development (OECD), in collaboration with Eurostat, has developed a harmonized definition of urban areas, focusing on **Functional Urban Areas (FUAs)**. An FUA consists of a densely inhabited city and its surrounding travel-to-work areas, reflecting the economic and social integration of the region. This approach transcends administrative boundaries, providing a more accurate representation of urbanization. In Slovakia, the OECD identifies several FUAs, categorized by population size:

- Small Urban Areas (Small FUAs): Populations between 50,000 and 200,000 inhabitants.
- Medium-Sized Urban Areas (Medium-Sized FUAs): Populations between 200,000 and 500,000 inhabitants.
- Metropolitan Areas (Metropolitan FUAs): Populations between 500,000 and 1.5 million inhabitants.
- Large Metropolitan Areas (Large Metropolitan FUAs): Populations exceeding 1.5 million inhabitants.

For example, Bratislava, the capital city of Slovakia, is classified as a Metropolitan FUA, reflecting its significant population and extensive commuting zone.

Impacts and Risks

There is a diverse range of climate impacts affecting urban areas. These include, but are not limited to, extreme events such as floods (pluvial and fluvial), landslides and mudslides, urban heat islands, tropical days and nights as well as changes in indoor temperatures and humidity. Furthermore, there is an increasing need for cooling in buildings in cities and towns responding to excess summer heat. Likewise, shading is required not only for buildings but also other public areas. In particular due to extreme events, (critical) infrastructure might be damaged, whereby low-lying infrastructure is facing adverse effects caused by pluvial flooding.

Relevant key risks address these climate impacts. Firstly, the risk to human comfort and health due to increased heat in urban centres and buildings (KR-TIB-2) draws attention to the fact that heat is one of the most pressing challenges for urban areas. This aspect is similarly reflected by the risk to population and infrastructure in urban (and also rural areas) from heat-, drought- and flood-related extreme events (KR-SP-1). With regard to urban planning, it should be noted that an increase of conflicts over land uses and the necessity to preserve wind corridors and green spaces in urban centres can be considered as non-climatic risk drivers, leading to an additional pressure and underscoring the relevance of spatial planning for both mitigation and adaptation. Other risks to be considered address the realm of disaster risk management. Widespread disruptions of (critical) infrastructure and services due to extreme events (KR-DRM-1) are also relevant in cities. The same applies to increasing maintenance, provision and emergencies costs (KR-DRM-2) as well as the risk to communities prone to increasing frequency and intensity of natural disasters (vulnerable to different extreme events, including impacts on human health; KR-DRM-3). All three risks related to disaster risk management reach very high levels in the far future under a pessimistic scenario, according to the assessment.

Actions

Actions proposed for urban planning and land-use in Slovakia include strategically integrating green spaces, green roofs, urban forests, wetlands, and other nature-based solutions to improve microclimatic conditions, regulate temperature, reduce air pollution, mitigate the urban heat island effect, and enhance flood control and biodiversity.

Urban zoning and planning actions also include promoting compact development, supporting public transport, and strategically locating renewable energy sources to reduce greenhouse gas emissions.

Building codes, regulations, and climate-resilient infrastructure, such as sponge city concepts, are proposed to incorporate climate-adaptive measures, including building orientation, energy efficiency, and integration with green infrastructure. Legislative reforms at both national and EU levels are proposed to improve spatial and landscape planning, environmental impact assessments, and building permits, while transposing EU Directives (EPBD, EED, RED, ETS) offers opportunities to align mitigation and adaptation objectives.

Actions further include strengthening financial support mechanisms, such as the State Fund of Housing Development, Recovery and Resilience Facility, and renovation programs for residential and public buildings, while revising project selection criteria to better reflect adaptation needs. These measures are proposed to enhance infrastructure resilience, link adaptation with climate mitigation benefits, identify funding gaps, and improve public awareness of adaptation measures.

Strategic direction addressed:							
<ul style="list-style-type: none"> SD-SP-2: Technical specifications and building regulations in urban planning for urban flooding, drought and urban heat island effect are proactively climate-adapted to limit heat stress on people and heat load on infrastructure. (NAP: 6.1, 6.2, 6.3, 6.4, 7.2) 							
Action	Integrate climate change risks into urban planning to reduce impacts of urban flooding, drought, and the urban heat island effect						Existing
Aim of the action: To enhance urban resilience by ensuring due consideration of climate change risks in urban planning. This will mitigate the impacts of urban flooding, drought, and the urban heat island (UHI) effect, reducing heat stress on people and minimizing heat load on infrastructure.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)³⁰²	Funding line	Output indicator	Link to other national activities
Ministry of the Environment	Authority for Spatial Planning and Construction of the Slovak Republic (ASPC SR)	National	ongoing	Low to medium	National (Public Budget, Municipalities)	Percentage increase in green roof coverage and urban tree canopy. Number of new urban projects	Slovakia's Smart Cities Initiative DELIVER - Developing resilient, low-carbon and more LIVable

³⁰² Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

	Ministry of Transport					integrating SuDS, rainwater harvesting, and permeable pavements.	urban Residential area ³⁰³ Acts on Construction and Spatial Planning ³⁰⁴
	Municipal Governments and Urban Planning Authorities						

Description of the Action:

Climate-Resilient Urban Planning Regulations:

- Require the use of heat-reflective materials, green roofs, and passive cooling techniques in construction to limit heat accumulation.
- Urban Water Management Regulations: Ensure all new developments include sustainable drainage systems (SuDS), rainwater harvesting, and permeable surfaces to reduce flood risks and water scarcity.
- Implement standards for heat-resistant roads and pavements in urban areas, improving durability during heatwaves.
- Explore incentives for encouraging the use of green infrastructure, such as parks, green roofs, permeable pavements, and urban meadows and forests, to mitigate climate impacts like heatwaves and stormwater runoff. Promote mixed-use developments that reduce transportation emissions and integrate nature-based solutions.

Expansion of Green and Blue Infrastructure:

- Green Roofs and Walls: Mandate vegetation on new public and commercial buildings to reduce surface temperatures and improve insulation.
- Tree Planting and Urban Forests: Establish a minimum percentage of tree cover in cities and along streets to provide shade and reduce air temperatures. Specifically include shading in cycling and pedestrian infrastructures through tree planting, installing solar panels, and other bioclimatic shading options (pergolas, etc).
- Water Bodies and Cooling Corridors: Integrate ponds, fountains, and shaded public spaces to cool urban areas and support biodiversity. Use stormwater and flood risk management projects to create “climate havens” through landscaping, permeable pavements, fountains, channels and other blue infrastructure, etc.

Smart Climate Monitoring and Early Warning Systems (see also chapter 4.3.1):

- Heat and Flood Risk Mapping: Develop and integrate GIS-based mapping tools for urban planners to identify high-risk zones and guide adaptation efforts.
- Temperature and Humidity Sensors: Deploy monitoring networks to track urban heat stress and trigger public cooling measures.
- Early Warning for Extreme Events: Strengthen heatwave and flood early warning systems to protect vulnerable populations.

Knowledge sharing and best practices:

- Conduct a study of best practices for limiting the urban heat island phenomenon. The findings of this study will be adapted and integrated into the appropriate institutional frameworks (development plans, building regulations etc.) to avoid/reduce the phenomenon of urban heat island, reduce energy consumption for cooling and outdoor shading etc.

Stakeholder Engagement and Capacity Building

³⁰³ Developed under project LIFE: DELIVER - DEveloping resilient, low-carbon and more LIVable urban Residential area. https://odolnesidliska.sk/wp-content/uploads/2023/01/Milestone-31_Posudenie-a-analyza-sucasneho-legislativno-regulacneho-ramca.pdf.

³⁰⁴ <https://www.slov-lex.sk/ezbierky/pravne-predpisy/SK/ZZ/2025/25/?ucinnost=01.04.2025>, <https://www.slov-lex.sk/ezbierky/pravne-predpisy/SK/ZZ/2022/200/?ucinnost=01.04.2025>

- Training for Urban Planners and Architects: Provide educational programs on climate-adaptive design principles.
- Public Awareness Campaigns: Inform citizens about cooling strategies, heat health risks, and water-saving measures.

Incentives for Private Sector Adaptation:

- Offer financial support, such as tax breaks or subsidies, for businesses and homeowners in urban areas implementing green infrastructure.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ³⁰⁵
<p>Enhances public health by reducing heat-related illnesses and improving access to shaded, cooler public spaces.</p> <p>Promotes urban liveability through greener, more comfortable neighbourhoods.</p> <p>Reduces social vulnerability by prioritizing protection for at-risk populations during extreme heat or floods.</p> <p>Increases public awareness and participation in climate adaptation through outreach and education.</p>	<p>Reduces long-term maintenance and repair costs by promoting durable, climate-resilient materials.</p> <p>Stimulates green sectors and innovation in sustainable construction and urban technologies.</p> <p>Attracts investment in climate-smart urban development and real estate.</p> <p>Offers economic incentives to the private sector, encouraging cost-effective adaptation measures.</p>	<p>Reduces the urban heat island effect and improves local air quality.</p> <p>Enhances stormwater management and reduces flood risks through SuDS and permeable surfaces.</p> <p>Supports biodiversity in urban ecosystems via green roofs, trees, and blue infrastructure.</p> <p>Promotes circular water use through rainwater harvesting and greywater systems.</p>	<p>Short-term: 1–3 years for updating urban planning codes, piloting heat-reducing materials, and initiating best-practice studies on the urban heat island effect.</p> <p>Medium-term: 4–7 years for rolling out green infrastructure requirements, deploying sensor networks, expanding early warning systems, and establishing financial incentives for adaptation.</p> <p>Long-term: 8–15 years for full implementation of climate-resilient planning regulations across urban areas, including widespread adoption of blue-green infrastructure and continuous capacity-building of stakeholders.</p>	<p>Over-reliance on technological solutions without nature-based infrastructure may limit long-term resilience.</p> <p>Insufficient public engagement could lead to underuse or mismanagement of green and blue infrastructure.</p> <p>Gentrification risks may arise if green developments increase living costs, potentially displacing low-income residents.</p> <p>Uniform application of standards without considering local climate, geography, and socioeconomic conditions may reduce effectiveness or cause unintended consequences.</p>

³⁰⁵ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

4.5.2. Social issues

Climate change does not affect all populations equally. Social issues such as inequality, poverty, access to resources, and vulnerability to environmental hazards are central to understanding the impacts of climate change and the effectiveness of adaptation measures. Vulnerable social groups, including low-income communities, elderly populations, homeless people, marginalized ethnic groups, and people with disabilities, are often disproportionately affected by climate-related risks, such as extreme weather events, flooding, and droughts. These communities may face challenges in accessing critical resources, healthcare, or support systems, making it harder for them to adapt to the changing climate.

Furthermore, adaptation measures need to address issues of social justice, ensuring that adaptation strategies do not exacerbate existing inequalities. Effective adaptation requires inclusive decision-making processes, where the voices of the most vulnerable are heard and integrated into policy development. For instance, providing affordable housing solutions that are climate-resilient, ensuring equitable access to green spaces, and improving the resilience of public health systems are essential to support communities in adjusting to climate impacts. In the absence of well-designed and inclusive policies, efforts to tackle climate change can have unintended consequences for the livelihoods of certain groups, including by placing a higher financial burden on poor households.³⁰⁶

Impacts and Risks

Next to the fact that climate change in general has disproportionately severe consequences for vulnerable groups, several climate impacts are particularly relevant as these groups have insufficient resources and capacities to cope with and to adapt to climate change. For instance, extreme events such as floods and heat waves may lead to acute adverse effects, including the loss of livelihoods and disproportionately high negative impacts on human well-being and comfort.

Several identified key risks draw attention to this aspect. In the context of disaster risk reduction, the risk of widespread disruptions of (critical) infrastructure and services due extreme events (e.g. forest and wildfires and flood events (pluvial, fluvial) (KR-DRM-1) as well as the risk to communities prone to increasing frequency and intensity of natural disasters (vulnerable to different extreme events, including impacts on human health) (KR-DRM-3) are of importance. With respect to limited financial capabilities of vulnerable groups, the risk of increasing insurance costs and uninsurable climate impacts potentially leading to a loss of risk transfer possibilities (KR-FI-3) has to be taken into account in action planning to ensure a socially just adaptation. Most importantly, the risk of rising costs of inaction due to insufficient mitigation and adaptation to climate change (KR-FI-3) has to be addressed to limit adverse climate change induced impacts on vulnerable groups. Furthermore, vulnerable groups might be also disproportionately affected by risk such as a decreasing ecosystem service provision from terrestrial and aquatic ecosystems, including forests (KR-B-2; KR-FO-1). For instance, already today, these groups often have limited access to green (urban/public) spaces and areas relevant for human well-being and recreation. Against this background, also spatial planning plays a particular role to tackle the risk to population and infrastructure in urban and rural areas from heat-, drought- and flood-related extreme events (KR-SP-1).

³⁰⁶ <https://www.worldbank.org/en/topic/social-dimensions-of-climate-change>.

Actions

Actions proposed for social policies and just transition in Slovakia include linking national social and energy policies with climate adaptation strategies to better use horizontal funding instruments and support vulnerable communities. Expanding funding programs that integrate energy poverty, social vulnerability, and climate adaptation - such as house renovation, renewable energy deployment, and the Social Climate Fund - is proposed to strengthen adaptation outcomes. Affordable housing projects with adaptation and energy efficiency components are highlighted as an example of local-level action with regional spillover effects.

Actions also include adopting a “leave no one behind” approach to climate adaptation, ensuring justice in adaptation and just resilience by avoiding maladaptive practices, reducing inequalities, and empowering local communities. Addressing regional disparities, prioritizing vulnerable groups, and implementing inclusive adaptation strategies are proposed to enhance resilience. Slovakia is encouraged to focus on three dimensions of just transition: distributive justice (addressing root inequalities), procedural justice (inclusive decision-making processes), and recognition justice (engaging all inhabitants regardless of socio-economic or ethnic status), thereby improving capacity for recovery, preventive measures, and long-term climate resilience.

Strategic direction addressed:							
<ul style="list-style-type: none"> All directions (see PART 1 chapter 3.2.2) 							
Action	Social inclusive program for vulnerable groups						New
Aim of the action: Empowering vulnerable communities to adapt to climate change through capacity building, training, and resource allocation.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)³⁰⁷	Funding line	Output indicator	Link to other national activities
Ministry of Labour, Social Affairs and Family of the Slovak	Ministry of Health Office of the Deputy Prime Minister of the Slovak Republic for the Recovery Plan and the Knowledge Economy, Ministry of Environment Ministry of Economy	Local, National	2026-2040	High	National (Public Budget, Municipalities), EU (ESIF), Private	Number of climate-resilient housing units delivered, or existing homes retrofitted for vulnerable populations. Number of targeted climate adaptation	Preparation of Social Climate Plan

³⁰⁷ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						programs or awareness campaigns implemented for vulnerable communities.	
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Description of the Action:

Develop and implement targeted programs to increase the climate resilience of vulnerable populations:

These could include:

- Providing climate-resilient housing solutions for low-income communities.
- Offering financial assistance or subsidies to help marginalized groups implement adaptation measures, such as retrofitting homes for better energy efficiency or flood protection.
- Create a social safety nets and support services to assist vulnerable populations during extreme weather events (e.g., heatwaves, Design and deliver targeted climate change education and awareness campaigns for vulnerable communities, focusing on practical climate adaptation approaches. This could include training on how to prepare for heatwaves, floods, or droughts, as well as how to access emergency services and resources.
- Ensure equitable access to climate-resilient infrastructure and services, such as reliable transportation, healthcare, and clean water.
- Prioritize the development of green spaces and public areas in neighbourhoods that serve vulnerable populations to help mitigate the urban heat island effect.

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ³⁰⁸
<p>Improves living conditions and health outcomes for low-income and marginalized groups.</p> <p>Reduces social inequality by prioritizing access to climate-resilient infrastructure and services.</p> <p>Builds community awareness and preparedness for climate-related risks.</p>	<p>Reduces economic vulnerability by providing financial support for household-level adaptation.</p> <p>Minimizes long-term public spending by pre-emptively addressing climate risks in at-risk communities.</p> <p>Creates job opportunities in retrofitting, green infrastructure, and outreach programs.</p>	<p>Supports nature-based solutions in underserved areas, improving urban microclimates.</p> <p>Promotes sustainable water and energy use through resilient housing and infrastructure upgrades.</p> <p>Helps reduce emissions by investing in energy-efficient housing and green mobility options.</p> <p>Enhances biodiversity and urban greening in vulnerable</p>	<p>Short-term: 1–3 years to identify vulnerable populations, launch targeted awareness campaigns, and establish emergency social support mechanisms.</p> <p>Medium-term: 4–7 years to implement widespread retrofitting programs, distribute subsidies, and expand equitable access to basic climate-resilient services.</p> <p>Long-term: 8–15 years to embed social resilience into national adaptation frameworks, complete infrastructure upgrades, and ensure continuous outreach, training, and monitoring in vulnerable communities.</p>	<p>Failure to consult vulnerable populations may lead to misaligned adaptation measures or lack of uptake.</p> <p>One-size-fits-all solutions may neglect specific local needs, reducing long-term effectiveness.</p> <p>Poorly planned financial incentives could be captured by better-off groups, worsening inequality.</p> <p>Overlooking cultural and social dynamics may create barriers to the adoption of resilience strategies.</p>

³⁰⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Strengthens social cohesion and trust through inclusive adaptation planning.	Encourages inclusive growth by integrating marginalized groups into the adaptation economy.	neighbourhoods through parks and open spaces.		
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4.5.3. Education and society

Education is the foundation for personal fulfilment, employability and active, responsible citizenship. It is essential to the vitality of European societies and economies. Access to quality and inclusive education, training and lifelong learning is a right for all citizens, as enshrined within the European Pillar of Social Rights³⁰⁹.

Impacts and Risks

With respect to climate change in general and adaptation and mitigation in particular, education and awareness raising play a significant role to address associated challenges. For instance, skilled labour is required to ensure climate-resilient planning and to avoid the risk of long-lasting maladaptation and lock-ins (KR-SP-2). Likewise, a workforce able to address damages and disruptions of (critical) infrastructure caused by extreme events such as heavy rain, storms and floods is needed. This aspect is related to several identified key risks in various sectors including disaster risk management, economy & industry, energy, health as well as information & communication technology (e.g. KR-DRM-1, KR-EI-3, KR-E-1, KR-H-3, KR-ICT-1). Furthermore, education and awareness raising is needed concerning the implementation of adaptation and coping strategies on individual level (e.g. knowledge how to act in event of a heat wave or floodings and which preventive measures can be taken already ahead).

Actions

Actions proposed for education and societal shifts in Slovakia include integrating climate change education into school and university curricula to equip students with knowledge, skills, and critical thinking for understanding climate impacts and solutions. Beyond formal education, public awareness campaigns and media initiatives are proposed to promote sustainable lifestyles, including reducing energy and water consumption and minimizing waste. Community-based initiatives, such as tree planting, clean-up campaigns, and advocacy for sustainable policies, are highlighted as means to foster collective action.

Actions also include targeted capacity-building programs for experts and decision-makers in sectors such as economy, urban development, energy, infrastructure, and health to strengthen the capacities of state and municipal administrations. Overall, a holistic approach combining education, societal engagement, and policy support is proposed to enhance climate adaptation and build a more resilient, sustainable future.

Strategic directions addressed:

³⁰⁹ <https://education.ec.europa.eu/about-eea/the-eea-explained>.

- All directions (see PART 1 chapter 3.2.2)

Action		Integrating Climate Change Adaptation into Educational Curricula, Public Awareness Campaigns and Trainings					New
Aim of the action: To enhance public understanding and preparedness for climate change by integrating climate adaptation principles into educational systems at all levels and promoting climate literacy. This will ensure that future generations are equipped with the knowledge and skills to address climate challenges and adapt to environmental changes.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low) ³¹⁰	Funding line	Output indicator	Link to other national activities
Ministry of Education, Science, Research and Sport	Ministry of Environment Slovak Academy of Sciences	National, Local	2026-2040	Low	National (Public Budget, Municipalities), Private (school owners, NGOs)	<p>Percentage of schools (primary, secondary, and tertiary) that have integrated climate change adaptation and resilience topics into their curricula.</p> <p>Number of individuals reached through national and local climate adaptation public awareness campaigns.</p> <p>Number of climate adaptation educational tools (online courses, toolkits, interactive platforms)</p>	

³¹⁰ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

						developed and distributed.	
<p>Description of the Action:</p> <p><u>Integration of Climate Change Adaptation into School Curricula:</u></p> <ul style="list-style-type: none"> Update and integrate climate change adaptation content into primary, secondary, and tertiary education curricula. This could include: <ul style="list-style-type: none"> Climate science, the causes and consequences of climate change. Climate adaptation strategies such as sustainable agriculture, energy efficiency, and urban resilience. Practical activities on how to reduce carbon footprints, prepare for climate-related disasters, and use green technologies. <p><u>Training and Capacity Building:</u></p> <ul style="list-style-type: none"> For Teachers and Educators <ul style="list-style-type: none"> Provide professional development programs for teachers to ensure they have the tools, knowledge, and confidence to teach climate adaptation topics. This could include workshops, seminars, and resources on climate science and adaptation strategies/approaches. Make use of the website https://www.ewobox.sk/ for centralizing access to tools, resources and materials on climate education For public administrations <ul style="list-style-type: none"> Offer trainings across sectors covered by the revised NAS according to the training program developed to accompany implementation of the strategy and work programme. For developers and site owners: <ul style="list-style-type: none"> Increase awareness, education and training for adequately addressing climate change risks and impacts in project design and planning as a key to ensuring success on all parts to sustain better place for residents, nature, municipality and profit. <p><u>Public Awareness Campaigns on Climate Change Adaptation:</u></p> <ul style="list-style-type: none"> Develop national and local public awareness campaigns focused on climate change adaptation, targeting different age groups and sectors of society. These campaigns could: Promote understanding of local climate risks (e.g., flooding, drought, heatwaves). Encourage climate action through local community projects. Educate local populations, especially in high-risk areas, on climate adaptation approaches and solutions. This could involve organizing workshops, creating informational materials, and collaborating with local governments to build resilience in the community. <p><u>Strengthen Research and Climate Change Education Resources:</u></p> <ul style="list-style-type: none"> Support research institutions and universities to develop resources, tools, and models for climate adaptation education. This could include creating online courses, educational toolkits, and interactive platforms to engage citizens and students in learning about climate resilience. <p><u>Integration of Climate Change Adaptation into Vocational and Technical Education:</u></p> <ul style="list-style-type: none"> Incorporate climate adaptation skills into vocational and technical training programs, focusing on sectors such as construction, agriculture, engineering, and public health. This could involve teaching climate-resilient construction techniques, sustainable agricultural practices, and water management in technical institutes. 							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective		Systemic risks ³¹¹		
Builds a climate-aware society by fostering understanding and	Strengthens the workforce by embedding climate adaptation skills	Promotes sustainable lifestyles and practices through climate literacy and behavioural change.	Short-term: 1–3 years to develop climate education modules, launch teacher training		Inadequate teacher training may result in misinformation or lack of student engagement.		

³¹¹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

engagement from an early age.	into vocational and technical education.	Encourages community-level adaptation actions that reduce environmental degradation.	programs, and initiate public awareness campaigns.	Failure to tailor education to local climate contexts could reduce relevance and effectiveness.
Empowers communities and individuals to take informed action to protect themselves and their environment.	Increases long-term economic resilience by preparing future professionals for climate-related challenges.	Supports the implementation of nature-based solutions through awareness and practical training.	Medium-term: 4–7 years to integrate adaptation topics into national curricula, expand vocational training programs, and embed training across sectors and professions.	Overreliance on awareness campaigns without structural support could lead to frustration or apathy.
Enhances social equity by ensuring access to climate education across demographics and regions.	Supports innovation and green job creation through climate-related research and development.	Fosters stewardship of local ecosystems and biodiversity through environmental education.	Long-term: 8–15 years for full cultural shift toward climate resilience through education, established research support systems, and generational knowledge transfer across society.	Unequal access to educational resources and digital tools may deepen existing social disparities.
Fosters intergenerational learning and shared responsibility for climate resilience.	Reduces economic losses from climate impacts by encouraging preventative adaptation behaviour.			

4.5.4. Research

Climate change research involves numerous disciplines of Earth system science as well as technology, engineering, and socio-economic science areas. Some major areas of climate change research include water, energy, ecosystems, air quality, solar physics, glaciology, human health, wildfires, and land use.

Impacts and Risks

All impacts and risks associated with climate change. are relevant for the sector Research. The climate risk and vulnerability assessment revealed numerous and multifaceted climate change impacts and associated risks. Furthermore, such climate risk assessments come along with several uncertainties. The Climate Risk Sourcebook (GIZ, 2023) draws attention to five key factors leading to uncertainties as displayed in Table 28.

Table 28: Sources of uncertainty in Climate Risk Assessments (CRA) according to GIZ (2023).

Key sources of uncertainty in Climate Risk Assessment (CRA)	
Uncertainty source	Description

Climate data and models	Climate observations might be sparse or incomplete. Climate models have high uncertainties specifically when it comes to precipitation-related factors and climate extremes.
Lack of understanding of processes related to adverse consequences	For complex impacts, knowledge of the mechanisms underlying climate risks may not be well understood.
Socio-economic factors	CRAAs also need to consider the potential impacts of socio-economic factors such as population growth, urbanisation, and land-use change that may influence vulnerability and exposure to climate risks.
Lack of local knowledge	Even if the evidence for certain climate risks may be high at the global level, a lack of data and knowledge at the regional to local level leads to large uncertainties.

The uncertainties and associated knowledge gaps highlight the need for sophisticated research related to climate change impacts and risks.

Actions

Actions proposed for climate research and knowledge in Slovakia include strengthening adaptation research as a national priority and better integrating it with strategic documents such as the Research and Innovation Strategy for Smart Specialization (RIS3) and the National Strategy for Research, Development and Innovation 2030. Increased domestic funding is proposed to complement EU support, enabling more comprehensive studies on climate impacts, socio-economic consequences, and sector-specific adaptation measures, as well as enhanced use of digital tools and big data for climate modelling and risk assessment.

Actions also include improving coordination and awareness among key research institutions, including the Slovak Academy of Sciences, Slovak Hydrometeorological Institute, Comenius University, Technical University in Zvolen, and Slovak University of Agriculture. Strengthening international cooperation and participation in EU research schemes is proposed to address knowledge gaps and exchange best practices. Better integration of research findings into policy and local-level decision-making is encouraged, supported by enhanced information exchange through platforms like the Slovak adaptation portal. Social science research on climate communication, public awareness, and addressing climate denialism is also proposed to ensure knowledge translates into effective adaptation measures.

Strategic direction addressed:							
<ul style="list-style-type: none"> All directions (see PART 1 chapter 3.2.2) 							
Action	Develop a national climate change adaptation research agenda and program						New
<p>Aim of the action: The primary aim of the research agenda is to strengthen Slovakia's understanding of climate change impacts, including the risks to human health, the environment, and the socio-political landscape. This agenda will focus on advancing scientific knowledge to inform decision-making across multiple levels and sectors. The climate change adaptation research program is the operational framework to implement the national agenda. It will translate the strategic priorities of the agenda into concrete actions, funding opportunities, and collaborative efforts.</p>							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)³¹²	Funding line	Output indicator	Link to other national activities
Ministry of Education, Science, Research and Sport	All ministries and private sector Slovak Academy of Sciences	National	2026-2040	Medium to High	National (Public Budget, R&D), EU (ESIF, R&D), Private	Number of national climate change adaptation research agenda and program established	
<p>Description of the Action:</p> <p>The <u>research agenda</u> will be designed to support the following key objectives:</p> <ul style="list-style-type: none"> Support Climate Policy Development <ul style="list-style-type: none"> Ensure that the research agenda supports Slovakia's climate policies at local, regional, national, and international levels, aligning with national adaptation strategies and global climate frameworks. Address Knowledge Gaps <ul style="list-style-type: none"> Focus on filling critical knowledge gaps related to climate change impacts, adaptation strategies, and vulnerability assessments, emphasizing areas with the most significant risks to Slovak society and ecosystems. Strengthen the Slovak Climate Research Community <ul style="list-style-type: none"> Foster collaboration among Slovak research institutions, universities, and scientific organizations to increase the visibility and impact of Slovak climate research both domestically and internationally. Increase International Collaboration <ul style="list-style-type: none"> Enhance Slovakia's participation in international climate research initiatives and projects (e.g., Horizon Europe, EU-funded research programs), fostering partnerships that strengthen the country's scientific influence on the global stage. Promote Private Sector Engagement <ul style="list-style-type: none"> Stimulate private research and development efforts to create market-oriented solutions, including new technologies, business models, and products that facilitate climate adaptation and resilience. 							

³¹² Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

The climate change adaptation research program is the operational framework to implement the national agenda. It will translate the strategic priorities of the agenda into concrete actions, funding opportunities, and collaborative efforts. The program will consist of the following key components:

- Research priorities and Focus areas (fill knowledge gaps and develop scientific methods and tools)
- Funding and Incentives for Climate Research
- Building research capacity: Support and strengthen the Slovakian climate research community and increase the visibility of research activities)
- International Research Collaboration (Support climate policy in Slovakia on local, regional, national and international scales (Strengthen the role of scientific community in the international scale (e.g. participation in EU funded projects) e.g. Horizon Europe)
- Public-Private-Partnerships: Stimulate private research activities to develop market-oriented solutions (e.g. technology development, business models).

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ³¹³
<p>Enhances public access to climate knowledge by informing evidence-based policies that protect vulnerable populations.</p> <p>Encourages the inclusion of diverse voices in setting research priorities, fostering trust and relevance in science-policy processes.</p> <p>Supports educational institutions and students through stronger academic networks and engagement with real-world climate issues.</p> <p>Builds societal awareness of climate risks and opportunities through transparent and inclusive research dissemination.</p>	<p>Drives innovation and competitiveness by fostering private-sector R&D in climate adaptation technologies and services.</p> <p>Supports long-term economic planning through robust, data-driven risk assessments and projections.</p> <p>Attracts international and EU research funding, boosting Slovakia's research and innovation sector.</p> <p>Helps reduce economic losses by informing cost-effective adaptation strategies and investments.</p>	<p>Enables science-based protection of ecosystems by filling knowledge gaps on climate vulnerability and impacts.</p> <p>Supports the design and implementation of nature-based solutions and ecosystem-based adaptation.</p> <p>Enhances Slovakia's capacity to monitor environmental change through improved tools and methodologies.</p> <p>Promotes the integration of biodiversity and ecosystem resilience into national adaptation planning.</p>	<p>Short-term: 1–3 years to establish research priorities, identify funding mechanisms, and launch initial capacity-building efforts.</p> <p>Medium-term: 4–7 years to strengthen domestic and international research networks, scale up funding programs, and align outputs with national adaptation goals.</p> <p>Long-term: 8–15 years for sustained integration of scientific evidence into all levels of policymaking, widespread uptake of research-driven solutions, and a mature national research ecosystem.</p>	<p>Research that is too narrowly focused or disconnected from policy needs may result in low uptake and limited impact.</p> <p>Delays in funding or institutional coordination could hinder timely action on critical knowledge gaps.</p> <p>Overdependence on international collaboration without domestic capacity-building might reduce Slovakia's research autonomy.</p> <p>Failure to involve the private sector may limit the development and deployment of practical, scalable adaptation solutions.</p>

³¹³ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

4.5.5. Governance

Given the global, national and local reach impact of climate change, multilevel governance is crucial to address its multilevel causes and impacts, and the participation of all social actors is necessary to provide an effective response. Multilevel climate governance is a continuous process of discussions and negotiations involving a diverse group of national and local governments, international organisations, the private sector, NGOs and other social actors. Its purpose is to promote opportunities and prompt action to address climate change. These decision-making and discussion processes may be formal or informal, flexible and adaptive, and take place at various levels: local, national, regional or international³¹⁴.

Impacts and Risks

The climate risk and vulnerability assessment revealed several climate impacts of high priority that require special attention in terms of governance as the respective frameworks currently in place are insufficient to ensure a sufficient level of adaptive capacity. These climate impacts include, but are not limited to, increase in water scarcity (agriculture), increase in water temperatures (standing waters; biodiversity and ecosystems), increase in floods (pluvial, fluvial), erosion and speed of many chemical reactions (cultural heritage), change in seasonal distribution of precipitation (disaster risk management), increase in low water levels in summer (economy and industry), increase in bed load of watercourses (energy), increase in insurance costs (finance), changes related to water availability and ground water level (geological environment and soil), increase in extreme events (including forest and wildfires), heat load and erosion (information and communication technology) as well as increase in extreme events (including summer/tropical days & nights, landslides/mudslides), increase in urban heat island effect, changes in indoor temperature and humidity, increasing impacts and adaptation requirements to heat such as cooling and shading (transport, infrastructure and buildings).

Furthermore, the assessment shows that there are several identified key risk that require sophisticated governance frameworks on national level. Most importantly, this is the case for the risks in the finance and insurance sector associated with financial instability due to climate related events (in particular extreme weather events (KR-FI-1), increasing insurance costs (KR-FI-2) and rising costs of inaction to tackle climate change (KR-FI-3) as well as the risk of long-lasting maladaptation and lock-ins in the spatial planning sector (KR-SP-2).

Actions

Actions proposed for climate governance and policy integration in Slovakia include reforming the Working Group on Adaptation and designating focal points for adaptation within competent ministries, self-governing regions, and municipalities. In parallel, regional and local climate adaptation plans are proposed to be developed in coordination with the National Adaptation Strategy.

³¹⁴ <https://www.undp.org/sites/g/files/zskgke326/files/2022-09/Volume%20III%20What%20is%20climate%20governance.pdf>.

Strategic directions addressed:							
<ul style="list-style-type: none"> All directions (see PART 1 chapter 0) 							
Action	Reform the Working Group on Adaptation and designate focal points for adaptation in competent ministries, self-governing regions and municipalities						New
Aim of the action: Strengthen the consideration of climate change in all ministries and competent authorities and ensure a coordinated and effective implementation of the revised National Adaptation Strategy (NAS)							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)³¹⁵	Funding line	Output indicator	Link to other national activities
Ministry of Environment	Members of the WGA in its current capacity	National	2026	Low	National (Public Budget)	Designation of climate change adaptation focal points Updated mandate of the Working Group on Adaptation to Climate Change Number of annual meetings	
Description of the Action:							
<p>The Working Group on Adaptation to Climate Change (WGA) oversees the work on:</p> <ul style="list-style-type: none"> A. Monitoring and evaluation of the NAS B. Updating the NAS within the national government. C. Development of the work programme and overseeing implementation of the current NAP (valid until 2027) D. Improve inter-administrative cooperation – both cross-sector and across levels of government E. Promote public outreach/participation processes, when necessary, for instance to disseminate the biannual implementation evaluation reports. <p>To achieve this, each competent Ministry and self-governing region will designate a climate change adaptation strategy focal point (CCASFP). The Union of Municipalities will also designate a CCASFP in representation of municipal governments and communities.</p> <p>All competent authorities will work together in the WGA under the leadership of Ministry of Environment, regularly inform each other about their activities and continuously set new goals in order to create the conditions for effective climate adaptation in Slovakia. The Meteorology Institute regularly accompanies the WGA to provide new information on observed climatic changes.</p> <p>In addition to regular bilateral communication between focal points on specific activities that require combined efforts of multiple actors, the full WGA will meet at least once a year.</p>							

³¹⁵ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ³¹⁶
<p>Promotes inclusive governance by engaging diverse public authorities, enhancing transparency and accountability in adaptation planning.</p> <p>Facilitates communication and cooperation between national, regional, and local levels, ensuring that adaptation measures are socially relevant and tailored to community needs.</p> <p>Encourages broader societal participation through outreach efforts, fostering trust and public ownership of adaptation strategies.</p> <p>Builds institutional and human capacity across government bodies through regular dialogue, shared learning, and coordination.</p>	<p>Improves efficiency and cost-effectiveness by streamlining coordination across sectors and avoiding duplication of efforts.</p> <p>Strengthens alignment between adaptation goals and investment planning, helping optimize public spending and leverage funding opportunities.</p> <p>Facilitates risk-informed decision-making, contributing to the resilience of economic sectors such as infrastructure, agriculture, and energy.</p> <p>Enhances long-term economic stability by institutionalizing adaptation governance as a continuous process.</p>	<p>Supports coordinated implementation of adaptation measures that protect ecosystems and natural resources across sectors and jurisdictions.</p> <p>Facilitates integration of the latest climate data into planning and monitoring, improving the environmental effectiveness of adaptation actions.</p> <p>Encourages ecosystem-based adaptation by linking all sector stakeholders in the WGA.</p> <p>Contributes to adaptive environmental governance, ensuring timely updates in response to emerging climate trends.</p>	<p>Short-term: 1–3 years to designate focal points, formalize WGA procedures, and establish regular communication channels between actors.</p> <p>Medium-term: 4–7 years to implement robust coordination mechanisms, update the NAS, and embed monitoring and evaluation in all relevant institutions.</p> <p>Long-term: 8–15 years for sustained governance capacity, adaptive institutional frameworks, and continuous iteration of adaptation strategies based on evolving climate risks.</p>	<p>Lack of coordination or insufficient clarity in roles could result in fragmented adaptation efforts and inefficient resource use.</p> <p>Failure to regularly update the NAS based on new evidence may lead to outdated or misaligned adaptation strategies.</p> <p>Limited engagement with regional and local authorities might result in top-down approaches that fail to address local vulnerabilities.</p> <p>Inadequate public outreach and participation can erode trust, reduce uptake of adaptation measures, and miss valuable community insights.</p>

³¹⁶ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Strategic directions addressed:							
<ul style="list-style-type: none"> All directions (see PART 1 chapter 3.2.2) 							
Action	Development of regional and local climate adaptation plans in coordination with the National Adaptation Strategy						New
Aim of the action: Municipalities develop and implement climate change adaptation measures within their respective areas of competence that are aligned with and contribute to National Climate Adaptation Strategy (NAS) goals.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)³¹⁷	Funding line	Output indicator	Link to other national activities
Municipalities	Ministry of Environment	Regional, Local	2026-2040	Low to Medium	National (Municipalities)	Number of municipalities that develop climate adaptation plans	
Description of the Action:							
Municipalities and communities are responsible for developing and implementing adaptation policies, plans and actions in various sectors – water supply and sanitation, urban transportation, tourism, cultural heritage, etc. – that are the focus of the national NAS. These policies, plans and actions should be aligned with the national NAS and be integrated into a regional/local climate adaptation plan to enhance synergies and complementarities and avoid contradictions.							
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective		Systemic risks³¹⁸		
Empowers local communities and municipalities to take ownership of climate adaptation, fostering active participation and accountability. Encourages the creation of region-specific climate adaptation plans, which reflect the unique vulnerabilities and needs of local populations. Supports the inclusion of diverse local stakeholders in the	Strengthens local economies by integrating climate resilience into key sectors such as water supply, sanitation, and tourism, ensuring long-term sustainability. Improves the cost-effectiveness of climate adaptation by aligning municipal and national strategies, avoiding duplicative efforts and ensuring efficient resource use.	Ensures that local climate adaptation plans complement national strategies, resulting in integrated approaches to environmental sustainability. Supports ecosystem-based adaptation through regional water management and sustainable urban planning practices, reducing local environmental degradation. Encourages municipalities to prioritize nature-based solutions in their adaptation policies, such as green infrastructure and urban biodiversity.	Short-term: 1–3 years to develop local adaptation plans in alignment with the national NAS and integrate them into regional policies. Medium-term: 4–7 years for the implementation of adaptation actions in key sectors, including water supply, sanitation, and urban transport, with clear synergies between national and local efforts. Long-term: 8–12 years for full integration of climate resilience into municipal governance and planning, with regular updates to ensure alignment with evolving climate challenges.		Misalignment between local and national strategies could result in contradictory or inefficient adaptation measures, undermining overall resilience. Inadequate consultation or stakeholder engagement in the development of local plans could lead to community resistance or neglect of vulnerable groups. Failure to account for local environmental conditions or vulnerabilities could result in ineffective or counterproductive adaptation actions, such as over-reliance on infrastructure solutions instead of nature-based options.		

³¹⁷ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

³¹⁸ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation

<p>planning process, including marginalized groups, ensuring equitable access to adaptation benefits.</p> <p>Promotes public awareness and education on local climate risks, enhancing community resilience and preparedness.</p>	<p>Increases the potential for local economic development by promoting climate-resilient infrastructure, such as improved urban transport and tourism systems.</p> <p>Enhances the economic resilience of municipalities by reducing climate-related losses in key sectors and improving long-term planning.</p>	<p>Enhances local climate resilience by protecting vital ecosystems, such as wetlands and forests, and integrating them into adaptation actions.</p>		<p>Lack of financial resources or political will at the local level may hinder the implementation of ambitious adaptation measures, delay progress and exacerbate vulnerability.</p>
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4.5.6. Regional and cross-border cooperation

Regional and cross-border cooperation in the context of climate change refers to collaborative efforts between different countries, regions, or local authorities to address the challenges posed by climate change. This type of cooperation is essential because climate change often transcends national borders, and its impacts can be felt across entire regions.

Impacts and Risks

When looking at regional and cross-border cooperation, it is the transboundary risks that are of particular importance as they have impacts across borders. When examining transboundary risks within the context of the Republic of Slovakia, the approach used adheres to the sovereignty and independence of European Union member states. This implies that transboundary impacts are not assessed in relation to the EU border. Essentially, this means that an impact in Slovakia resulting from a climate event in, for example, Poland (an EU member state), would be treated similarly to an event occurring in, say, Brazil – both are regarded as transboundary.

The climate risk and vulnerability assessment revealed that transboundary risk understanding is not yet comprehensively understood in existing literature. Transboundary risks pose several challenges due to their high levels of connectivity, major uncertainties and non-linear cause-effect relationships. Existing literature indicates the mode of transmission as most explored and explained approach to understanding transboundary risks. The assessment framework by Carter et al., 2021 is based on the mode of transmission and focuses on how a climate impact occurring at a given location may be transmitted across borders, potentially presenting a risk to a region of interest that is remote from the initial impact, which may require a response from actors in that region. According to Carter et al, 2021 there are seven pathways for the cross-border

transmission of climate risks categories: trade, finance, people, psychological, geopolitical, biophysical, and infrastructure³¹⁹. The transmitted aggregate impact – recipient risk – may necessitate responses to mitigate damage or harness benefits. Additionally, spatial complexity can occur if these risks are propagated via system components located in more than one country.

For Slovakia, two key possible transboundary risks in Slovakia were identified as:

- **Energy Supply and Trade:** Slovakia is integrated into a regional energy network. Extreme weather events could disrupt energy production and supply in neighbouring countries, affecting Slovakia's energy imports. For example, disruptions in hydropower generation in Austria due to droughts could impact Slovakia's electricity imports.
- **Water Resources and River Basin Management:** Slovakia shares river basins like the Danube with neighbouring countries. Changes in precipitation patterns and increased frequency of extreme weather events (e.g., floods, droughts) could affect water availability and quality. This could lead to disputes over water management and allocation among countries sharing these resources.

Actions

Actions proposed for regional and cross-border cooperation include strengthening and actively supporting Slovakia's participation in regional conventions, such as the Carpathian Convention and the Danube River Protection Convention. Slovakia is also encouraged to align its adaptation efforts with broader EU strategies and directives and to engage in coordinated approaches with neighbouring countries, particularly for biodiversity protection, transboundary water management, and addressing cross-border climate impacts.

Strategic directions addressed:							
<ul style="list-style-type: none"> • All directions (see PART 1 chapter 3.2.2) 							
Action	Strengthen International Cooperation						Existing
Aim of the action: To enhance Slovakia's involvement in global climate change adaptation efforts by strengthening international partnerships, sharing knowledge, and collaborating on innovative solutions. This action aims to leverage international expertise, funding opportunities, and networks to support Slovakia's climate adaptation strategy while contributing to global resilience to climate change.							
Responsible actor(s)	Supportive actors	Spatial scope	Timeframe	Estimated Costs (high-medium-low)³²⁰	Funding line	Output indicator	Link to other national activities

³¹⁹ Carter, T.R., Benzie, M., Campiglio, E., Carlsen, H., Fronzek, S., Hildén, M., Reyer, C.P., West, C. (2021). A conceptual framework for cross-border impacts of climate change. *Global Environmental Change* 69, 102307.

³²⁰ Low: €100,000 or less; Medium: €100,000 – €1,000,000; High: over €1 million

Ministry of Foreign and European Affairs Ministry of Environment	WGA	International	2026-2040	Low	National (Public Budget)	Number of global climate adaptation advocacy events (conferences, summits) attended by Slovak representatives and the number of policy recommendations made. Number of climate adaptation technologies transferred to Slovakia and the number of capacity-building workshops or training sessions held.	Climate Diplomacy Slovak Strategy on Development Cooperation
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Description of the Action:

Strengthening Engagement in International Climate Adaptation Networks:

- Actively participate in global and regional climate adaptation forums, such as the UN Framework Convention on Climate Change (UNFCCC), the European Union's climate programs, and international organizations like the World Bank and IPCC.
- Attend international conferences, workshops, and dialogues to exchange knowledge and best practices.
- Increase Slovakia's visibility in international platforms, contributing to global discussions on climate adaptation strategies.

Bilateral and Multilateral Partnerships for Climate Adaptation:

- Establish and deepen bilateral and multilateral partnerships with countries that face similar climate challenges (e.g., flood-prone areas, drought-prone regions, urban heat islands).
 - Engage in joint climate adaptation projects, knowledge sharing, and capacity building.
 - Strengthen collaboration with neighbouring countries (e.g., Czech Republic, Austria, Hungary, Poland) on transnational adaptation initiatives.
 - Actively engage in joint activities under regional conventions, i.e. the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention), or the Convention on Cooperation in the Protection and Sustainable Use of the Danube River (Convention on the Protection of the Danube River).

Capacity Building and Technology Transfer:

- Collaborate with international partners to enhance capacity building and the transfer of climate-resilient technologies to Slovakia.

<ul style="list-style-type: none"> Enhance Slovakia's participation in international technology exchange programs to introduce new adaptation technologies in areas like water management, sustainable agriculture, and climate-resilient infrastructure. <p><u>Further support development cooperation and humanitarian aid</u> through the Slovak Agency for International Development Cooperation (SAIDC) which can inter alia include:</p> <ul style="list-style-type: none"> Strengthen partnerships with international organizations, UN agencies, NGOs, and other donor countries to scale up global climate adaptation efforts and increase the impact of Slovak development cooperation. Facilitate the transfer of knowledge and best practices on climate adaptation strategies from Slovakia to partner countries, including technical expertise, disaster preparedness, and sustainable agricultural practices. Provide emergency response and humanitarian aid to regions affected by climate-related disasters, such as hurricanes, floods, and wildfires, including assistance with recovery and rebuilding efforts. 				
Social context	Economic context	Environmental context	Time frame for planning and implementing to be fully effective	Systemic risks ³²¹
<p>Promotes global cooperation and solidarity by fostering knowledge exchange between countries with similar climate challenges.</p> <p>Strengthens Slovakia's role in advocating for climate justice and resilience on international platforms, representing both local and regional interests.</p> <p>Enhances social resilience through cross-border collaboration, particularly in areas such as disaster response, recovery, and climate adaptation capacity building.</p>	<p>Enhances Slovakia's access to international funding opportunities and climate adaptation projects through bilateral and multilateral partnerships.</p> <p>Stimulates the local economy by encouraging technology transfer and the development of innovative climate-resilient technologies.</p> <p>Expands market opportunities for Slovak companies by engaging in international projects and partnerships focused on sustainable infrastructure and climate-resilient solutions.</p> <p>Increases the potential for Slovakia to attract</p>	<p>Strengthens Slovakia's contribution to global climate adaptation by promoting transnational environmental cooperation, particularly in shared ecosystems like the Carpathians and Danube River.</p> <p>Encourages sustainable environmental management practices by sharing knowledge on climate-resilient infrastructure, water management, and sustainable agriculture.</p> <p>Supports the development and exchange of innovative technologies that reduce environmental impacts, improve resource efficiency, and enhance climate resilience.</p> <p>Enhances Slovakia's environmental sustainability through the adoption of international best</p>	<p>Short-term: 1–3 years to engage in international climate adaptation networks, establish initial partnerships, and participate in global forums and conferences.</p> <p>Medium-term: 4–6 years for deepening bilateral and multilateral partnerships, implementing joint climate adaptation projects, and facilitating the transfer of technology and knowledge.</p> <p>Long-term: 7–10 years to establish Slovakia as a key player in international climate adaptation efforts, with a strong reputation for leadership in capacity building, technology transfer, and global collaboration.</p>	<p>Overemphasis on international networks without adequately integrating local needs could result in solutions that are not contextually appropriate or effective for Slovakia.</p> <p>Lack of alignment between global and national strategies may lead to mismatched priorities or ineffective adaptation projects that fail to address Slovakia's most pressing climate risks.</p> <p>Insufficient capacity at the local level to implement international climate technologies or practices could lead to frustration or waste of resources.</p> <p>Overreliance on external partnerships may divert attention from strengthening domestic systems and capacities for climate adaptation.</p>

³²¹ Reflecting unintended negative consequences of poorly designed or implemented adaptation measures, potentially leading to maladaptation.

Supports vulnerable populations globally by sharing Slovakia's experience with climate adaptation strategies and disaster preparedness.	investment in climate adaptation technologies and services by positioning itself as a leader in international collaborations.	practices in climate adaptation strategies and technologies.		
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ANNEXES

Annex 1: List of sectoral key risks

In the following, all key risks for each sector are listed, including the assessment of current and future risk as well temporal dynamics and spatial variability. Each key risk has a code to link it to the respective sector and support its quick identification: A = Agriculture; B = Biodiversity & Ecosystems; CH = Cultural Heritage; DRM = Disaster Risk Management, Civil Protection & Critical Infrastructure; E = Energy; EI = Economy & Industry; FI = Finance; FO = Forestry; GES = Geological Environment & Soil; H = Health; ICT = Information & Communication Technology; WM = Hydrological Regime & Water Resource Management; SP = Spatial Planning; T = Tourism; TIB = Transport, Infrastructure & Buildings.

Table 29: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Agriculture (KR-A) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-A-1 Risk of loss of agricultural land	low	medium	medium	medium	high	slow onset	regional
KR-A-2 Risk of loss of livelihoods and income from agriculture due to increase in costs, impacts of extreme events and pests/harmful organisms	medium	high	high	high	very high	slow onset acute	regional
KR-A-3 Risk of malfunctioning and failure of water management systems in agriculture	high	high	high	very high	very high	acute	local regional
KR-A-4 Risk of decreased food security & lack of food	medium	high	high	high	very high	slow onset acute	regional national

Table 30: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Biodiversity & Ecosystems (KR-B) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		

KR-B-1 Risk of loss of biodiversity and habitats (terrestrial & aquatic)	high	high	high	very high	very high	slow onset	local regional national
KR-B-2 Risk of decreasing ecosystem service provision from terrestrial and aquatic ecosystems	medium	high	high	high	very high	slow onset	regional local

Table 31: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Cultural Heritage (KR-CH) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-CH-1 Risk of loss of historical, archaeological, cultural and natural sites, landscapes values, traditional practices and authenticity	medium	medium	medium	high	high	slow onset	national regional local

Table 32: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Disaster Risk Management, Civil Protection, Critical Infrastructure (KR-DRM) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-DRM-1 Risk of widespread disruptions of (critical) infrastructure & services due to extreme events (e.g. forest & wildfire and flood events (pluvial, fluvial))	high	high	high	high	very high	acute	local regional
KR-DRM-2 Risk of increasing costs for maintenance, provisions and emergencies	medium	high	high	high	very high	slow onset	national
KR-DRM-3 Risk to communities prone to increasing frequency and intensity of natural disasters (vulnerable to different extreme events, including impacts on human health)	high	high	high	high	very high	acute slow onset	local regional

Table 33: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Economy & Industry (KR-EI) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-EI-1 Risk to businesses and industries due to extreme events (floods, droughts)	low	medium	medium	high	high	acute	national regional local
KR-EI-2 Risk of missed opportunities and unutilised innovation potential	medium	medium	medium	medium	medium	slow onset	national

KR-EI-3 Risk of loss of jobs and lack of skilled workers	low	medium	medium	medium	medium	slow onset	national
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Table 34: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Energy (KR-E) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-E-1 Risk of failure and impairment of energy production, supply and disruption of infrastructure due to extreme events	medium	medium	medium	high	very high	acute	regional national
KR-E-2 Risk of fluctuations in energy production	low	medium	medium	medium	medium	slow onset	national

Table 35: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Finance (KR-F) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-FI-1 Risk of fiscal and individual financial instability and instability of bank portfolios due to climate-related events, in particular extreme weather events	low	medium	medium	high	high	slow onset	national
KR-FI-2 Risk of increase in insurance costs and uninsurable climate impacts potentially leading to a loss of risk transfer possibilities	high	high	high	very high	very high	slow onset acute	national
KR-FI-3 Risk of rising costs of inaction due to insufficient	high	high	high	very high	very high	slow onset	national

mitigation and adaptation to climate change							
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Table 36: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Forestry (KR-FO) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-FO-1 Risk of loss of ecosystem services provided by forests (e.g. water regulation, carbon sequestration) due to forest degradation and forest disturbances	high	high	high	very high	very high	slow onset	regional local
KR-FO-2 Risk of inadequate forest management (e.g. due to lack of knowledge and insufficient flexibility of legislation), in particular under changing climate conditions	high	high	high	high	high	acute slow onset	regional local
KR-FO-3 Risk of loss of economic viability of forestry	low	medium	medium	medium	high	slow onset	regional

Table 37: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Geological Environment & Soil (KR-GES) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-GES-1 Risk of soil degradation, including erosion	medium	high	high	high	very high	slow onset acute	regional
KR-GES-2 Risk of decreasing groundwater availability and quality	medium	medium	medium	high	high	slow onset	regional

Table 38: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Health (KR-H) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-H-1 Risk to human health from extreme heat events and overall increase in heat	medium	high	high	very high	very high	slow onset acute	national regional
KR-H-2 Risk of increases in air-, insect-, water- and food-borne diseases, pathogens and allergens	medium	medium	medium	high	very high	slow onset acute	national regional
KR-H-3 Risk of a lack for access to public water infrastructure	low	medium	medium	high	high	slow onset	local regional
KR-H-4 Risk of health-related increases in economic losses and burdens	medium	high	high	high	very high	slow onset	national

Table 39: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Hydrological Regime & Water Resource Management (KR-WM) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-WM-1 Risk to population and infrastructure from flooding	high	high	high	very high	very high	slow onset acute	national regional
KR-WM-2 Risk of unreliable water supply	medium	high	high	high	very high	slow onset	regional
KR-WM-3 Risk to wastewater infrastructure and sewage systems	medium	high	high	high	very high	slow onset acute	regional local
KR-WM-4 Risk of decreasing groundwater availability and quality	medium	medium	medium	high	high	slow onset	regional

Table 40: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Information & Communication Technology (KR-ICT) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-ICT-1 Risk of damage to ICT infrastructure and widespread disruptions of ICT services e.g. due to extreme events	medium	medium	medium	high	very high	acute slow onset	local regional

Table 41: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Spatial Planning (KR-SP) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-SP-1 Risk to population and infrastructure in urban and rural areas from heat-, drought- and flood-related extreme events	high	high	high	high	very high	acute slow onset	regional local
KR-SP-2 Risk of long-lasting maladaptation and lock-ins	low	medium	medium	high	high	slow onset	national regional
KR-SP-3 Risk of uncontrolled migration (urban/rural)	low	medium	medium	high	high	slow onset	regional

Table 42: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Tourism (KR-T) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-T-1 Risk of decreasing tourism competitiveness due to increasing costs for tourism providers	medium	high	high	high	high	slow onset	regional national

(adaptation, energy, water, labour etc.)							
KR-T-2 Risk of newly emerging, competing destinations at national and international level	low	low	low	low	low	slow onset	regional national
KR-T-3 Risk of loss of touristic attractiveness, key sources & limited accessibility of tourist attractions due to extreme heat and damage induced by other extreme events (floods, storms, fires)	medium	medium	medium	high	high	acute	local regional

Table 43: Assessment of identified key risks including their temporal dynamics and spatial variability in the sector Transport, Infrastructure & Buildings (KR-TIB) for two future time horizons (each for an optimistic (RCP4.5) and pessimistic scenario (RCP8.5)).

Key Risk	Current Risk Assessment	Near Future (2021-2050)		Far Future (2071-2100)		Temporal Dynamics	Spatial Variability
		Optimistic	Pessimistic	Optimistic	Pessimistic		
KR-TIB-1 Risk of damage to infrastructure and buildings e.g. due to landslides/mudslides & pluvial floods and loss of livelihoods	medium	high	high	high	very high	acute	national
KR-TIB-2 Risk to human comfort and health due to increased heat in urban centres and buildings	high	high	high	very high	very high	acute	regional

Annex 2: Glossary of Key Terms

Adaptive Capacity. In this report, adaptive capacity describes the *current* ability of systems, institutions, humans and other organisms to adjust to potential damages and climate impacts, to take advantage of opportunities, or to respond to consequences. Adaptive capacity therefore describes the status quo of all presently available adaptation options, including e. g. financial or human resources. The adaptive capacity might differ between risks and sectors (European Environment Agency (EEA n.d.); IPCC, 2021c) and is highly dependent on volatile factors such as political direction, leadership and administrative actions, which decreases the reliability of predictions about its future development. Although the adaptive capacity can adjust and alter flexibly, limits to adaptation might be reached, when a system's needs or an actor's objective cannot be secured from intolerable risks, which threaten 'core social objectives associated with health, welfare security or sustainability' (IPCC, 2022a). Those limits might be soft, when adaptation options exist but are currently not available, or hard, when no adaptive actions are possible or feasible to avoid intolerable risks. Climate change will exacerbate the occurrence of hard limits to adaptation, which have already been reached in some natural ecosystems (IPCC, 2022a). Additionally, not all adaptive measures show an immediate effect. To achieve large-scale adaptation, far-reaching adaptation actions might be necessary, which in turn require longer periods to unfold their full impact. This also encompasses the time needed for preparatory and implementation steps. Examples of sectors with prolonged adaptation times are forestry, the geological environment and soil.

Climate impact. A climate impact describes an already observed or possible future, relevant impact of one or more climatic influences on a defined system and/or system components (e. g. livelihoods, social/cultural objects, ecosystems). Climate impacts can be described as consequences or results and can be disadvantageous or advantageous. A climate impact always refers to a specific period. As a rule, the term climate impact is used based on the definition of the IPCC up to the point at which an assessment of the climate risk takes place (GIZ, 2023; Umweltbundesamt (UBA), 2021).

Climate impact chain. Climate impact chains (CIC) are used to visualise cause-effect relationships between climate impacts and associated risks as well as cross-sectoral interdependencies (GIZ, 2023). In this report, climate impact chains are structured as the ones developed in the course of the EUCRA (EEA, 2024), whereby slight adaptations were made.

Climatic impact driver. A climatic impact driver describes a changing aspect of the climate system that influences a component of a man-made or natural system. The stronger the climatic influence, the stronger the climate impact tends to be (Umweltbundesamt (UBA), 2021).

Exposure. Defined by the IPCC as 'presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected' (IPCC, 2021c). Following the sectoral assessment approach, which focuses on one system (e. g. agriculture) at a time, exposure refers to the extent to which a respective climate impact within the system is dependent on climate change.

Hazard. A hazard is defined as the 'potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources' (GIZ, 2023).

Key risk. According to the Climate Risk Sourcebook, so-called key risks are defined as having ‘potentially severe adverse consequences for humans and social ecological systems resulting from the interaction of climate-related hazards with vulnerabilities of societies and systems exposed’ (GIZ, 2023). Contrary to climate risks (see below), key risks have consequences of high magnitude or likelihood, they affect essential systems and functions and might have a critical timing, i. e. severe impacts are already occurring.

Sensitivity. Sensitivity is defined as the extent to which a system might be positively or adversely affected by climatic changes and is therefore susceptible to harm. An example might be the demographic age distribution or forest structures (IPCC, 2022d; Umweltbundesamt (UBA), 2021). Factors and indicators determining the sensitivity of a system can be derived from the characteristics and attributes, which make the system susceptible to changing hazards (Deutsches Institut für Normung e. V., 2021).

Strategic directions. The strategic directions describe the fundamental objectives within each sector, supporting the targeted planning of measures and achieve short- and long-term goals. They should enable stakeholders to maintain greater consistency in decision-making processes.

Risk. Risk, or more precisely climate risk refers to the potential for adverse impacts on man-made or natural systems, considering the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise both from the potential impacts of climate change and from human responses to climate change. In connection with the effects of climate change, risks arise from dynamic interactions between climatic influences and the spatial exposure as well as the sensitivity and adaptive capacity of the affected system. The term climate risk is used as soon as the risk is assessed (GIZ, 2023; Umweltbundesamt (UBA), 2021). It has to be noted that the mentioned aspects influencing the risk are subject to spatio-temporal changes and come along with uncertainties (e. g. likelihood of occurrence) (GIZ, 2023).

Vulnerability. According to the IPCC, vulnerability is understood as ‘[t]he propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt’ (IPCC, 2022b).

Annex 3: Financial estimates and mechanisms required to carry out the identified short and mid-term actions (up to 2040) proposed for the revised NAS

Budgetary allocations and mechanisms required

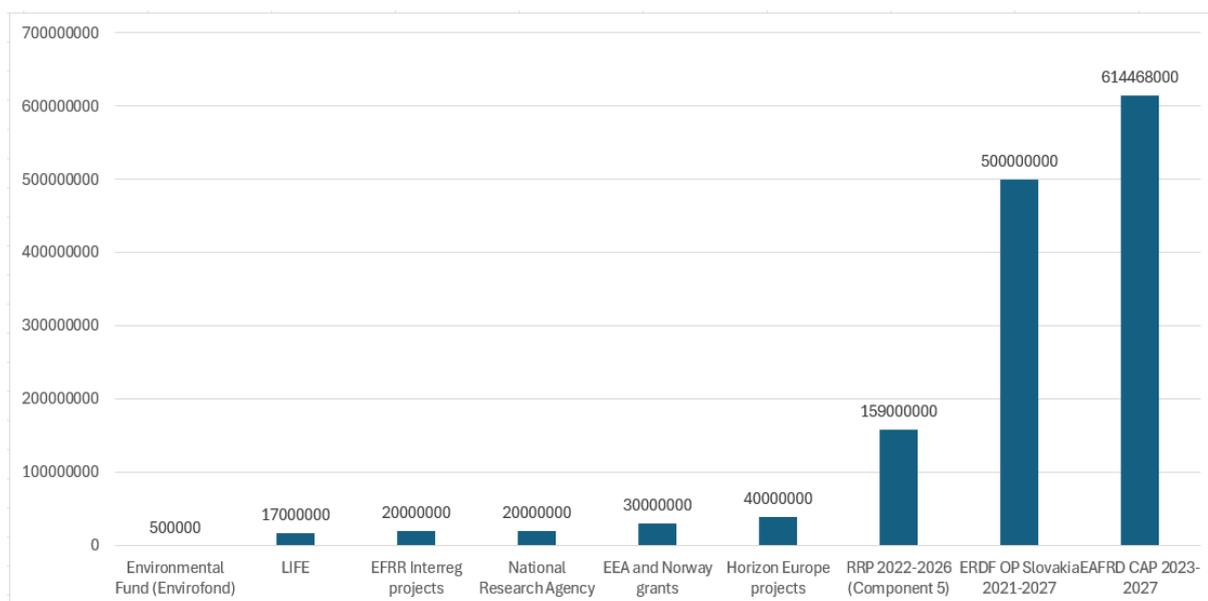
Financing the implementation of the revised National Adaptation Strategy involves three priority sources: (i) European sources of funding for adaptation measures; (ii) National sources of funding for adaptation; and (iii) Mobilizing private funding for adaptation action.

European sources of funding for adaptation measures

A significant portion of Slovakia's climate adaptation measures is financed through **European funds**. OECD Environmental Performance Reviews: Slovak Republic 2024 reports that "around 70% of spending on environmental protection (mainly capital expenditure) is financed by EU funds, well ahead of the state budget (18%) and the Environmental Fund (10%)"³²². Additionally, there is a growing level of activity at the local level, with towns and municipalities increasingly investing in adaptive measures. Figure 8 presents an overview of estimated investments from European sources and national Environmental Fund.

³²² OECD (2024), OECD Environmental Performance Reviews: Slovak Republic 2024, OECD Environmental Performance Reviews, OECD Publishing, Paris, <https://doi.org/10.1787/108238e8-en>.

Figure 8: Mapping of funding sources and estimates for measures addressing climate change adaptation until 2027



Source: Adapted from Ministry of Environment of the of the Slovak Republic. (2021c) COMPLEMENTARY FUNDING PLAN

The financing of the National Adaptation Plan (NAP) is based on the principle of combining available funding sources and ensuring their complementarity. To implement the NAP (under the current validity until 2027 and expected update) effectively, it will be essential to make full use of the resources available through 2027 (with the potential continuation of funded projects until 2029) and to prepare thoroughly for the negotiations of the next Multiannual Financial Framework for 2028–2034.

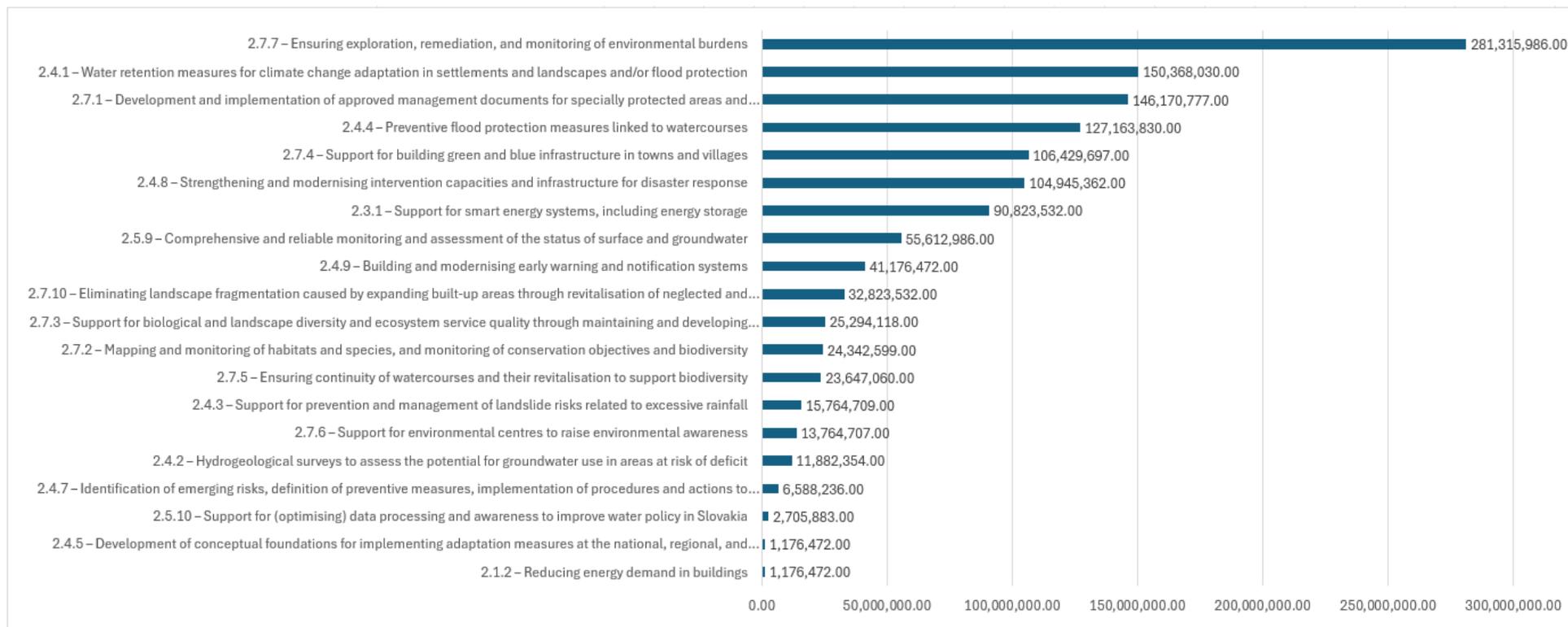
As illustrated in Figure 8, the significant funding source for climate adaptation measures - particularly in agriculture, but with significant overlap in forestry and biodiversity - is the Common Agricultural Policy (CAP). During the 2023–2027 programming period, assistance is provided through the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD).

Interventions take the form of direct payments, transitional national payments, sectoral interventions, and rural development interventions, organized under nine specific objectives and one cross-cutting goal. Specific objective no. 4 focuses on contributing to climate change mitigation and adaptation by reducing greenhouse gas emissions, enhancing carbon sequestration, and promoting sustainable energy use. In accordance with Article 93 of the EAFRD, a minimum of 35% of allocations (excluding the outermost regions) must be dedicated to environmental and climate-related objectives. Slovakia’s indicative allocations for these priorities are as follows: €12.64 million in 2025, €45.28 million in 2026, and €36.85 million in 2027. These investments have already contributed - or are expected to contribute - to enhanced climate resilience and greater environmental sustainability in the agricultural industry and rural development programmes.

An equally important source of investment supporting climate adaptation is the European Regional Development Fund (ERDF), along with resources distributed through the Operational Programme Slovakia. For the 2021-2027 programming period, under Priority 2P2 – Environment, Specific Objective RSO2.4 (Support for climate change adaptation and disaster risk prevention and resilience, considering ecosystem-based approaches, ERDF and CF) plays a central role.

However, climate adaptation, as a cross-cutting theme, is also addressed within other investment areas. Figure 9 summarises the main domains with significant overlap with climate adaptation. As previously noted, many of these investments are multifunctional and serve multiple policy objectives and are thus not solely focused on climate adaptation.

Figure 9: Operational Programme Slovakia (Cohesion Policy 2021-2027): Financial resources relevant for NAS Actions.



Source: MIRRI, 2024

An additional EU instrument available till mid-2026 is the Resilience and Recovery Fund (RRF). Within the scope of climate adaptation, Slovakia's Recovery and Resilience Plan includes six key components aimed at supporting the transition toward climate neutrality and environmental sustainability (Renewable energy sources and energy infrastructure, Building renovation, Sustainable transport, Industrial decarbonisation, Climate change adaptation, and REPowerEU). These priorities reflect an integrated approach to economic recovery that aligns with both EU climate targets and national adaptation needs.

Several large-scale projects have been supported that have a direct or indirect impact on resilience and climate change adaptation. These include, for example: *Adaptation of regions to climate change with an emphasis on nature conservation and biodiversity development* (EUR 3,056,013), *Support for the functioning of the Slovak Environmental Inspectorate related to decarbonisation* (EUR 5,991,982)³²³, or *Improving energy efficiency in family homes and supporting the renovation of households at risk of energy poverty* (EUR 39,186,171).³²⁴

A specific and growing role for EU-supported investment can be seen in the field of research and development, where a substantial share of activities likely addresses climate adaptation.

Research and innovation funding includes targeted schemes for scientific research and technological development, such as Horizon 2020, the Slovak Research and Development Agency (APVV), the Scientific Grant Agency (VEGA), and others, although precise data are not currently available. Climate change related research is a primary theme in funding instruments the Recovery and Resilience Plan (RRP), and national grant programmes. The RRP also supports infrastructure development projects at Slovak universities (e.g., the Slovak University of Agriculture in Nitra), where indirect contributions to adaptation are anticipated.

Additional resources include a variety of alternative funding mechanisms such as the EU LIFE programme, grants from the European Economic Area (EEA) and Norway Grants, and other bilateral or multilateral instruments.

National sources of funding for adaptation

The role of the state budget and national financing may be more limited in terms of direct investments and project funding; however, it is crucial for financing state infrastructure and public administration. The national government aims to support priority adaptation actions and strategic objectives, particularly in synergy with agricultural policy, economic development strategies, and sectoral strategies implemented by the Ministry of the Environment.

In this context, it will be important to ensure synergies with the following national plans and programmes:

- Water Policy Concept of the Slovak Republic until 2030 with a view to 2050
- Priority action framework for financing Natura 2000 in the Slovak Republic for the EU program period 2021 – 2027 (2020)
- Updated Concept of the Hydropower Potential of Watercourses of the Slovak Republic until 2030 (2017)
- Integrated National Energy and Climate Plan for 2021 – 2030 (2019)
- Low-carbon development strategy of the Slovak Republic until 2030 with a view to 2050 (2020)

³²³ The support programme is intrinsically linked to both decarbonisation and climate adaptation objectives. By enhancing enforcement capabilities and integrating environmental considerations into planning and management, monitoring and protecting natural resources, the Inspectorate contributes to building resilience against climate impacts, such as floods and droughts.

³²⁴ Although not framed explicitly as an adaptation measure, the energy efficiency renovation programme under the Slovak RRP delivers important climate adaptation co-benefits, especially for vulnerable populations. It enhances climate resilience at the household level, resilience during heatwaves and cold spells.

- Strategic plan for the development of transport in the Slovak Republic until 2030 (2017)
- The Conceptual Framework of Urban Development of the Slovak Republic until 2030 (2018)
- Flood Risk Management Plan in Sub-basins of the Slovak Republic (2015)
- Water Plan of Slovakia for the years 2022- 2027 (2022)
- Concept of the Water Policy of the Slovak Republic until 2030 with a view to 2050 (2022)
- A set of measures in the field of hydromelioration for adaptation to climate change and restoration of irrigation infrastructure in Slovakia (2022)
- The Strategy of the Economic policy of the Slovak Republic until 2030 (2018)
- Landslide Risk Prevention and Management Program (2021 – 2029) (2021)

The State Environmental Fund (*Envirofond*) has so far played a minor role in financing adaptation measures (as shown in Figure 8). According to the 2023 fund Annual Report, there were additional revenues 584 mil EUR and the number of resources in the fund has been constantly growing.³²⁵ Initial supported initiatives have already emerged, including *Climate change adaptation as part of broader environmental sustainability support schemes*.

Increasingly important for financing climate change adaptation are municipal budgets. However, national statistic covering municipal budgets are not available. Financial contributions from local and regional governments are particularly important for the implementation of local adaptation measures and community-based projects.

Mobilizing private funding for adaptation action

Private sector funding offers a range of opportunities to synergize investments from businesses and private entities, including public-private partnerships (PPPs). Such investments are essential for scaling up adaptive capacity and delivering infrastructure and innovation at scale. However, there is currently only anecdotal evidence of private investment in climate adaptation in Slovakia, and further research in this area is needed to better understand its potential and barriers.

Financing adaptation actions 2026/2027

For the purposes of financing the revised National Adaptation Strategy (NAS), a comprehensive mapping of climate change adaptation financing for the period 2026 - 2027 is provided, aligned with the strategic priorities and specific actions outlined in the NAS. This mapping aims to identify key funding streams - whether from European Union sources, national budgets, or other mechanisms - and assess their alignment with adaptation needs across sectors and regions.

Table 44 presents this overview and also outlines indicative funding targets and projections, which may help in development of forward-looking perspective for the next Multiannual Financial Framework (2028–2034). The table is designed to highlight both existing financial estimations and emerging gaps that may require new instruments, stronger coordination, or increased involvement from private and local actors. The findings from the mapping exercise are reflected in the sectoral Factsheets in chapter 5 and provide the basis for cost estimations and funding lines.

³²⁵ The 2023 Annual report is available at: https://envirofond.sk/wp-content/uploads/2024/04/2023-Vyrocnna-sprava_comp.pdf

This structured approach provides a foundation for building a robust and integrated financing framework for climate resilience in Slovakia, ensuring that financial planning is closely tied to national adaptation priorities and implementation capacity.

The financing overview in Table 44 focuses on the period 2026–2027 because this is the bridging phase between the current EU programming period (2021–2027) and the preparations for the next Multiannual Financial Framework (2028–2034). The years 2026–2027 are therefore critical for both finalising commitments under existing programmes and shaping priorities for the upcoming financing cycle.

The compilation of the table was based on a review of official budgetary documents, progress in spendings in EU funding instruments, national expenditure plans, and sectoral adaptation strategies. Available figures were triangulated across multiple sources, including the Ministry of Environment, Ministry of Finance, European Commission funding databases, and relevant project-level data, to ensure consistency and comparability. Where official allocations were not available, indicative estimates were developed using past spending patterns, expert assessments, and alignment with sectoral priorities identified in the revised NAS.

Table 44: Mapping of proposed Climate Change Adaptation Actions (based on Part 2) Financing 2026 – 2027.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
CLUSTER BIOECONOMY								
Agriculture								
Climate resilient agriculture	Primary Approx 1 Mil EUR annually ³²⁶			2026: 45 275 502,00 EUR 2027: 36 852 153,00 EUR ³²⁷	1.947.405 EUR ³²⁸	LIFE, Horizon	APVV, VEGA	Substantive, but limited data available
Biodiversity, Ecosystems and Natural Heritage								

³²⁶ Sectoral Interventions – Market-Oriented Expenditures under the Common Agricultural Policy.

³²⁷ Environmental and Climate Targets EPFRV (article 93).

³²⁸ Support to Nitra Agricultural University and scientific infrastructure.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Build a robust legislative framework to enhance ecosystem preservation and strengthen enforcement mechanisms	MoE		1,17 mil EUR (2.4.5.)		5.991.98 2 EUR ³²⁹	LIFE, Horizon	APVV, VEGA	
Foster Adaptive Management Practices for Ecosystem Services Sustainability in key sectors	MoE, MoA		127,2 mil EUR (2.7.1.) 24,3 mil EUR (2.7.3.)			LIFE, Horizon	APVV, VEGA	
Establish and Expand Ecological Corridors and enhance their connectivity	MoE, M of Transport		127,2 mil EUR (2.7.1.) 24,3 mil EUR (2.7.3.) 104,9 mil EUR (2.7.4.) 1620,5 Mil EUR (RSO3.1) ³³⁰	Environmental and Climate Targets EPFRV (article 93)		National Motorway Company (NDS)		
Protecting Slovakia's Natural Heritage through Climate-Resilient Landscape Management	MoE, MoA		127,2 mil EUR (2.7.1.) 24,3 mil EUR (2.7.3.)		3.056.01 3 EUR ³³¹	LIFE, Horizon	APVV, VEGA	

³²⁹ Supporting the functioning of the Slovak Environmental Inspectorate.

³³⁰ Development of a smart, safe, sustainable, and climate-resilient intermodal TEN-T.

³³¹ Adaptation of regions to climate change with an emphasis on nature conservation and biodiversity development.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
			104,9 mil EUR (2.7.4.) 25,3 mil EUR (2.7.10.)					
Forestry								
Enhance Forest Health Monitoring and Early Warning Systems	MoE, MoA			European Agricultural Fund for Rural Development (EAFRD)				
Forest Restoration and Protection through adaptive silviculture	MoE, MoA			European Agricultural Fund for Rural Development (EAFRD)		The EIB loans ³³² Cross-Border Cooperation Initiatives: Slovak and Hungarian forestry ³³³		Substantive, but limited data available

³³² EIB extended a €120 million loan in 2014 to Slovakia to finance projects contributing to afforestation, improved forest protection and management, and the upgrading of agricultural infrastructure in rural areas.

³³³ More information at: https://www.hungarianconservative.com/articles/culture_society/hungary-slovakia-forest-conservation-collaboration/.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Promote and transition to Sustainable Forest Management Practices	MoE, MoA			European Agricultural Fund for Rural Development (EAFRD)		LIFE, Horizon	APVV, VEGA	Substantive, but limited data available
Geological Environment & Soil								
Foster sustainable soil and water balance management practices	MoE, MoA		150,4 mil EUR (2.4.1) 15,8 mil EUR (2.7.5.)	European Agricultural Fund for Rural Development (EAFRD)		LIFE, Horizon	APVV, VEGA	
Advance risk mapping to account for increasing climate-related geohazards	MoE, Slovak Hydrometeorological Institute		281,3 mil EUR (2.7.7.)			Horizon		
Hydrological Regime & Water Resource Management								
Climate-Integrated Hydrological Planning and Monitoring	National Public Budget: Ministry of Environment (e.g. through	Towns and municipalities	1,18 mil EUR (2.5.10.)	Common Agricultural Policy (CAP) Strategic Plan (eco-schemes, rural		European Investment Bank (EIB) climate		

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
	Slovak Water Management Enterprise) Ministry of Agriculture and Rural Development			development funds)		adaptation loans ³³⁴		
Assess, climate proof, improve and maintain water and waste water infrastructure	MoE		6,6 mil EUR (2.4.2.) 41,2 mil EUR (2.5.9.) 104,9 mil EUR (2.7.4.) 150,4 mil EUR (2.4.1.)					
Reinforcing existing flood protection measures	MoE	Towns and municipalities	106,4 mil EUR (2.4.4.)					
CLUSTER ECONOMY								
Economy and Industry								

³³⁴ The European Investment Bank (EIB) provided a €240 million loan to Slovakia for co-funding of EU-supported green and digital projects. The credit is the first part of an €800 million EIB loan approved to Slovakia for national contributions mandatory for European Union-supported project.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Establish industry-specific drought prevention measures	MoE, MoA	Towns and municipalities	41,2 mil EUR (2.5.9.) 150,4 mil EUR (2.4.1.)					Substantive, but limited data available
Strengthening regional value chains within Slovakia	Ministry of Economy		485,7 mil EUR (RSO1.2) ³³⁵					
Continue to support human capital and business development initiatives	Min of Economy, Min of social Affairs		RSO1.2. RSO1.3. RSO1.4.					
Energy								
Security of energy supply	Min of Economy		259 mil EUR ³³⁶					

³³⁵ Harnessing the benefits of digitalisation for citizens, businesses, research organisations, and public authorities

³³⁶ ESIF - 2.1.3 – Supporting the development of regional and local energy systems.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Climate proofing energy and electricity infrastructure	Min of Economy		55,6 mil EUR ³³⁷			LIFE, Horizon	APVV, VEGA	Substantive, but limited data available
Inform the general public about individual measures to be taken with regards to both supply and demand of energy	Min of Economy, MoE		1174 mil EUR (RSO2.1) ³³⁸					
Financial and Insurance System								
Mainstream adaptation into public administration budgets	Public administration budget Internal funding							
Strengthen the insurance scheme	Min of Finance, Min of Economy		EU Climate and Disaster Risk Reduction Funds					Substantive, but limited data available
Tourism								

³³⁷ ESIF - 2.3.1 – Support for smart energy systems, including energy storage.

³³⁸ Support for energy efficiency and reduction of greenhouse gas emissions.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Update the national tourism strategy	Min of Tourism, Planned for 2025 (including Tourism Support Fund/estimate 20 mil EUR annually)							
CLUSTER SAFETY AND WELL-BEING								
Disaster Risk Management, Civil Protection and Critical Infrastructure								
Strengthening Climate-Resilient Critical Infrastructure and Disaster Preparedness	Min of Internal Affairs		6,6 mil EUR ³³⁹					Substantive, but limited data available
Development of a Comprehensive Multi-Level Emergency Preparedness and Response Program	Min of Internal Affairs		104,9 mil EUR ³⁴⁰ and 41,2 mil EUR ³⁴¹					

³³⁹ ESIF - 2.4.7 – Identification of emerging risks, definition of preventive measures, implementation of procedures and actions to ensure preparedness and response to climate-induced disasters.

³⁴⁰ ESIF - 2.4.8 – Strengthening and modernising intervention capacities and infrastructure for disaster response.

³⁴¹ ESIF - 2.4.9 – Building and modernising early warning and notification systems.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Develop and implement a National Heat-Resilient Healthcare Infrastructure Program	Min of Health				11,18 mil EUR ³⁴²			
Inform the general public about individual measures to be taken in environmental emergencies	MoE, Min of Internal Affairs		11,9 mil EUR (2.7.6.)					
Health Care								
Specific Healthcare Measures for Minority Groups	Min of health, Min of Social Affairs		245,2 mil EUR ³⁴³					
Improve water management practices accounting for climate risks	MoE National (wastewater fee)		6,6 mil EUR (2.4.2.) 41,2 mil EUR (2.5.9.)			LIFE, Horizon	APVV, VEGA	

³⁴² Part of the scheme focused on New hospital network – construction, reconstruction and equipment (Project by the Ministry of Health).

³⁴³ RSO4.5 – Ensuring equal access to healthcare and increasing the resilience of healthcare systems, including primary care, as well as supporting the transition from institutional care to family- and community-based care.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Safeguarding climate-resilient drinking water supply	MoE National (water fee)		150,4 mil EUJR (2.4.1.)					
Information and Communication Technology								
Implement regulatory technical standards specifying ICT risk management tools, methods, processes, and policies and framework	MoE, Min of Economy		485,7 mil EUR ³⁴⁴			European Investment Bank (EIB) climate adaptation loans ³⁴⁵		Substantive, but limited data available
Develop and Implement a Green ICT Resilience and Awareness Program	MoE, Min of Economy							
CLUSTER BUILT ENVIRONMENT AND SPATIAL PLANNING								
Cultural Heritage								
Implement a national preventive maintenance program for cultural heritage sites, integrating climate-adaptive measures.	Min of Culture	Municipalities and towns	275,5 mil EUR ³⁴⁶		Reconst ruction of sites			Substantive, but limited data available

³⁴⁴ RSO1.2 – Harnessing the benefits of digitalisation for citizens, businesses, research organisations, and public authorities.

³⁴⁵ The European Investment Bank (EIB) provided a €240 million loan to Slovakia for co-funding of EU-supported green and digital projects. The credit is the first part of an €800 million EIB loan approved to Slovakia for national contributions mandatory for European Union-supported project.

³⁴⁶ RSO4.6 – Strengthening the role of culture and sustainable tourism in economic development, social inclusion, and social innovation.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
			103,1 mil EUR ³⁴⁷					
Safeguard and promote intangible cultural heritage for cultural continuity and local identity	Min of Culture	Municipalities and towns	275,5 mil EUR ³⁴⁸					Substantive, but limited data available
Establish effective governance frameworks for the protection of cultural heritage	Min of Culture National (Monument fund of the Slovak Republic)		REPowerEU ³⁴⁹					
Spatial Planning								
Establish and enhance ecologically relevant areas and bio-corridors	MoE		23,6 mil EUR (2.7.2.)					
Integrate latest climate impact and risk science into decisions on infrastructure	MoE, Min of Economy		104,9 mil EUR (2.7.4.)			Horizon	APVV, VEGA	
Integrate Climate Adaptation Strategies into Spatial Development Plans	MoE	Municipalities and towns				Horizon	APVV, VEGA	

³⁴⁷ 5.1.5 - Investments in cultural and natural heritage, local and regional culture, management, services and infrastructure supporting community development and sustainable tourism.

³⁴⁸ RSO4.6 – Strengthening the role of culture and sustainable tourism in economic development, social inclusion, and social innovation.

³⁴⁹ <https://www.mindop.sk/ministerstvo-1/zalezitosti-eu-a-medzinarodnych-vztahov-14/fondy-eu/plan-obnovy/obnova-budov-54280>.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Transport, Infrastructure and Buildings								
Develop and Implement Governance Frameworks for Climate-Resilient Transport, Infrastructure, and Buildings	Min of Economy, MoE		1620,5 mil EUR ³⁵⁰					Business and business associations
Enhance the climate resilience of transport, infrastructure, and buildings through materials, technology, and nature-based solutions	Min of Economy, MoE		OP Slovakia		Retrofitting of buildings	Horizon	APVV, VEGA	Business and business associations
CROSS-CUTTING ASPECTS								
Urban Areas								
Integrate climate change risks into urban planning to reduce impacts of urban flooding, drought, and the urban heat island effect	MoE	Towns and municipalities	150,4 mil EUR (2.4.1.)					

³⁵⁰ RSO3.1 – Development of a smart, safe, sustainable, and climate-resilient TEN-T intermodal network.

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
			106,4 mil EUR (2.4.4.) 104,9 mil EUR (2.7.4.)					
Social Issues								
Social inclusive program for vulnerable groups	Min of Social Affairs		Horizontal priority					Social organisations and foundations
Education and Society								
Integrating Climate Change Adaptation into Educational Curricula, Public Awareness Campaigns and Trainings	Min of Education, MoE		11,9 mil EUR (2.7.6.)					Green associations and foundations
Research								
Develop a national climate change adaptation research agenda and program	MoE, Min of Education						APVV, VEGA	
Governance								
Reform the Working Group on Adaptation and designate focal points for adaptation in competent ministries, self-governing regions and municipalities	MoE							
Development of regional and local climate adaptation plans in coordination with the National Adaptation Strategy	MoE	Towns and municipalities						

Action	State Budget	Municipal Budgets	ESIF	CAP	RRP	Supplementary	R&D Funding	Private Sector
Regional and Cross-Border Cooperation								
Strengthen International Cooperation	MoE	Towns and municipalities in border regions	Support for international cooperation in research, development, and innovation			HORIZON, Cross-border programmes, INTERREG		

Financing adaptation action until 2040: Finance gaps, opportunities and outlook for the next EU Multiannual Financial Framework (2028-2034)

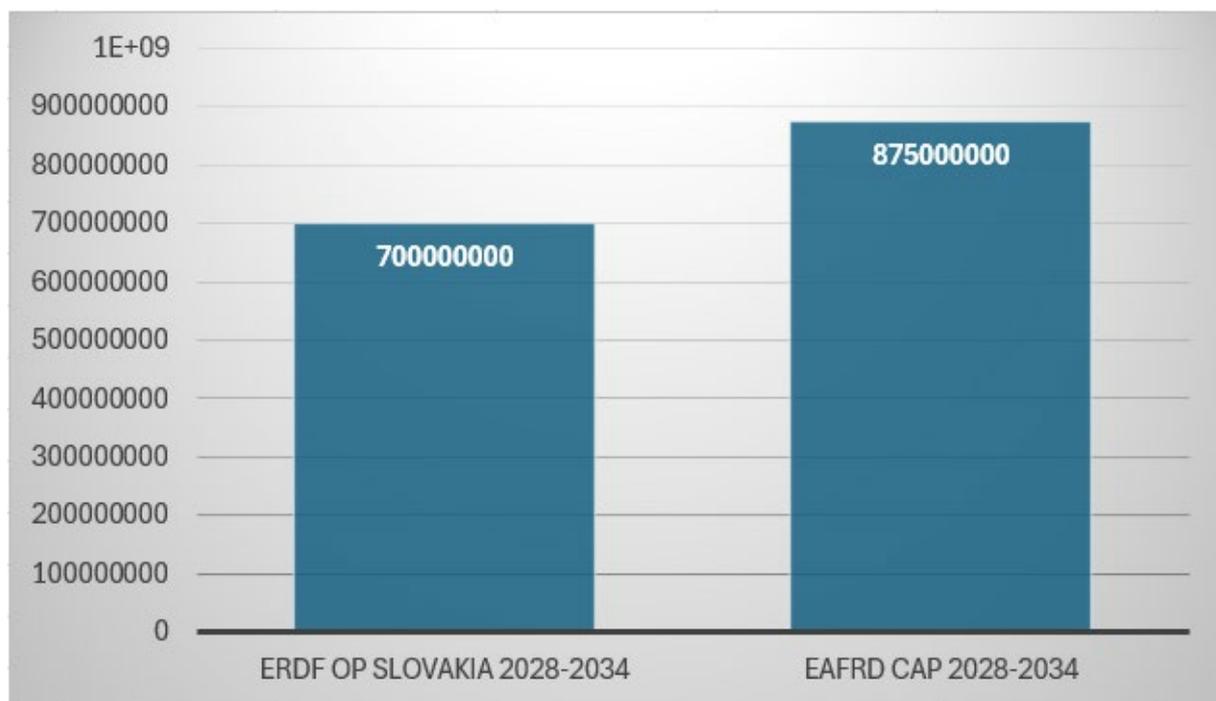
There are three principal sources of financing for climate adaptation actions during the next multiannual programming period (2028–2034): the National Public Budget, the Common Agricultural Policy (CAP), and the ERDF Operational Programme Slovakia. Additional sources include the State Environmental Fund (Envirofond), the EU LIFE Programme, European Investment Bank (EIB) climate adaptation loans, as well as municipal and private sector resources.

The Slovak state budget will support climate change adaptation through a combination of direct national funding, co-financing of EU and international grants, and implementation of strategic policy frameworks. Importantly, it will continue to fund public administration capacities and expertise essential for the development of strategies, policy coordination, and law enforcement.

A key instrument for improving climate adaptation is the Common Agricultural Policy. Already in the current programming period, a minimum of 35% of CAP funding is reserved for environmental and climate objectives under the EAFRD (Article 93). It will be important to reassess implementation practices and continue earmarking resources for agri-environmental measures in line with the objectives of the revised National Adaptation Strategy (NAS).

Preliminary estimates of financial needs for the 2028–2034 period, along with indicative allocations from CAP and ERDF, are summarised in Figure 10.

Figure 10: Preliminary estimations of the financial needs for the next multiannual programming period 2028 - 2034.



Source: Adapted from MoE SR, COMPLEMENTARY FUNDING PLAN

Based on OECD estimations, the Operational Programme Slovakia during the latest EU Programming period (2021 – 2027), contains over EUR 239 million assigned to adaptation measures and the strengthening of resilience. This funding targets several adaptation-related development areas, including conceptual policy steps

towards the implementation of adaptation measures at the national, regional and local levels, water retention measures, prevention measures against floods, and others.³⁵¹

Expert estimates suggest that the actual figure may be higher, as additional measures in areas such as education, social cohesion, and the energy transition also contribute to resilience and adaptation to climate change.

³⁵¹ Adaptation measurement: Assessing municipal climate risks to inform adaptation policy in the Slovak Republic. OECD Environment Policy Paper No. 35.

Table 45: Funding targets and outlook with focus on next Multi-Annual Financial Framework 2028-2034.

Action	Time frame	Main Funding Sources
Climate resilient agriculture	2028-2034	National Public Budget (NPB): Ministry of Environment, Ministry of Agriculture and Rural Development, CAP Private
Build a robust legislative framework to enhance ecosystem preservation and strengthen enforcement mechanisms	2028 - 2034	NPB
Foster Adaptive Management Practices for Ecosystem Services Sustainability in key sectors	2028 - 2034	NPB, ESIF
Establish and Expand Ecological Corridors and enhance their connectivity	2028 - 2034	NPB, ESIF, Municipalities
Protecting Slovakia's Natural Heritage through Climate-Resilient Landscape Management	2028-2034	EU Funding Instruments: EU Cohesion Fund, LIFE Programme (especially under Nature and Biodiversity, and Climate Action sub-programmes), Common Agricultural Policy (CAP) Strategic Plan (eco-schemes, rural development funds) National Public Budget: Ministry of Environment, Ministry of Agriculture and Rural Development Other Sources: European Investment Bank (EIB) climate adaptation loans
Enhance Forest Health Monitoring and Early Warning Systems	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Agriculture and Rural Development Other Sources: European Investment Bank (EIB) climate adaptation loans
Forest Restoration and Protection through adaptive silviculture	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Agriculture and Rural Development Other Sources: European Investment Bank (EIB) climate adaptation loans
Promote and transition to Sustainable Forest Management Practices	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Agriculture and Rural Development Other Sources: European Investment Bank (EIB) climate adaptation loans

Action	Time frame	Main Funding Sources
Foster sustainable soil and water balance management practices	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Agriculture and Rural Development Other Sources: European Investment Bank (EIB) climate adaptation loans
Advance risk mapping to account for increasing climate-related geohazards	2028-2034	National Public Budget: Ministry of Environment, Ministry of Economy, Ministry of Agriculture and Rural Development, Ministry of Transport, Slovak Hydrological Institute Other Sources: EU and domestic Research programmes
Measures to protect from flooding	2028-2040	National Public Budget: Ministry of Environment (e.g. through Slovak Water Management Enterprise), Ministry of Agriculture and Rural Development EU Funding Instruments: EU Cohesion Fund, LIFE Programme (especially under Nature and Biodiversity, and Climate Action sub-programmes), Common Agricultural Policy (CAP) Strategic Plan (eco-schemes, rural development funds) Other Sources: European Investment Bank (EIB) climate adaptation loans
Assess, climate proof, improve and maintain water and waste water infrastructure	2028 - 2034	National Public Budget: Ministry of Environment, Slovak Hydrological Institute Other Sources: EU and domestic Research programmes ESIF
Reinforcing existing flood protection measures	2025-2034	National Public Budget: Ministry of Environment (e.g. through Slovak Water Management Enterprise), Ministry of Agriculture and Rural Development EU Funding Instruments: EU Cohesion Fund, Common Agricultural Policy (CAP) Strategic Plan (eco-schemes, rural development funds) Other Sources: European Investment Bank (EIB) climate adaptation loans
Establish industry-specific drought prevention measures	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Agriculture and Rural Development
Strengthening regional value chains within Slovakia	2028 - 2034	National Public Budget: Ministry of Economy

Action	Time frame	Main Funding Sources
		EU Funding Instruments: EU Cohesion Fund
Continue to support human capital and business development initiatives	2028 - 2034	National Public Budget: Ministry of Economy EU Funding Instruments: EU Cohesion Fund
Security of energy supply		National Public Budget: Ministry of Economy EU Funding Instruments: EU Cohesion Fund
Climate proofing energy and electricity infrastructure	2028-2034	National Public Budget: Ministry of Economy EU Funding Instruments: EU Cohesion Fund
Inform the general public about individual measures to be taken with regards to both supply and demand of energy	2028-2034	National Public Budget: Ministry of Economy EU Funding Instruments: EU Cohesion Fund
Mainstream adaptation into public administration budgets	2028- 2034	National Public Budget: Ministry of Environment
Strengthen the insurance scheme	2028-2034	National Public Budget: Ministry of Finance EU Funding Instruments: EU Climate and Disaster Risk Reduction Funds Private Sector Funding (via Public-Private Partnerships)
Update the national tourism strategy	2028 - 2034	National Public Budget: Ministry of Tourism
Strengthening Climate-Resilient Critical Infrastructure and Disaster Preparedness	2028 - 2034	National Public Budget: Ministry of Interior Affairs EU Funding Instruments: EU Cohesion Fund
Development of a Comprehensive Multi-Level Emergency Preparedness and Response Program	2028 - 2034	National Public Budget: Ministry of Interior Affairs EU Funding Instruments: EU Cohesion Fund

Action	Time frame	Main Funding Sources
Develop and implement a National Heat-Resilient Healthcare Infrastructure Program	2028 - 2034	National Public Budget: Ministry of Health EU Funding Instruments: EU Cohesion Fund
Inform the general public about individual measures to be taken in environmental emergencies	2028-2034	National Public Budget: Ministry of Interior Affairs EU Funding Instruments: EU Cohesion Fund
Specific Healthcare Measures for Minority Groups	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Social Affairs EU Funding Instruments: EU Cohesion Fund
Improve water management practices accounting for climate risks	2028 - 2034	National Public Budget: Ministry of Interior Affairs EU Funding Instruments: EU Cohesion Fund Other Sources: National (wastewater fee)
Updating water management practices	2028 - 2034	National Public Budget: Ministry of Interior Affairs EU Funding Instruments: EU Cohesion Fund Other Sources: National (wastewater fee)
Implement... regulatory technical standards specifying ICT risk management tools, methods, processes, and policies and framework	2028 - 2034	National Public Budget: Ministry of Economy EU Funding Instruments: EU Cohesion Fund
Develop and Implement a Green ICT Resilience and Awareness Program	2028 - 2034	National Public Budget: Ministry of Economy EU Funding Instruments: EU Cohesion Fund
Implement a national preventive maintenance program for cultural heritage sites, integrating climate-adaptive measures.	2028-2034	National Public Budget: Ministry of Culture EU Funding Instruments: EU Cohesion Fund

Action	Time frame	Main Funding Sources
Safeguard and promote intangible cultural heritage for cultural continuity and local identity	2028-2034	National Public Budget: Ministry of Culture EU Funding Instruments: EU Cohesion Fund
Establish effective governance frameworks for the protection of cultural heritage	2028-2034	National Public Budget: Ministry of Culture EU Funding Instruments: EU Cohesion Fund Other Sources: National (Monument fund of the Slovak Republic) REPowerEU ³⁵²
Establish and enhance ecologically relevant areas and bio-corridors	2028-2034	National Public Budget: Ministry of Environment, Ministry of Agriculture and Rural Development EU Funding Instruments: EU Cohesion Fund, LIFE Programme (especially under Nature and Biodiversity, and Climate Action sub-programmes), Common Agricultural Policy (CAP) Strategic Plan (eco-schemes, rural development funds) Other Sources: European Investment Bank (EIB) climate adaptation loans
Integrate latest climate impact and risk science into decisions on infrastructure	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Transport
Integrate Climate Adaptation Strategies into Spatial Development Plans	2028-2034	National Public Budget: Ministry of Environment, Ministry of Internal Affairs
Develop and Implement Governance Frameworks for Climate-Resilient Transport, Infrastructure, and Buildings	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Transport

³⁵² <https://www.mindop.sk/ministerstvo-1/zalezitosti-eu-a-medzinarodnych-vztahov-14/fondy-eu/plan-obnovy/obnova-budov-54280>.

Action	Time frame	Main Funding Sources
Enhance the Climate Resilience of Transport, Infrastructure, and Buildings through Materials, Technology, and Nature-Based Solutions	2028-2034	National Public Budget: Ministry of Environment, Ministry of Transport EU Funding Instruments: EU Cohesion Fund
Integrate climate change risks into urban planning to reduce impacts of urban flooding, drought, and the urban heat island effect	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Transport, Ministry of Internal Affairs EU Funding Instruments: EU Cohesion Fund Other Sources: Municipal budgets
Social inclusive program for vulnerable groups	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Economy, Ministry of Social Affairs EU Funding Instruments: EU Cohesion Fund Other Sources: Municipal Budgets Other Sources: Municipal budgets
Integrating Climate Change Adaptation into Educational Curricula, Public Awareness Campaigns and Trainings	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Education EU Funding Instruments: EU Cohesion Fund
Develop a national climate change adaptation research agenda and program	2028 - 2034	National Public Budget: Ministry of Environment, Ministry of Education EU Funding Instruments: EU Cohesion Fund
Reform the Working Group on Adaptation and designate focal points for adaptation in competent ministries, self-governing regions and municipalities	2028 - 2034	National Public Budget: Ministry of Environment
Development of regional and local climate adaptation plans in coordination with the National Adaptation Strategy	2028 - 2034	National Public Budget: Ministry of Environment Other Sources: Municipal Budgets
Strengthen International Cooperation	2028 - 2034	National Public Budget: Ministry of Environment

Action	Time frame	Main Funding Sources
		Other Sources: Cross-border cooperation programmes

Financial risks and risk management

Climate change poses significant financial risks to Slovakia’s economy, infrastructure, and public finances. These risks arise both from physical impacts - such as floods, droughts, and extreme weather - and from the transition to a low-carbon economy, which requires substantial investments and regulatory adjustments. A comprehensive risk management system is essential to anticipate, monitor, and mitigate these financial risks and to ensure the resilience of both public institutions and private actors.

Table 46: Key financial risks and risk management measures

Risk Type	Key Financial Risks	Description	Risk Management Measures	NAS Actions
Physical	Impact of extreme weather events	<p>Floods and flash floods damage infrastructure (roads, bridges, public buildings), disrupt economic activity, and increase emergency response costs.</p> <p>Droughts reduce agricultural yields, damage forests, and affect water supply for households and industry.</p> <p>Heatwaves strain healthcare systems and energy grids due to increased cooling demand.</p>	<p>Climate risk assessments in planning (integrated into public investment planning, land use, and budgetary decisions)</p> <p>Stress testing for critical systems and scenario analysis (for financial institutions and critical infrastructure under different climate futures)</p> <p>Climate risk disclosure and reporting obligations (particularly for state-owned enterprises and large-scale public projects)</p> <p>Insurance schemes (public-private) to cover climate-related losses and support recovery in high-risk areas.</p>	<p>Measures to protect from flooding</p> <p>Protecting Slovakia’s Natural Heritage through Climate-Resilient Landscape Management</p> <p>Advance risk mapping to account for increasing climate-related geohazards</p> <p>Reinforcing existing flood protection measures</p> <p>Development of a Comprehensive Multi-Level Emergency Preparedness and Response Program</p>

Risk Type	Key Financial Risks	Description	Risk Management Measures	NAS Actions
	Cost of chronic Climate Stressors	<p>Long-term temperature and precipitation shifts may reduce productivity in agriculture, tourism, and forestry.</p> <p>Water scarcity in some regions can jeopardize industrial operations and lead to inter-sectoral competition for resources.</p>	<p>Establish public climate funds and fiscal buffers to cover the long-term cost of slow-onset climate impacts.</p> <p>Promote risk transfer tools like agricultural insurance and regional risk pooling schemes.</p> <p>Mobilize capital via green bonds and climate-linked financing for resilient infrastructure.</p> <p>Integrate climate risks into fiscal planning and public investment through budget tagging and contingency mechanisms.</p> <p>Engage the private sector using blended finance, ESG frameworks, and resilience-focused investment incentives.</p>	<p>Climate resilient agriculture</p> <p>Foster Adaptive Management Practices for Ecosystem Services Sustainability in key sectors</p> <p>Forest Restoration and Protection through adaptive silviculture</p> <p>Promote and transition to Sustainable Forest Management Practices</p> <p>Foster sustainable soil and water balance management practices</p> <p>Improve water management practices accounting for climate risks</p>
	Public Sector Liabilities	Unplanned budgetary strain from disaster response, infrastructure repair, and compensation for uninsured losses.	Prioritisation of adaptation in state budget	Integrate Climate Adaptation Strategies into Spatial Development Plans

Risk Type	Key Financial Risks	Description	Risk Management Measures	NAS Actions
		<p>Legal exposure, for failure to mitigate or adapt to climate risks - e.g., in planning or construction</p> <p>Reputational risks if the government fails to protect citizens or is held accountable for inadequate adaptation.</p>	<p>Using EU funds (e.g. RRF, Cohesion Fund) as the leverage and piloting.</p> <p>Green budgeting (track and align public expenditures with climate goals)</p> <p>Blended finance and private capital mobilization</p> <p>Local financial instruments (e.g., resilience bonds, revolving adaptation funds) to support municipalities)</p> <p>Regional partnerships</p>	<p>Integrate latest climate impact and risk science into decisions on infrastructure</p>
Transition	Policy and Regulatory Risks	<p>Introduction of stricter EU and national climate regulations may increase compliance costs for businesses and public entities.</p> <p>Potential non-compliance penalties or loss of EU funding if Slovakia fails to meet climate and energy targets.</p>	<p>Inter-ministerial coordination (finance, environment, regional), and coordinated institutional framework involving the Ministry of Finance, Ministry of Environment, National Bank of Slovakia, and regional governments.</p>	<p>Integrate Climate Adaptation Strategies into Spatial Development Plans</p>

Risk Type	Key Financial Risks	Description	Risk Management Measures	NAS Actions
			<p>Capacity building for municipalities and local governments to assess, plan, and finance adaptation.</p> <p>Regulatory integration and national development planning</p>	
	Stranded Assets	Investments in repair and maintenance of existing infrastructure which may prove inadequate in a longer run	<p>Stress testing for critical systems and scenario analysis (for financial institutions and critical infrastructure under different climate futures)</p> <p>Assessment of long-term priorities for high exposure in agriculture, biodiversity, energy/public infrastructure (aging flood protection and water systems)</p>	<p>Assess, climate proof, improve and maintain water and waste water infrastructure</p> <p>Security of energy supply</p> <p>Climate proofing energy and electricity infrastructure</p> <p>Strengthening Climate-Resilient Critical Infrastructure and Disaster Preparedness</p> <p>Enhance the Climate Resilience of Transport, Infrastructure, and Buildings through Materials, Technology, and Nature-Based Solutions</p>

Risk Type	Key Financial Risks	Description	Risk Management Measures	NAS Actions
	Capital Investment Pressures	<p>High upfront costs for adaptation infrastructure investments (e.g., water retention).</p> <p>Risk of underinvestment or misallocation of EU and public funds due to capacity constraints or unclear planning.</p>	<p>Strategic pipelines of bankable adaptation projects with clear prioritization and technical preparation.</p> <p>Use blended finance to combine EU/public grants with private or concessional capital and reduce upfront risk.</p> <p>Integrate climate criteria into public investment management and monitor fund use for efficiency and alignment.</p>	<p>Develop and Implement Governance Frameworks for Climate-Resilient Transport, Infrastructure, and Buildings</p> <p>Establish industry-specific drought prevention measures</p> <p>Strengthening regional value chains within Slovakia</p> <p>Continue to support human capital and business development initiatives</p> <p>Update the national tourism strategy</p>
	Social and Regional Inequality	Transition policies may disproportionately affect low-income households or vulnerable regions, leading to social discontent or economic decline if not managed fairly (just transition risk).	<p>Direct funding toward socially and geographically vulnerable groups using climate justice criteria.</p> <p>Engage communities in planning and tailor solutions to local social and environmental needs.</p>	<p>Inform the general public about individual measures to be taken with regards to both supply and demand of energy</p> <p>Develop and implement a National Heat-Resilient Healthcare Infrastructure Program</p>

Risk Type	Key Financial Risks	Description	Risk Management Measures	NAS Actions
			<p>Link adaptation with social protection, ensuring access to finance and services for low-income households.</p> <p>Develop regional just transition plans that combine climate resilience with inclusive economic development.</p> <p>Monitor equity outcomes of adaptation finance and establish accountability mechanisms.</p>	<p>Specific Healthcare Measures for Minority Groups</p> <p>Social inclusive program for vulnerable groups</p>
Macro	Financial instability	<p>Decreased economic output from climate damages can reduce GDP, tax revenues, and increase public debt levels.</p> <p>Rising insurance premiums or withdrawal of coverage in high-risk areas.</p> <p>Credit rating risks if Slovakia is perceived as fiscally or climatically vulnerable.</p>	<p>Integrate climate risks into national fiscal and debt planning through stress testing and expenditure frameworks.</p> <p>Develop new tools for insurance and catastrophe bonds to manage large-scale loss risks and ensure liquidity.</p> <p>Build contingency reserves for rapid climate emergency response and avoid ad hoc borrowing.</p>	<p>Mainstream adaptation into public administration budgets</p> <p>Strengthen the insurance scheme</p>

Risk Type	Key Financial Risks	Description	Risk Management Measures	NAS Actions
		<p>Contingent liabilities becoming fiscal obligations,</p> <p>Rising public debt and credit risk from borrowing to finance recovery and adaptation measures.</p> <p>Liquidity shortfalls due to the need for rapid emergency funding without pre-arranged reserves.</p>	<p>Reform tax and revenue systems to align with green goals and reduce vulnerability to climate-impacted sectors.</p> <p>Strengthen financial sector resilience with climate risk disclosure, ESG alignment, and sustainable finance incentives.</p>	

Annex 4: Monitoring, Evaluation and Learning (MEL) Indicators

This Annex presents a Monitoring, Evaluation and Learning (MEL) framework to support the implementation of Slovakia's revised National Adaptation Strategy (NAS) for the period 2026–2040. It introduces a structured set of indicators that aim to track adaptation progress, assess effectiveness, and enable evidence-based decision-making.

The development of this MEL system recognises that while monitoring, evaluation, and learning (MEL) frameworks are well-established in many policy areas, the use of impact and outcome indicators specifically for climate change adaptation remains a novel and evolving field. Globally, there is no single agreed framework or standardised set of adaptation indicators. It is therefore suggested to adopt a flexible, learning-oriented approach, drawing on emerging international good practices while tailoring the system to national climate risks, institutional capacities, and strategic priorities.

The suggested approach builds on principles and guidance from international sources (including recent development to establish a framework for the Global Goal on Adaptation (GGA)³⁵³; Toolkit for Monitoring, Evaluation and Learning for National Adaptation Plan Processes (2024)³⁵⁴ and Vincent (2024)³⁵⁵ as well as examples from other European countries), while directly linking with sector-specific implementation indicators presented in Part 2 (Factsheets) of this Strategy.

Purpose of the MEL Indicators

A comprehensive indicator system for MEL is designed to:

- **Systematically monitor adaptation progress and implementation** across national, sectoral, and regional levels in accordance with EU Climate Law requirements.
- **Rigorously assess the effectiveness, efficiency, and equity of adaptation actions**, supporting evidence-based decision-making.
- **Quantitatively measure progress in reducing climate vulnerability by employing validated indicators and robust datasets**, while identifying and addressing data and methodological gaps where vulnerability reduction remains a prioritized policy objective.
- **Facilitate iterative learning and adaptive policy refinement** through continuous monitoring, evaluation, and feedback loops.
- **Ensure compliance with EU and international reporting obligations**, including mandates outlined in the EU Climate Law, the Monitoring Mechanism Regulation (MMR), and the Paris Agreement.
- **Provide consistent, transparent, and policy-relevant performance information** for stakeholders and decision-makers.

³⁵³ Beauchamp, E. & Józefiak, I. (2023). Next Steps for Defining a Monitoring, Evaluation, and Learning System for the Global Goal on Adaptation by COP 28. International Institute for Sustainable Development (IISD), May 30, 2023. <https://www.iisd.org/system/files/2023-05/global-goal-on-adaptation-monitoring-evaluation-learning-framework-cop-28.pdf>

³⁵⁴ Beauchamp, E., Leiter, T., Pringle, P., Brooks, N., Masud, S., & Guerdat, P. (2024). Toolkit for monitoring, evaluation, and learning for National Adaptation Plan processes. NAP Global Network & Adaptation Committee. International Institute for Sustainable Development.

³⁵⁵ Vincent, K. (2024). Climate Adaptation and its Measurement: Challenges and Opportunities. Washington, DC: Resilience Evaluation, Analysis and Learning (REAL) Associate Award.

- **Integrate performance-level monitoring with broader strategic evaluations** to support long-term, evidence-informed policy adjustments.

Importantly, during the remaining validity of the current Slovak National Adaptation Plan (NAP) until 2027, emphasis will be placed on the development of robust baseline data and indicator methodologies. This foundational work will ensure that full-scale tracking of trends and targets is possible in the period 2028–2040.

MEL Indicators

Structure of the indicator framework

The indicator framework is organized into three interlinked levels, forming a coherent chain from implementation to outcomes and long-term impacts:

Impact-level indicators

Reflect long-term, systemic changes and progress toward the NAS Vision 2050 (e.g. reduced climate vulnerability, increased resilience of people and ecosystems).

Outcome-level indicators

Measure medium-term results of adaptation efforts toward the Strategic Objectives (SOs) and Sectoral Strategic Directions (SDs).

Output indicators

Track implementation of specific actions in the sectoral Factsheets (Part 2) of this strategy (e.g. number of flood risk maps developed, hectares of forests managed adaptively).

This Annex includes impact- and outcome-level indicators, while the output indicators are integrated in Part 2 Factsheets. All three levels are intended to be applied together and must be closely aligned during implementation to ensure consistent and meaningful monitoring.

Each indicator is described by:

- Definition and unit of measurement
- Data sources and responsible institutions
- Reporting frequency

Please note that a redefinition of indicators might be needed in the context of the new MFF and the related reporting requirements that might arise from it. This should reduce the administrative burden. It is recommended that the final indicator set additionally provides disaggregation (e.g. gender, region, vulnerable group) where needed and relevant.

Impact Indicators

(Examples - to be refined and formalized in official reporting tables)

Cluster Bioeconomy

Includes: Agriculture, Forestry, Biodiversity, Soil, Water

Table 47: Impact Indicators aligned with Strategic Objectives for Cluster Bioeconomy

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
BI1	Resilience of Natural Ecosystems	<p>Percentage of ecosystems showing stable or improving performance across at least 4 of these 7 functions:</p> <ul style="list-style-type: none"> • Biodiversity maintenance (species richness, functional diversity, habitat continuity) • Carbon sequestration and storage (above and below ground biomass, soil carbon) • Hydrological regulation 	Percentage	Every 6 years	MoE SR, Slovak Academy of Sciences, SAŽP	SO1, SO5

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<p>(flood buffering, groundwater recharge, water retention)</p> <ul style="list-style-type: none"> • Soil health and fertility (organic matter, nutrient cycling, erosion control) • Pollination and reproduction services (especially for wild and cultivated plants) • Microclimate regulation (temperature buffering, evapotranspiration effects) • Invasive species resistance and natural regeneration capacity 				
BI2	Long-term Agricultural Climate Resilience	Percentage reduction in inter-annual yield	Percentage	Every 5 years	Statistical Office of the Slovak Republic (SOSR),	SO1, SO2

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<p>variability for key crops due to climate extremes (e.g. drought, heatwaves, heavy rainfall) over a rolling 10-year period</p> <p>Measured through changes in:</p> <ul style="list-style-type: none"> • Crop yield variability (standard deviation or coefficient of variation in yields over 10 years) • Climatic exposure-adjusted yield losses (yields normalized by severity/frequency of climate events) • Stability index for production of key crops (e.g., wheat, maize, barley, potatoes) 			Ministry of Agriculture, SHMI (climate data), and farm-level surveys	

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
BI3	Water Resource Sustainability Index	<p>Composite score of long-term water availability, quality, and ecosystem function, combining metrics on:</p> <p>Water availability</p> <ul style="list-style-type: none"> Renewable freshwater resources per capita (m³/person/year) Seasonal flow variability and drought frequency Groundwater recharge vs. abstraction ratio <p>Water quality</p> <ul style="list-style-type: none"> % of monitored water bodies in good chemical and ecological status (WFD criteria) Nitrate/phosphate 	<p>Index (0–100)</p> <p>Scoring approach (illustrative):</p> <ul style="list-style-type: none"> 0–33: At risk / unsustainable 34–66: Moderate sustainability 67–100: Sustainable <p>Possible weighting:</p> <ul style="list-style-type: none"> 40% availability 30% quality 30% ecosystem function 	Every 5 years	Slovak Hydrometeorological Institute (SHMI), Water Research Institute (VÚVH), MoE SR (Water Framework Directive reporting), EU Environmental Indicators (EEA, Eurostat)	SO1

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<p>concentrations in surface and groundwater</p> <ul style="list-style-type: none"> Urban and industrial wastewater treatment efficiency <p>Ecosystem water function</p> <ul style="list-style-type: none"> % of wetlands and riparian zones in good hydromorphological condition Environmental flow compliance (minimum flow thresholds for aquatic life) Ecosystem service capacity of aquatic ecosystems (e.g., flood regulation, habitat provision) 				

Cluster Economy

Includes: Economy and Industry, Energy, Tourism, Financial Systems

Table 48: Impact Indicators aligned with Strategic Objectives for Cluster Economy

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
EC1	Macroeconomic Resilience to Climate Shocks	<p>Degree to which the national economy maintains stability in GDP growth, employment, and sectoral productivity in the face of increasing frequency and severity of climate-related shocks (e.g., droughts, floods, heatwaves).</p> <p>Sub-metrics:</p> <ul style="list-style-type: none"> • GDP sensitivity to climate extremes: Year-on-year GDP deviation in shock years vs. non-shock years; 5-year rolling standard deviation of GDP. • Employment resilience: Employment fluctuations in climate-exposed sectors (agriculture, tourism, construction) and labour market recovery time post-disaster. • Sectoral output stability: Sectoral GVA deviation in relation to climate event exposure; share of climate-resilient sectors in national GDP. • 	% deviation from baseline (to be defined)	Every 5 years	Ministry of Economy, Slovak Statistical Office, SHMI (for climate event data), Eurostat (for harmonized economic tracking)	SO2, SO5
EC2	Sustainable Tourism Resilience Score	Composite indicator assessing the tourism sector's ability to sustain environmental quality, economic viability, and climate preparedness over time, despite growing climate risks.	<p>Index (0–100)</p> <p>Scoring approach (illustrative):</p>	Every 3–5 years, aligned with strategic tourism	Slovak Tourism Board, Ministry of Transport and Construction, SHMI (climate trends), Eurostat (Tourism Satellite	SO2

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<p>Measures in the key dimensions:</p> <p>Ecosystem-Based Tourism Health (40%)</p> <ul style="list-style-type: none"> • % of tourism destinations in or near protected/natural areas maintaining ecological integrity • Visitor carrying capacity compliance (trails, parks, mountain areas) • Biodiversity sensitivity of tourism zones (e.g., Alpine, forested, riverine areas)³⁵⁶ <p>Climate-Related Revenue Risk (30%)</p> <ul style="list-style-type: none"> • Seasonality compression (shortened or erratic seasons due to climate conditions) • Changes in international vs. domestic tourism patterns linked to climate impacts (e.g. number of overnight stays, tourist expenditures, length of stay, and visitor distribution across regions and seasons) <p>Adaptation Readiness (30%)</p> <ul style="list-style-type: none"> • % of tourism operators with climate adaptation or crisis management plans 	<ul style="list-style-type: none"> • 0-33: Vulnerable, at high risk • 34-66: Moderate resilience • 67-100: High resilience, climate-ready 	reporting cycles	Accounts), National Park Authorities, Regional tourism operators	

³⁵⁶ The “Biodiversity sensitivity of tourism zones” can be calculated by combining the ecological value of a zone (e.g., species richness, presence of endangered species, habitat types) with its vulnerability to tourism pressures (e.g., visitor numbers, infrastructure, habitat disturbance). A simple score can be derived by multiplying biodiversity value by sensitivity to tourism, with higher scores indicating areas of high ecological importance that are more vulnerable to tourism impacts.

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<ul style="list-style-type: none"> Amount of public and private investments in sustainable tourism infrastructure (green building, water/energy efficiency) Number of promotional campaigns for off-season, low-carbon tourism strategies 				
EC3	Financial System Preparedness for Climate Risks	<p>Percentage of banks, insurers, pension funds, and other financial institutions that integrate physical climate risks (e.g., flood, drought, heatwave, wildfire exposure) into their long-term strategic planning, risk management frameworks, and investment portfolios.</p> <p>This includes regulated financial institutions that meet at least 3 of the 5 following criteria:</p> <ul style="list-style-type: none"> Conduct climate-related financial risk assessments (aligned with the Task Force on Climate-related Financial Disclosures (TCFD) or EU taxonomy) Integrate physical climate risk scenarios into stress testing and asset valuation Reflect physical risk exposure in loan, underwriting, or investment policies Report on climate risks in public disclosures or regulatory filings Participate in national or EU-level sustainable finance initiatives 	Percentage	Biennial, aligned with supervisory reports and national adaptation progress reviews	National Bank of Slovakia (NBS), Ministry of Finance, Financial market supervision reports, Voluntary disclosures (TCFD, Sustainable Finance Disclosure Regulation (SFDR)) EU Sustainable Finance Platform	SO2, SO5

Cluster Safety and Well-being

Includes: Health, Civil Protection, ICT

Table 49: Impact Indicators aligned with Strategic Objectives for Cluster Safety and Well-being

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
SW1	Reduction in National Climate-Related Mortality	<p>Long-term reduction in the mortality rate (per 100,000 population) attributable to climate-related extreme events, such as heatwaves, floods, storms, drought-induced food insecurity, and cold spells.</p> <p>Measurement includes:</p> <ul style="list-style-type: none"> • Direct deaths from acute events (e.g., flash floods, storms, heatwaves) • Indirect mortality from climate-exacerbated conditions (e.g., cardiovascular or respiratory diseases during heatwaves or air pollution episodes) 	Number of climate-related deaths per 100,000 population	Annual (with multi-year trend analysis over 5–10 year periods)	<p>National Public Health Authority, Ministry of Health, Civil Protection / Ministry of Interior, Slovak Hydrometeorological Institute (event records)</p> <p>Eurostat / WHO (for harmonized mortality attribution)</p>	SO4
SW2	Population Climate Resilience Index	<p>Composite index measuring the resilience of the population to climate-related hazards</p> <p>Measured through:</p> <p>Exposure to Climate Hazards (e.g., 35% of index)</p> <ul style="list-style-type: none"> • % of population living in areas with high flood, drought, heatwave, wildfire, or landslide risk • Urban heat island (UHI) exposure by neighbourhood • Share of critical infrastructure-dependent populations (e.g., remote, elderly, mobility-impaired) 	<p>Index (0 -100)</p> <p>Scoring approach (illustrative):</p> <ul style="list-style-type: none"> • 0-33: Low resilience / high vulnerability • 34-66: Moderate resilience • 67-100: High resilience / adaptive capacity 	Every 3-5 years	<p>Slovak Statistical Office, Ministry of Health, Civil Protection Authority, SHMI (hazard mapping)</p> <p>Social and public health surveys Municipal preparedness reports</p>	SO4, SO5

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<p>Adaptive Capacity (<i>e.g.</i>, 40% of index)</p> <ul style="list-style-type: none"> • % of population with access to basic services during emergencies (healthcare, water supply) • Socioeconomic vulnerability score (income, age, education, housing quality) • Access to social protection and safety nets • Housing resilience (<i>e.g.</i>, insulation, flood-proofing) <p>Risk Awareness and Preparedness (<i>e.g.</i>, 25% of index)</p> <ul style="list-style-type: none"> • % of population receiving early warnings • Number of participants in local climate awareness or preparedness programs • Literacy on climate risks and self-protection behaviour (survey-based) 				
SW3	Continuity of Critical Services During Climate Events	<p>Percentage of critical public services that remain operational and accessible during and immediately after climate-related extreme events (<i>e.g.</i>, heatwaves, floods, windstorms, droughts), functioning within pre-defined performance thresholds (<i>e.g.</i>, ≥90% uptime, ≤2-hour response time).</p> <p>Services include:</p> <ul style="list-style-type: none"> • ICT infrastructure: mobile networks, internet connectivity, data centres • Energy systems: electricity and heating/cooling grid functionality 	Percentage	every 2–3 years; with real-time assessment during major events	<p>Ministry of Interior (Civil Protection and Emergency Services), Ministry of Transport and ICT, Ministry of Economy / Energy Regulators, National and regional utilities and service providers</p> <p>Disaster event reports and resilience audits</p>	SO4, SO5

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<ul style="list-style-type: none"> Emergency services: 112 response, ambulances, civil protection units Water supply and sanitation: operational status of urban and rural systems Health services: hospitals, clinics during extreme events 				

Cluster Built Environment and Spatial Planning

Includes: Infrastructure, Buildings, Spatial Planning, Cultural Heritage

Table 50: Impact Indicators aligned with Strategic Objectives for Cluster Built Environment and Spatial Planning

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
BE11	National Infrastructure Resilience Index	<p>Percentage of critical infrastructure assets (by value or network length) that are assessed and proven capable of maintaining core functions under current and projected climate stressors (e.g., floods, heatwaves, drought, storms).</p> <p>Components to assess may include:</p> <ul style="list-style-type: none"> Infrastructure Climate Risk Exposure Assessment (% of infrastructure assets assessed for exposure to key climate hazards (e.g., flood zones, heat hotspots)) Design Climate Compatibility (% of infrastructure built or retrofitted to withstand mid- to long-term climate projections (e.g., 2050 RCP 4.5)) 	Percentage	Every 5 years	Ministry of Transport and Construction, Ministry of Economy (energy infrastructure), Ministry of Environment (flood zones, hazard mapping), National Infrastructure Audit Reports, Civil Protection Authority, Regional Development Agencies	SO3, SO5

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<ul style="list-style-type: none"> Functional Continuity Readiness (Availability of backup systems, redundancy, or fail-safes under extreme weather conditions) Resilience Certification or Audit (Assets with climate resilience assessments integrated into national infrastructure audits or lifecycle planning) <p>The Resilience Index is computed as follows: [Total number of critical assets/Number of compliant assets] x 100</p>				
BEI2	Preservation of Climate-Sensitive Cultural Heritage	<p>Percentage of nationally significant sites protected/adapted for future climate risks, i.e., meeting at least two of the following criteria:</p> <ul style="list-style-type: none"> Assessed for climate vulnerability (e.g. risk of deterioration, erosion, flood impact) Covered by a climate-informed management or adaptation plan Benefitting from protective measures (e.g. drainage, ventilation, structural reinforcement) Included in funding schemes for climate adaptation or disaster risk reduction 	Percentage	Every 5 years	<p>Ministry of Culture (national heritage registry), Monuments Board of the Slovak Republic, Regional heritage conservation offices, Site management plans</p> <p>Project databases (e.g. EU-funded heritage adaptation)</p>	SO3, SO5
BEI3	Climate-Responsive Spatial Planning Coverage	<p>Percentage of national territory governed by spatial planning documents (regional, local, or sectoral) that integrate climate risk assessments and long-term adaptation objectives into land-use decisions.</p> <p>Key functions tracked:</p>	%	Every 5 years	<p>Ministry of Transport and Construction (national and regional spatial planning), Ministry of Environment (climate hazard maps, adaptation planning), Slovak Hydrometeorological Institute, Local government spatial planning records,</p>	SO3, SO4

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		<ul style="list-style-type: none"> • Avoidance of construction in high-risk zones (e.g., floodplains, erosion-prone slopes) • Preservation of green infrastructure and ecosystem corridors • Integration of blue-green infrastructure in urban development • Strategic retreat or re-zoning based on hazard projections • Mainstreaming of climate change scenarios (e.g. RCP4.5/8.5) into spatial development frameworks 			National Spatial Development Framework (ÚSES, ÚPN)	

Cluster Cross-Cutting Aspects

Includes: Urban areas, Social vulnerability, Research, Education, Governance

Table 51: Impact Indicators aligned with Strategic Objectives for Cluster Cross-Cutting Aspects

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
CC1	National Adaptation Capacity Index	<p>Composite of institutional, technical, and financial capacity to implement adaptation</p> <p>Institutional: Existence of coordination bodies and legal mandates</p> <ul style="list-style-type: none"> • Integration of adaptation in key sectors and planning systems • Participation of subnational actors and civil society <p>Technical: Availability of climate data and risk mapping</p> <ul style="list-style-type: none"> • Monitoring, evaluation, and learning systems • Adaptation-relevant training and workforce capacity <p>Financial: Dedicated public funding for adaptation (national/local)</p> <ul style="list-style-type: none"> • Access to EU/international finance • Integration of adaptation in budget planning and public investment 	Index (0–100), where higher values indicate greater national adaptive capacity	Every 5 years	<p>National Adaptation Plan and updates, National budget reports and expenditure reviews, Ministry of Environment and sectoral ministries</p> <p>EU adaptation project reports</p> <p>OECD or UNFCCC reporting (e.g., NCS, BURs)</p>	SO5

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		Each dimension is scored (e.g., 0–5 or 0–100), then normalized and averaged to produce a composite national score (0–100).				
CC2	Reduction in Social Vulnerability to Climate Impacts	<p>Percentage change in a composite Social Vulnerability Index (SVI) over time, based on key socio-demographic and health-related factors that influence a population’s capacity to anticipate, cope with, and recover from climate hazards.</p> <p>SVI Change (%) = [(SVI current - SVI baseline)/SVI baseline] x 100</p> <p>Key components to measure:</p> <p>Income: Median income, poverty rate, energy poverty</p> <p>Age: % of population over 65 or under 5</p> <p>Health: Prevalence of chronic illness, disability, access to healthcare</p> <p>Isolation: % of single-person or elderly households, distance to services, digital divide</p> <p>Each component is normalized (e.g. 0–1 scale), weighted (equal or policy-defined), and aggregated into a</p>	<p>Percentage</p> <p>A negative percentage indicates a reduction (i.e. improved social resilience).</p>	Every 5 years	Slovak Statistical Office, Ministry of Labour, Social Affairs and Family, Ministry of Health, Health insurance and public health registries, EU-SILC (Statistics on Income and Living Conditions), Social services and civil protection data	SO4, SO5

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		composite index score (0 = no vulnerability, 1 = highest vulnerability).				
CC3	Policy Coherence and Governance Effectiveness Score	<p>Qualitative index of intersectoral coordination, stakeholder engagement, and policy consistency</p> <p>Possible Index components:</p> <ul style="list-style-type: none"> • Intersectoral Coordination: Existence and functionality of cross-sector adaptation committees; joint planning and resource sharing; integrated policy frameworks • Stakeholder Engagement: Inclusion of civil society, private sector, vulnerable groups in decision-making processes; transparency and public participation mechanisms • Policy Consistency: Alignment of climate adaptation objectives across sectoral policies and plans; reduction of 	Index (1–10)	Every 5 years	<p>Government reports and NAS progress reviews, Stakeholder survey results and engagement records, Legal and policy document analysis</p> <p>Third-party governance assessments (e.g., OECD, EU reports)</p> <p>Workshop and consultation summaries</p>	SO5

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
		conflicting mandates; legal and regulatory support ³⁵⁷				

Outcome Indicators

(Examples - to be refined and formalized in official reporting tables)

Cluster Bioeconomy

Includes: Agriculture, Forestry, Biodiversity, Soil, Water

Table 52: Outcome Indicators aligned with Strategic Objectives for Cluster Bioeconomy

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
BO1	Adoption of Climate-Smart Agricultural Practices	% of farms using drought-resistant crops, soil conservation, agroforestry	Percentage	Annual	Ministry of Agriculture	SO1, SO2
BO2	Increase in Protected/Restored Ecosystems	% increase in land under active restoration or ecosystem-based adaptation	Percentage	Biennial	Ministry of Environment SR (MoE SR), Slovak Environmental Agency (SAŽP)	SO1

³⁵⁷ Could be measured by:

- Share of sectoral policies explicitly integrating adaptation objectives (e.g., % of new/revised transport, agriculture, energy, or health policies that reference adaptation).
- Number of conflicting mandates reduced or resolved (e.g., cases where sectoral policies previously contradicted adaptation goals, but have since been harmonized).
- Legal and regulatory instruments adopted that support climate adaptation (e.g., new standards, laws, or amendments).

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
BO3	Water Retention in Managed Landscapes	% increase in water retained through green infrastructure or land use change	Percentage	Biennial	Slovak Hydrometeorological Institute (SHMI), Water Research Institute	SO1, SO5
BO4	Expansion of Sustainable Forestry Practices	% of forests managed with climate-resilient principles	Percentage	Annual	National Forest Centre	SO1, SO5

Cluster Economy

Includes: Economy and Industry, Energy, Tourism, Financial Systems

Table 53: Outcome Indicators aligned with Strategic Objectives for Cluster Economy

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
EO1	Business Adaptation Action Rate	% of firms implementing business continuity or adaptation plans	Percentage	Biennial	Ministry of Economy, sector associations	SO2, SO5
EO2	Renewable and Climate-Resilient Energy Share	% of energy system that is both renewable and climate-resilient	Percentage	Biennial	SEPS, Ministry of Economy	SO2, SO3
EO3	Tourism Sector Climate Risk Mitigation Coverage	% of tourism operators with heat/flood/drought contingency measures	Percentage	Biennial	Slovak Tourism Board	SO2
EO4	Increase in Green Financial Products	Number of loans, insurance, and investments supporting adaptation	Count	Annual	Financial regulators, insurance providers	SO2, SO5

Cluster Safety and Well-being

Includes: Health, Civil Protection, ICT

Table 54: Outcome Indicators aligned with Strategic Objectives for Cluster Safety and Well-being

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
SWO1	Access to Early Warning Systems	% of population covered by effective and timely climate hazard warnings	Percentage	Biennial	Civil Protection, SHMI	SO4

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
SWO2	Health System Preparedness for Climate Events	% of hospitals with climate-related emergency plans (heatwaves, floods)	Percentage	Biennial	Ministry of Health	SO4, SO5
SWO3	Public Participation in Adaptation Awareness Campaigns	% of population engaged in education or outreach on climate adaptation	Percentage	Triennial	Ministry of Education, NGOs	SO4
SWO4	ICT Sector Resilience Enhancements	% of ICT infrastructure adapted to reduce disruption from climate events	Percentage	Biennial	Cybersecurity Centre, Ministry of Transport	SO4, SO5

Cluster Built Environment and Spatial Planning

Includes: Infrastructure, Buildings, Spatial Planning, Cultural Heritage

Table 55: Outcome Indicators aligned with Strategic Objectives for Cluster Built Environment and Spatial Planning

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
BEO1	Implementation of Climate-Adapted Local Plans	% of municipalities with climate-adapted land use or zoning plans	Percentage	Biennial	MoE SR, local governments	SO3, SO5
BEO2	Retrofit Rate of Existing Buildings	% of buildings retrofitted to improve thermal performance and flood resistance	Percentage	Annual	Building authority, municipalities	SO3

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
BE03	Protection Plans for Vulnerable Cultural Heritage Sites	% of key heritage sites with active adaptation or protection measures	Percentage	Biennial	Monuments Board	SO3, SO5
BE04	Green and Blue Infrastructure Coverage	% of urban area with functional green/blue infrastructure for climate adaptation/mitigation	Percentage	Biennial	SAŽP, municipalities	SO3

Cluster Cross-Cutting Aspects

Includes: Urban areas, Social vulnerability, Research, Education, Governance

Table 56: Outcome Indicators aligned with Strategic Objectives for Cluster Cross-Cutting Aspects

No.	Indicator	Definition	Unit	Frequency	Data Source	Strategic Objective(s)
CCO1	Integration of Adaptation in Local Governance	% of local/regional governments with formal adaptation strategies	Percentage	Biennial	MoE SR, UMS	SO5
CCO2	Research Output on Adaptation	Number of peer-reviewed publications or national research projects on adaptation	Count	Annual	Slovak Academy of Sciences, research grants	SO4, SO5
CCO3	Participation in Adaptation Education	% of schools/universities integrating climate adaptation into curriculum	Percentage	Biennial	Ministry of Education	SO4
CCO4	Stakeholder Engagement in Adaptation Planning	% of national/sectoral processes with stakeholder involvement	Percentage	Biennial	MoE SR, MEL reporting	SO5

Cross-Cutting Considerations

To ensure the Monitoring, Evaluation and Learning (MEL) framework functions as an integrated and effective system, several cross-cutting considerations must guide its development and implementation. These include practical steps for operationalisation, alignment with sectoral planning, integration of research and innovation, and acknowledgment of evolving methodological standards. The following points highlight key factors that will shape the success and usability of the MEL system:

- **Baseline Development Phase (2025–2027):** This period will be used to develop and test baseline data for impact and outcome indicators. The current NAP provides the policy window for this foundational effort.
- **Alignment with Sectoral Monitoring:** The indicators in this Annex are strategically linked to the sector-specific implementation and output indicators found in Part 2 (Factsheets). All sectors must ensure that their monitoring arrangements are coherent with this three-level MEL structure.
- **EU Project Integration – UNDERPIN:** The Horizon Europe project UNDERPIN³⁵⁸ will develop science-based climate risk and adaptation indicators, which Slovakia can closely follow, with a view to integrating relevant findings and outputs in its MEL. UNDERPIN provides a unique opportunity to test and refine the MEL framework in line with cutting-edge European research.
- **Flexibility and Innovation:** Given the novelty of impact and outcome MEL, the framework is intentionally adaptive, iterative, and open to improvement. Stakeholder input, pilot testing, and alignment with evolving EU policy (e.g. EU Climate Resilience Framework) will guide further refinement.

Recommended Steps

- Finalize indicator metadata and reporting templates by 2026.
- Collect baseline data and integrate indicator tracking into sectoral plans.
- Pilot MEL reporting in selected regions or sectors.
- Adopt relevant outputs of the UNDERPIN project as available.
- Evaluate MEL system performance and revise as needed in 2030 and 2035.

³⁵⁸ <https://cordis.europa.eu/project/id/101215153>

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