

Climate Change Risks and Adaptation in the Podravje Region

Preliminary Results



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Table of Content

Figures	4
Tables	6
Executive summary	8
1 Socio-economic profile	14
1.1 Demography	14
1.2 Economy.....	15
2 Regional risks to climate change	21
2.1 Flooding	21
2.2 Extreme heat.....	25
2.3 Drought.....	30
2.4 Landslides.....	34
2.5 Labor market outcomes in Podravška: levels, trends, and gaps	38
3 Governance Structures	49
3.1 Stakeholder Landscape.....	49
3.2 Adaptation-oriented innovation system.....	52
3.3 Key challenges.....	56
3.4 Opportunities & Way forward	59
4 Justice Dimensions in Adaptation Planning	60
4.1 Strategic Planning Context.....	60
4.2 Justice Considerations Identified in Interviews	67
5 Barriers and enabling conditions	74
5.1 Introduction	74
5.2 Barriers to Climate Change Adaptation	75
5.3 Barriers along the CCA policy cycle	84
5.4 Sectors affected by barriers to Climate Change Adaptation	85
5.5 Overcoming barriers to climate change	86
6 Conclusion & way forward: from risk to climate action	88
6.1 From climate risk to adaptation priorities	88
6.2 Strategic directions for adaptation	88
6.3 Way forward: towards adaptive and coordinated action	92
7 References.....	93
8 Appendix	96
8.1 Supporting material for flood assessment	96
8.2 Supporting material for development of SoVI	96



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8.3	Supporting material for extreme heat assessment.....	100
8.4	Supporting material for drought assessment	100
8.5	Supporting material for landslide assessment	103
8.6	Methodology of Adaptation Justice Index review.	105
8.7	Methodology and questionnaire for the survey on barriers to CCA.....	116

Figures

Figure 1: TiCCA4Danu Research Framework (WP2) and Report Structure	8
Figure 2: Stakeholder Map - Climate Adaptation Governance in Maribor and Podravje Region. Influence-Interaction Matrix.	11
Figure 3: Top 10 barriers to climate change adaptation, sorted by relevance.	13
Figure 4: Regional contributions to the Slovenian gross domestic product. Data: SiStat (n.d.), accessed: March 2026	15
Figure 5: Development of the distribution of employment across economic sectors in Podravska from 2000 to 2024. Data: SiStat (n.d.). Accessed: March 2026.....	17
Figure 6: Regional innovation indicators for Vzhodna Slovenija. Source: European Commission (2025).	19
Figure 7: Historical flood events affecting Podravje, categorized by flood type and reported cause, based on the HANZE dataset for the period 1870-2025.	22
Figure 8: Settlement-level population exposure to the 1-in-100-year fluvial flood in Podravje.	22
Figure 9: Settlement-level Social Vulnerability Index (SoVI) and dominant contributing indicator for flood-exposed settlements in Podravje.	24
Figure 10: Distribution of flood-exposed population across Social Vulnerability Index (SoVI) classes and inundation-depth categories for the 1-in-100-year fluvial flood in Podravje.....	24
Figure 11: Annual variation in extreme-heat indicators across Podravje from 1990 to 2025, derived from the EMO-1 dataset.....	25
Figure 12: Spatial distribution of mean annual extreme-heat indicators across Podravje for the period 2016-2025, derived from the EMO-1 dataset.	26
Figure 13: Municipal-level population exposure to mean annual tropical-night frequency in Podravje for the period 2016-2025.	27
Figure 14: Settlement-level Social Vulnerability Index (SoVi) and dominant contributing indicator for tropical night-exposed settlements in Podravje.....	28
Figure 15: Distribution of the exposed population across Social Vulnerability Index (SoVi) classes and mean annual tropical-night frequency classes in Podravje for the period 2016-2025.	29
Figure 16: Temporal evolution of meteorological drought in Podravje between 1990 and 2025 based on EMO-1.	31
Figure 17: Spatial characteristics of meteorological drought in Podravje based on EMO-1 SPEI3 drought severity for 1990–2025.....	32
Figure 18: Agricultural exposure to cumulative SPEI3 drought severity across municipalities in Podravje for 1990–2025.	33
Figure 19: Agricultural drought exposure by sector and municipality in Podravje for 1990–2025.	34
Figure 20: Spatial distribution of field-verified landslides, rockfalls, and debris/mass flows in Podravje.....	35
Figure 21: Road susceptibility to slope mass-movement hazards across municipalities in Podravje.....	37
Figure 22: Road susceptibility by functional road type in Podravje.....	37
Figure 23: Labor market outcomes. Source: SURS/AJPES.....	38

Figure 24: Cumulative labour market effects of extreme river flooding in Podravska, 2005-2024.....	41
Figure 25: Cumulative labour market effects of heat days in Podravska, 2005-2024.....	41
Figure 26: Cumulative labour market effects of drought in Podravska, 2005-2024.	42
Figure 27: Cumulative labour market effects of extreme wind speed in Podravska, 2005-2024.	43
Figure 28: Climate hazard exposure across Podravska's territory.	45
Figure 29: Socioeconomic vulnerability across Podravska's territory.	46
Figure 30: TX95p heat days Podravska, 2005–2024.	47
Figure 31: Stakeholder Map - Climate Adaptation Governance in Maribor and Podravje Region. Influence-Interaction Matrix.	49
Figure 32: Visions on climate change adaptation in the Podravje Region.	52
Figure 33: Difference on climate adaptation visions between state- and non-state stakeholders (in %).	54
Figure 34: Word cloud of interviews coded as “understanding of innovation” (and sub-codes), MaxQDA.....	55
Figure 35 Assessments of Slovenian National and Maribor Municipal adaptation strategies with the adaptation justice index, showing achieved score as a percentage of the total possible across indicators of distributional, procedural, recognitional, and restorative/corrective justice.	63
Figure 36: Share of “Energy Poor” Households by Slovenian Administrative Regions in %.	72
Figure 37: Distribution of stakeholder groups	74
Figure 38: Overview of relevance of barrier categories.....	76
Figure 39: Overview barriers “resources”	77
Figure 40: Overview barriers “conflict of interest”.....	78
Figure 41: Overview barriers “governance and institutional constraints”	79
Figure 42: Overview barriers "awareness and communication"	80
Figure 43: Overview barriers "attitudes, values and motivations"	81
Figure 45: Overview barriers “science and data”	81
Figure 46: Overview barriers “leadership”	82
Figure 47: Overview of barriers sorted along significance.....	83
Figure 48: Policy cycle of climate change adaptation	84
Figure 49: Barriers along the CCA policy cycle, sorted according to relevance	84
Figure 50: Sectors affected by barriers to CCA, according to relevance, overall.....	86
Figure 51: Spatial distribution of population and indicators used in the Social Vulnerability Index (SoVI) across Podravje.....	99
Figure 52: Spatial distribution and extent of agricultural land-use classes considered in the meteorological drought exposure analysis for Podravje.....	102
Figure 53: Distribution of agricultural drought exposure by sector and municipality in Podravje for 1990–2025.....	103
Figure 54: Adaptation cycle Ideal-type stages of the adaptation decision-making process; Source: ClimateADAPT 2025	119

Tables

Table 1: Justice Dimensions in Adaptation Planning	12
Table 2: Sectoral contribution to the GVA of Podravska and Slovenia 2000 vs. 2024 in EUR millions. Colour code: orange: < 4%, yellow: < 8%, light green: < 12%, dark green: < 20%, and purple: ≥ 20%. Data: SiStat (n.d.). Accessed: March 2026.	16
Table 3: Sectoral contributions to GHG emissions. Data Source: Eurostat (2025c).	18
Table 4: Population exposure to the 1-in-100-year fluvial flood in Podravje by inundation-depth class.	23
Table 5: Population exposure to mean annual tropical-night frequency classes in Podravje for the period 2016-2025, including the estimated number and share of elderly residents and children exposed, as well as the population living in settlements with SoVI values above 0.40. Estimates of elderly and child exposure are based on the demographic composition of the underlying population units.	29
Table 6: Climate hazard effects on Podravska's labour market.	40
Table 7: Projected business losses under IPCC AR6 climate scenarios.	48
Table 8: Forms of justice in climate adaptation	60
Table 9: Justice Indicators based on the Adaptation-Justice Index	61
Table 10: Indicators included in the Social Vulnerability Index (SoVI) for Podravje, including their rationale and assigned weights.	98
Table 11: RABA land-use classes considered for the meteorological drought exposure analysis in Podravje, including the rationale for their inclusion or exclusion from the agricultural sector assessment.	102
Table 12: Analyzed plans at the national and city level	105
Table 13: Adaptation Justice Assessment of SSF-CCA	105
Table 14: List of barriers to CCA used in survey	117
Table 15: Questionnaire on barriers to climate adaptation in Podravje	122

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Executive summary

Introduction

Disclaimer: Please be aware that these are preliminary research results to be refined for the final report (due in November 2026). Any feedback on the results is appreciated.

TiCCA4DANU aims to drive systemic and transformative climate change adaptation (CCA) across the Danube Macro-Region. Working with city-regions, TiCCA4Danu develops practical tools, training, and governance models to successfully implement adaptation strategies across these city-regions. These real-world policy experiments are grounded in interdisciplinary research. This report summarizes the current status of our academic work on CCA in the Podravje Region (Slovenia) and is organized as follows.

The first two chapters take a quantitative approach to describe the Podravje region's climate risk and vulnerability context. Chapter 1 develops a socio-economic profile of the region, examining demographic trends and economic structures to identify key sectors and vulnerable social groups that are particularly relevant for subsequent climate risk and adaptation assessments. Chapter 2 analyses climate risks by identifying current and projected hazards – floods, drought, landslides and extreme heat – and assessing the exposure of infrastructure, population, economic sectors, and labour markets.

To address existing climate risks, the municipalities in Podravje have already initiated several adaptation measures. Chapters 3, 4 and 5 take a qualitative approach to deepen the understanding of the current CCA landscape. Chapter 3 maps the institutional and governance settings in which climate adaptation currently takes place within Podravje's regional innovation system. It also highlights stakeholders' existing visions, initiatives, and innovations for improving climate adaptation in the region. Chapter 4 analyses existing CCA documents (the National Strategy on CCA and several strategies at the level of Maribor City) for their inclusion of justice considerations and establishes an understanding of how justice and fairness are perceived in the Podravje Region. Chapter 5 diagnoses existing barriers to ongoing climate change adaptation, including policy, financial, technical, social, and governance obstacles.

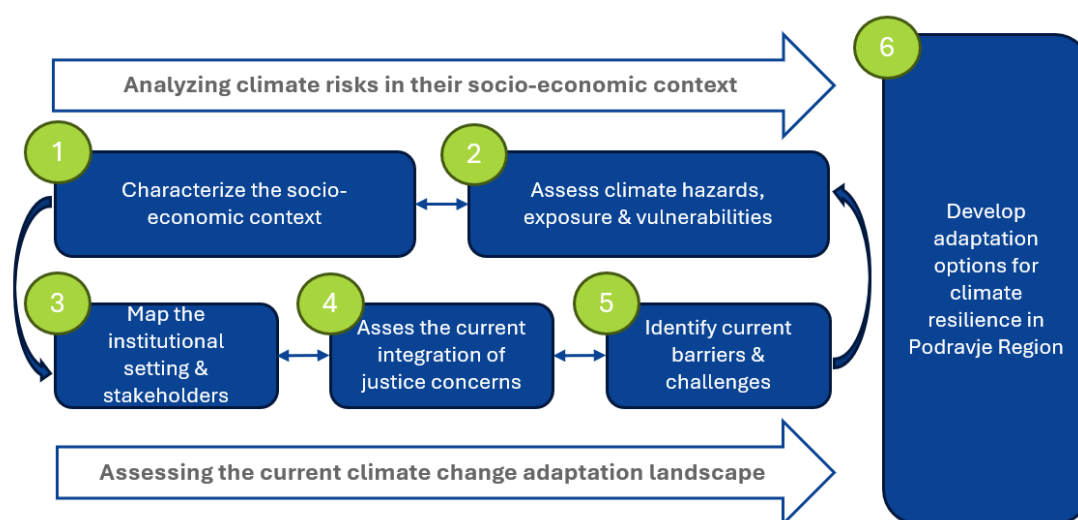


Figure 1: TiCCA4Danu Research Framework (WP2) and Report Structure

The two tracks converge in Chapter 6, where findings are synthesized to design transformative adaptation measures and policies for Podravje Region. As such, the research project first characterizes risks and impacts (what and who is affected by what risks?), simultaneously assesses the institutional and justice context (who can act, how fairly and what hinders action?), and then integrates both to propose transformative, context-appropriate adaptation strategies for the district (see Figure 1). A short summary of each chapter follows.

Socio-economic context

Podravska is Slovenia's second-most populous statistical region, with around 331,500 residents in 2024, and Maribor, its principal urban centre, reaching approximately 114,300 inhabitants in 2025. Population growth in both cases has been driven primarily by positive net migration which counterbalances a continuing natural population decline. At the same time, the region is confronted with pronounced demographic ageing: the share of residents aged 65+ has risen to around 23% in Podravska and 24% in Maribor, while the working-age population has steadily declined. These trends increase climate vulnerability, as older residents are disproportionately exposed to heat, poor air quality, and disruptions to health and care services, while a shrinking labour force may limit municipal, health-care, and emergency-response capacity. Socioeconomic conditions further compound these risks. Some more rural municipalities experience depopulation that can weaken local capacities to prepare for and recover from climate-related shocks. Additionally, Podravska has Slovenia's second-highest at-risk-of-poverty rate (17.7% in 2025).

Economically, Podravska remains Slovenia's second-largest regional economy in total output, with a GRP of EUR 8.6 billion in 2024, but its GDP per capita, productivity, and employment performance remain below the national average and substantially behind the Ljubljana-centred Osrednjeslovenska region. The regional economy is strongly anchored in manufacturing, construction, trade, transport, and public services, including several energy-intensive industries that face substantial decarbonisation, energy-price, and carbon-cost pressures. Innovation capacity is moderate, constrained by relatively low public and private R&D spending, declining collaboration among innovative SMEs, and the concentration of high-value activities and research institutions around Ljubljana. Nevertheless, growing product and process innovation, broadband coverage, and participation in lifelong learning offer potential foundations for climate-resilient transformation. Current estimates suggest that 23% of Podravska's population may be exposed to potentially harmful hazards such as floods, windstorms, and water shortages; the region contains a large share of Slovenia's irrigated agricultural land and the country's longest sewage network, both exposed to drought and heavy-rainfall impacts. Yet environmental-protection investment remains low, only at around 0.2% of regional GDP in 2024. Adaptation should therefore be integrated with industrial decarbonisation, social inclusion, housing improvement, rural service provision, and regional economic development, rather than pursued as a stand-alone disaster preparation agenda.

Regional risks to climate change

The regional risk assessment shows that climate risk in Podravje is highly spatially differentiated. Extreme heat affects a large share of the population, while riverine flood exposure is more spatially concentrated. Agricultural drought exposure and landslide susceptibility show distinct spatial patterns across the region. Social vulnerability also differs between settlements, meaning that similar levels of physical exposure may have different consequences. These findings provide an evidence base for targeting adaptation according to local risk, vulnerability and sectoral conditions rather than applying uniform measures across the region.

Riverine flooding affects a comparatively limited but spatially concentrated share of the regional population. Approximately 11,224 residents in 167 settlements are exposed to the 1-in-100-year flood, with the largest exposed populations located in Maribor, Ptuj and Spodnji Duplek. The SoVI was used to provide additional insight into the social vulnerability of flood-exposed settlements. Among the flood-exposed settlements, low earnings are the most frequently dominant contributor to social vulnerability, occurring in 61 settlements (36.5%), followed by the share of elderly residents in 44 settlements (26.3%) and low educational attainment in 37 settlements (22.2%).

Extreme heat conditions in Podravje show a clear increase over the 1990–2025 period, as reflected across all three heat indicators considered. Population exposure to tropical nights was further assessed for 2016–2025, showing that approximately 303,518 residents, or 91.5% of Podravje's population, lived in areas experiencing more than 30 tropical nights per year on

average. Most of this population was exposed to >30–35 tropical nights annually, while approximately 14,616 residents experienced more than 35. Among those exposed to more than 30 tropical nights per year, an estimated 69,670 were elderly residents and 40,624 were children. The results show that nighttime heat is already a widespread regional pressure rather than a hazard confined to a limited number of locations.

The **drought assessment** shows marked spatial and sectoral differences in agricultural exposure. The largest exposed agricultural areas are found in Slovenska Bistrica (9,363 ha), Ormož (8,236 ha), Pesnica (4,891 ha), and Maribor (4,556 ha). Arable land and permanent grassland account for most of the exposed area, while orchards and vineyards show more localized patterns, with particularly high vineyard exposure in Ormož. The results help identify priority areas for more detailed assessment of drought vulnerability, water availability, irrigation needs, and crop-specific adaptation options. The analysis reflects exposure to meteorological drought and does not directly quantify agricultural losses or crop vulnerability.

The **landslide assessment** explores the distribution of historical landslides, as well as the spatial distribution of susceptibility to landslides, rockfalls and debris/mass flows. We further examine the road network located in areas that show favourable local conditions for landslide occurrence. Around 64.0% of roads lie within landslide-susceptible areas, of which 87.1% fall within medium to very high susceptibility classes. A similar share intersects debris-flow-susceptible areas, although most of this exposure is in very low and low classes, while rockfall exposure is limited to about 0.5% of the road network. Road susceptibility exposure is largely driven by tracks, which make up most of the network. However, disruption of higher-order roads may have greater consequences, so adaptation priorities should consider both susceptibility and the functional importance of the affected road type.

Effects of climate change on **the labour market**: Econometric analysis of 213 Slovenian municipalities over 2005–2024 finds that climate hazards can impose persistent local economic costs in Podravska. Extreme river flooding significantly reduces employment and real wages, while extreme wind events produce the largest wage losses. Extreme heat does not have a statistically significant effect on employment or wages but is associated with a delayed reduction in the number of firms. Interestingly, municipalities with repeated flood exposure appear better able to protect employment and wages - potentially suggesting that adaptation measures work. Looking ahead, continued warming could materially affect the regional business base: under IPCC-consistent scenarios, Podravska may face annual losses of roughly 201–459 firms and €86–197 million in real revenue by 2030–2040, with cumulative revenue losses potentially reaching €2.0–3.2 billion by 2040.

Governance Structures of the adaptation-oriented regional innovation system

Climate adaptation governance in Podravje is multilevel but fragmented. Figure 2 highlights how stakeholders in Podravje rank the importance and interaction with different actor groups on climate adaptation: Municipalities emerge as the main implementation actors. While some municipalities coordinate adaptation across departments or integrate it into routine decision-making, others currently address risks such as heatwaves or landslides solely on a reactive ad-hoc basis. Most of the region's 41 municipalities are small, predominantly rural and struggle due to limited staff availabilities, lack of expertise, and difficulties with accessing funding for adaptation measures. The existing regional bodies for Podravje, including the Regional Development Agency and ENERGAP, provide support in climate adaptation but lack the authority of a formal regional government over municipalities to align efforts. National and EU institutions shape priorities through funding opportunities, while other stakeholder groups such as NGOs, research bodies, and civil society contribute knowledge and implementation support. The private sector is currently less involved.

The region's adaptation-oriented innovation system is led primarily by public institutions, combining strategic planning, infrastructural, and nature-based solutions with increasing attention to vulnerable groups and public participation. Common measures include the development of regional and municipal climate strategies, greening and depaving, heat-preparedness activities, and support for farmers, schools, and care institutions. Innovation in

the context of adaptation is mainly understood as institutional and organizational change, including improved cooperation, cross-sectoral planning, and mainstreaming adaptation across municipal responsibilities. Nature-based solutions are the most visible practical innovation, while social and behavioural innovation is recognized but less developed. Technological and market-led approaches are viewed as useful complements - such as risk-monitoring technologies or corporate green infrastructure - but are not seen as the primary drivers of adaptation. Non-state actors put relatively greater emphasis on vulnerability, inclusion, and the needs of affected populations, whereas state actors give more weight to strong public institutions and institutional implementation.

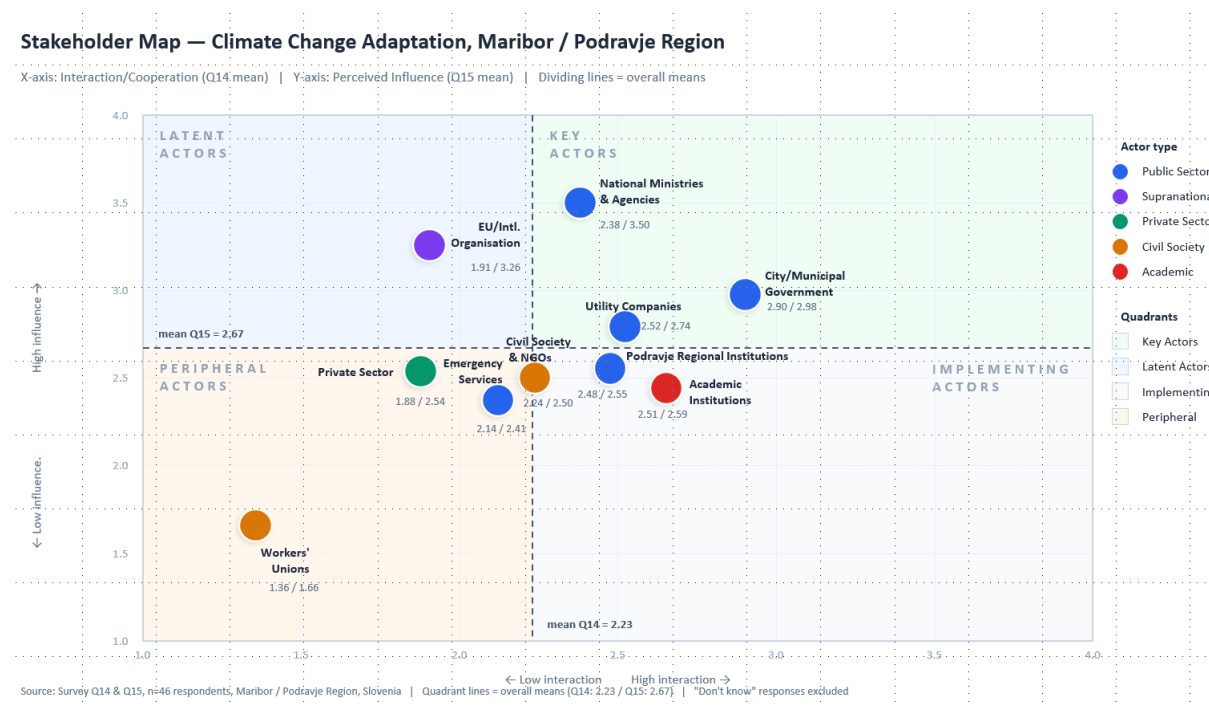


Figure 2: Stakeholder Map - Climate Adaptation Governance in Maribor and Podravje Region. Influence-Interaction Matrix.

Key barriers in the regional innovation system are weak regional coordination, limited cooperation between municipalities, short-term project funding, and insufficient adaptation finance. Smaller rural municipalities are particularly affected, although their close community ties and flexible decision-making are also considered as strengths by some interviewees. Moving forward, Podravje would benefit from more stable national and local funding for adaptation, stronger inter-municipal cooperation, and clearer regional coordination. Recommended measures by interviewees include mainstreaming climate resilience across municipal departments, appointing local climate contact persons for better cooperation, building staff capacity, supporting nature-based solutions and SME innovation, and framing adaptation around direct benefits for residents and vulnerable groups.

Justice Dimensions in Adaptation Planning

Implementation of climate change adaptation at city and regional level is guided by national and municipal strategic planning documents. The Adaptation Justice Index (AJI) provides a structured tool of assessing this integration across four dimensions - distributive, procedural, recognitional, and restorative justice (see Table 1) using 16 indicators. Our current assessment is only provisional, based on current available documents. Slovenia's dedicated national Climate Change Adaptation Strategy is still under development - expected to be completed in 2028 - and Maribor does not yet have a single comprehensive adaptation strategy. The national assessment is therefore based on the 2016 Slovenian Strategic Framework for Climate Change Adaptation, and the municipal assessment aggregates evidence from the Municipal Environmental Protection Programme, Heat Action Plan, and

Climate Change Vulnerability Assessment. This limits direct comparability with assessments of dedicated adaptation plans, but provides a first idea of how justice is currently reflected in planning processes.

Form	Description
Distributive Justice	justice in the way that the risks of climate change, and the costs and benefits of adaptation are distributed within a social context.
Procedural Justice	justice in the processes which are used to come to decisions, including who has a say in decisions, the degree of influence they have, and the rules which govern these interactions.
Recognitional Justice	justice in whose needs, desires, and interests are accounted for in adaptation planning and governance, including the differences in the ability and needs of different social groups in adaptation.
Restorative	justice in the way in which existing or previous injustices are accounted for and rectified.

Table 1: Justice Dimensions in Adaptation Planning

Across both national and municipal planning, distributive justice is accounted for by risk and vulnerability assessments but does not consistently lead to targeted measures, fair allocation criteria, or transparent analysis of who benefits from/who bears the costs of adaptation. The integration of procedural justice elements is more uneven: national planning includes stakeholder consultation but only limited evidence of broad, public participation. Maribor's Heat Action Plan offers a stronger example of participation by vulnerable groups, even though their future roles in implementation and evaluation could be more clearly defined. Recognitional justice is partly present through acknowledgement that climate impacts are unevenly experienced, particularly by older people, children, rural and agricultural communities, low-income households, people with chronic health conditions, and other marginalised communities; nevertheless, plans rarely analyse how social, economic, historical, and institutional structures shape their vulnerabilities and adaptive capacities. Restorative justice does not appear in the plans in any significant way. They do not offer guidance for compensation for climate-related harm, maladaptation, or unequal access to adaptive resources.

Overall, interviews reinforce the findings from the document analysis. On the one hand, they highlight some good local practices, e.g., participatory budgeting approaches, targeted support for heat-vulnerable groups, and vulnerability-based prioritisation. On the other hand, they mention barriers such as fragmented inter-municipal cooperation, dependence on EU project funding, limited funding for civil society organizations, and uneven public participation.

Barriers and enabling conditions

The survey on barriers to climate change adaptation shows that the level of agreement to the diverse range of potential barriers is generally very high. The barriers perceived most significant are diverse in terms of thematic areas but mainly led by barriers from the topic of "resources". Priority barriers within this topic include a lack of municipal government staff time and finances, a lack of regional institutions' finances as well as a lack of funding from the national to the regional and municipal level. Furthermore, there appears to be a lack of political will as well as powerful interests hindering the planning and implementation of adaptation measures, a lack of alignment between national climate policies and regional/municipal priorities as well as a lack of collaboration and cooperation across different government levels and some mistrust of the national government among the public. Figure 3 shows a list of the ten most relevant barriers - as listed by survey respondents.

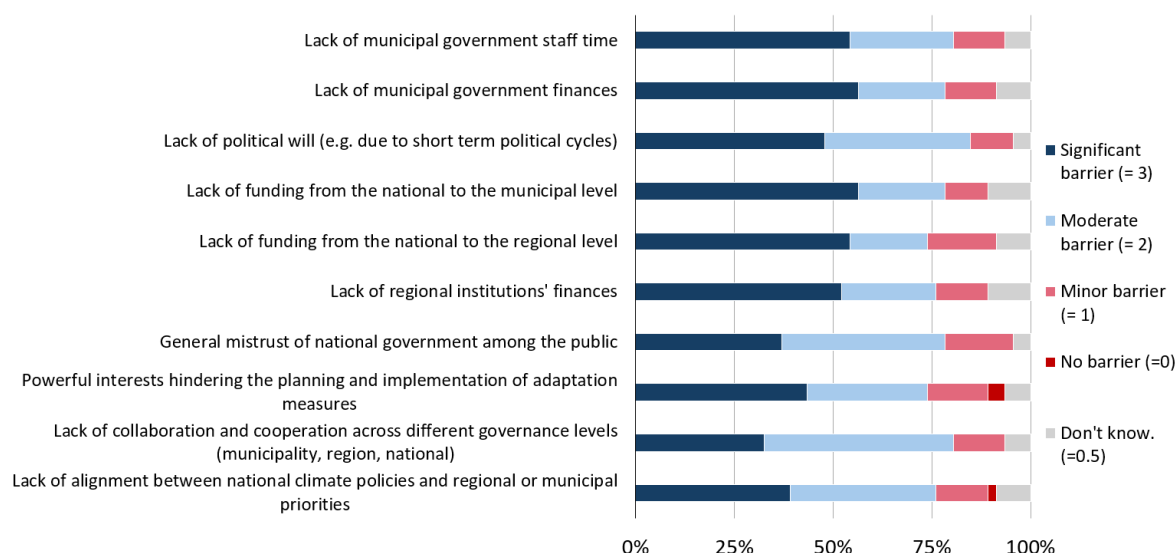


Figure 3: Top 10 barriers to climate change adaptation, sorted by relevance.

The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant, moderate, minor, non-existent, or “don’t know” (implies low relevance). n=46

According to the survey respondents, barriers to climate change adaptation mostly appear in the implementation phase of the adaptation policy cycle, but also at the very beginning, when preparing the ground for adaptation and assessing risks vulnerabilities to climate. The sector most affected by barriers to climate change adaptation is the sector of agriculture. Respondents identified various ways of overcoming these barriers: Exchange and cooperation between different stakeholders; awareness-raising, knowledge generation and capacity building of decision-makers and the public; ensuring clear and harmonized legislative frameworks on implementing adaptation measures; strengthening access to and assessment of relevant data; and acquiring more financial resources for climate change adaptation.

Conclusions

Climate adaptation in Podravje must address more than individual hazards. Flooding, heat, drought and landslides affect municipalities, population groups, economic sectors and infrastructure unevenly, while the severity of the impacts is influenced by social vulnerability, available resources and institutional capacity. The assessment identifies priority risk patterns, but effective action will also depend on coordinated governance, adequate financing, technical capacity and the meaningful inclusion of vulnerable groups. The report identifies several strategic directions for Podravje: tailoring action to local differences in risk, vulnerability and municipal capacity; mainstreaming climate considerations into everyday municipal decision-making; strengthening cooperation across municipalities and governance levels; mobilising the region’s innovation, learning and stakeholder-engagement capacities; and creating more accessible, flexible and durable financing arrangements. Particular attention is needed for the majority of smaller municipalities in the region, which may lack staff, expertise and resources, and for sectors such as agriculture, spatial planning and water management. Adaptation should also be integrated with mitigation, social justice and broader regional-development objectives to maximise synergies and avoid transferring disproportionate burdens to less-resourced communities. The evidence presented in this report provides a foundation - not a fixed plan - for a co-created and adaptive process in which stakeholders prioritise risks, explore feasible measures and financing options, and progressively develop adaptation pathways that can be reviewed and adjusted as climate conditions, knowledge and regional priorities evolve. The proposed options will be refined and prioritized in workshop sessions with local stakeholders in October in Maribor.

1 Socio-economic profile¹

1.1 Demography

Podravska's population increased to around 331,500 residents in 2024, representing approximately 15.5% of Slovenia's total population and making it the country's **second-most populous region** after Osrednjeslovenska, which includes Ljubljana. While Podravska's population has also been naturally decreasing, net migration (from abroad and between regions) positively offset these developments (SiStat, n.d.). Migration movements from the regions Pomurska, Osrednjeslovenska, and especially from Savinjska to Podravska displayed the highest numbers in this regard, stressing a persisting **urban-rural migratory divide** in Slovenia (OECD, 2026). As such, also **the population of Maribor** has been steadily rising to about 114,300 inhabitants (2025). This growth has occurred despite a **continuing natural population decline**, as migrations from abroad have counterbalanced this development, especially in recent years (SiStat, n.d.). Migrants from countries of former Yugoslavia account for a large share of migrants in Maribor, many of which are employed in the construction, manufacturing, transportation, or logistics industry (EURES, 2025).

An **ageing population** represents a particularly important source of climate vulnerability in Maribor and Podravska. While the share of young children aged 0-4 has remained broadly stable over the past 15 years - between approximately 3.8% and 5.4% across Maribor, Podravska, and Slovenia - the proportion of **residents aged 65+ has increased substantially**. Since 2008, the share of older people rose from 16% to 22% nationally, from 17% to 23% in Podravska, and from 19% to 24% in Maribor (SiStat, n.d.). In parallel, the **working-age population (15-65y)**, has **declined steadily** over the last two decades, from an average of around 70.5% in the late 1990s and early 2000s to approximately 63.5% in 2025 across the different spatial scales.

Socioeconomic conditions further shape **unequal exposure and adaptive capacity**. The share of households with less than 60% of the median disposable income has dropped both on the national and regional level since 2014 but remains **geographically uneven**. While the country's economic powerhouse, Osrednjeslovenska, registered a share of population at-risk-of-poverty of 10.6% in 2025, populations outside the nation's capital region were exposed to a much higher risk of poverty. Podravska currently has the **second-highest at-risk-of-poverty rate in Slovenia, at 17.7%**, right behind Zasavka with 19.9% in 2025 (SiStat, n.d.). Housing indicators are mixed: overcrowding is relatively low (9.5% in 2025 vs. 11.3% nationally), but 21% of households in Eastern Slovenia report **poor dwelling conditions** (vs. 17% in Western Slovenia), and **energy affordability** issues affect 6% vs. 3%, respectively; environmental problems (e.g., traffic/industrial pollution) are reported by 16% of households in both cohesion regions (SiStat).

However, some upward trends can be observed: the share of households with adequately cool dwelling during the summer has increased in Podravska, with the share rising from 82% in 2012 to 88% in 2025 (Slovenian average: 88% in 2025) (SiStat, n.d.). Additionally, Slovenia performs strongly **on well-being in international comparisons on life-satisfaction** and ranks third with a score of 7.7 of 10 in 2024 among European countries (OECD, 2026). Also, the OECD's Better Life Index (analyzing eleven indicators, including health, housing, work, etc.) confirms this and places Slovenia just above the OECD median. But also here, an **east-west divide** was found, with Western Slovenia scoring better in almost all indicators than Eastern Slovenia (OECD, 2026).

¹ All data marked by the in-text citation SiStat, n.d. was retrieved from the database of the Statistical Office of the Republic of Slovenia. <https://pxweb.stat.si/SiStat/en>.

1.2 Economy

1.2.1 General economic performance

In terms of **gross regional product (GRP)**, Podravska ranks **second** (8,636 Mio. EUR in 2024) among Slovenian regions with a substantial gap to Osrednjeslovenska, hosting the national capital with 26,921 Mio. EUR in 2024 (SiStat, n.d.). Figure 4 illustrates the regional percental contribution to the national gross domestic product, underlining the economic dominance of Ljubljana and its surroundings.

Notably, the GRP of Podravska (and of all other Slovenian regions) has **not taken a large hit (-3%) during the COVID-19 pandemic**, with GRP levels exceeding pre-pandemic levels already in 2021 and continuing to further grow in 2023 and 2024 (2022/2023: 12% & 2023/2024: 7%) (SiStat, n.d.). Potential reasons behind the strong economic recovery were reportedly a combination of **strong domestic demand, export-driven growth, and extensive government support** (wiiw, 2021).

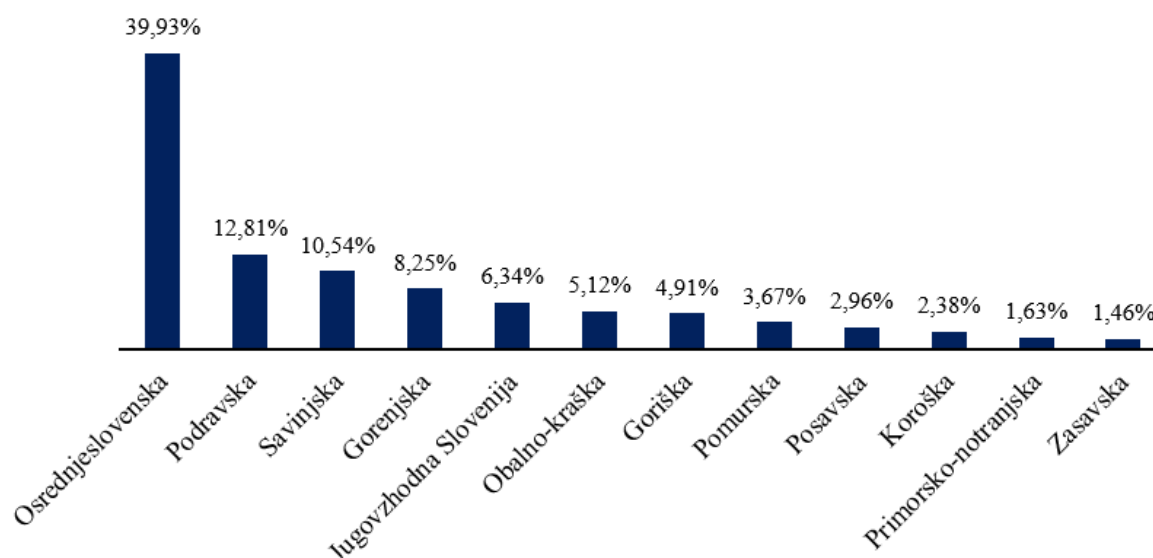


Figure 4: Regional contributions to the Slovenian gross domestic product. Data: SiStat (n.d.), accessed: March 2026

In terms of GDP per capita, Osrednjeslovenska remains Slovenia's dominant economic region, recording 47,483€ per resident in 2024 - significantly above the national average of 31,698€. Although Podravska ranks second among Slovenia's regions in terms of total economic output, its GDP per capita was only 26,112€ in 2024. This placed Podravska **eighth out of Slovenia's twelve statistical regions**, indicating that its relatively large overall economy does not translate into similarly high output per resident.

Several labour-market factors may help explain this position. Podravska's **unemployment rate stood at 5.7% in 2025, above the Slovenian average of 4.8%**. The region's labour productivity, measured as output per employed person, was comparatively low: 54,612€ in 2024, compared with the Slovenian average of 68,959€. Podravska therefore ranked in the bottom third of Slovenian regions in terms of productivity.

For a better understanding of trends in the regional economy, a closer look at the different economic sectors follows. This is important to understand the different sectors at risk of impacts from climate change.

1.2.2 Economic specialization

Table 2 showcases the sectoral contributions to Podravka's and Slovenia's gross value added (GVA). **Manufacturing** remains the dominant economic sector in Podravka and Slovenia with contributions of about a quarter to the respective GVA. **Trade and transportation as well as public administration** remain on the national scale and in Podravka equally strong and rank second or third in GVA contribution. While the **agricultural sector** on both the national and regional level further decreases in importance (notably, more on the national level than in Podravka), the **construction grows (absolute & relative) in Podravka**, while stagnating nationally. Also, the private service sector gains traction since 2000 in Podravka and Slovenia. In Podravka, financial and insurance as well as real estate activities have increased, but decreased slightly in relative numbers. In summary, while manufacturing remains dominant, some service industries do gain traction in Podravka and on the national scale (SiStat, n.d.).

	Podravka				Slovenia			
	2000		2024		2000		2024	
	Total	%	Total	%	Total	%	Total	%
Gross value added	2,160	100%	7,646	100%	16,343	100%	59,694	100%
Agriculture	84	3.89%	147	1.92%	562	3.44%	1036	1.74%
Manufacturing, mining, etc.	595	27.55%	1952	25.53%	4,643	28.41%	15,621	26.17%
Construction	139	6.44%	672	8.79%	1060	6.49%	3,976	6.66%
Trade, hospitality, transport	364	16.85%	1,215	15.89%	2,982	18.25%	11,674	19.56%
Information, communication	61	2.82%	220	2.88%	614	3.76%	2,650	4.44%
Finance, insurance activities	110	5.09%	332	4.34%	775	4.74%	3,190	5.34%
Real estate activities	202	9.35%	659	8.62%	1,305	7.99%	4,233	7.09%
Professional, technical and other business activities	170	7.87%	810	10.59%	1,176	7.20%	5,904	9.89%
Public administration and defence, education, health	385	17.82%	1,473	19.26%	2,690	16.46%	10,041	16.82%
Others	50	2.31%	167	2.18%	536	3.28%	1370	2.30%

Table 2: Sectoral contribution to the GVA of Podravka and Slovenia 2000 vs. 2024 in EUR millions. Colour code: orange: < 4%, yellow: < 8%, light green: < 12%, dark green: < 20%, and purple: ≥ 20%. Data: SiStat (n.d.). Accessed: March 2026.

Figure 5 tracks employment by sector in Podravka from 2000 to 2024. The **share of employment in agriculture has continued to fall** since the early 2000s, and **manufacturing has also declined** over the past two decades. By contrast, financial services and wholesale and trade have remained broadly stable. **Among the growing sectors, public administration and defense together with health and social work as well as construction** increased. These gains align with the region's gross value added trends.

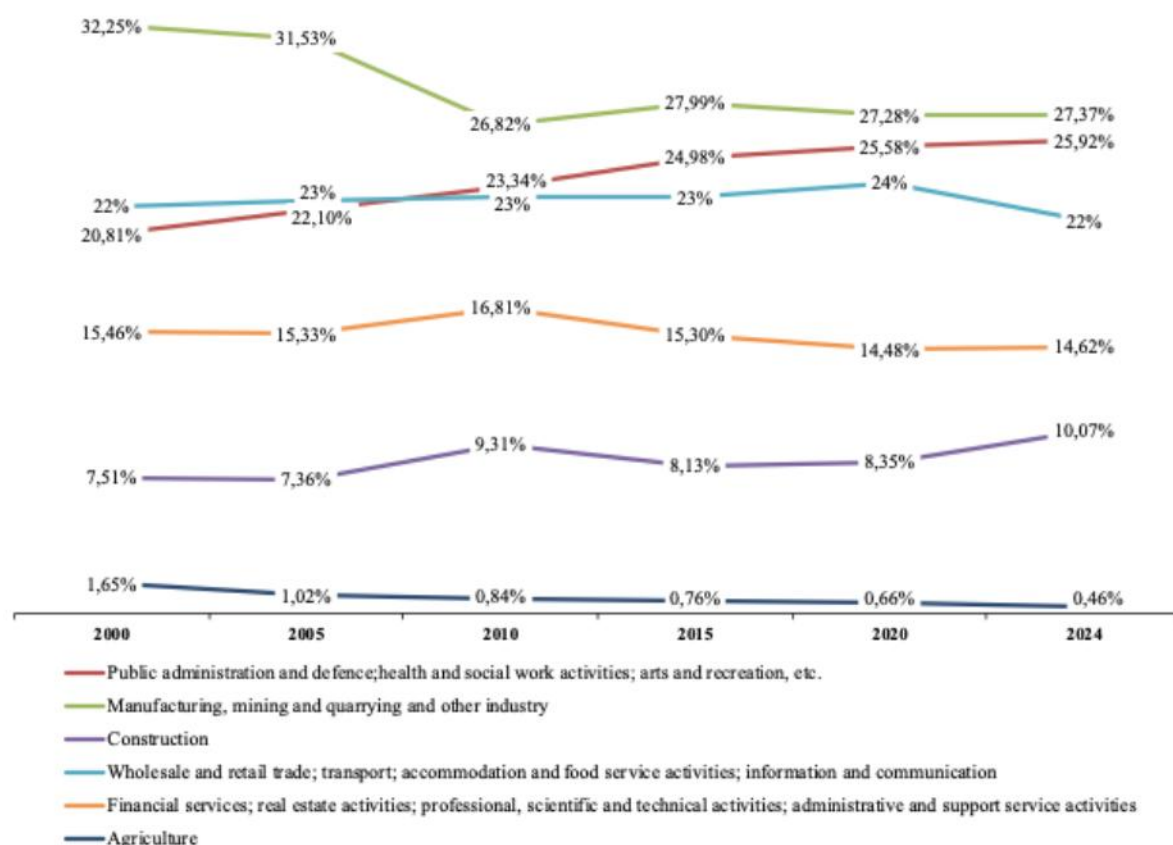


Figure 5: Development of the distribution of employment across economic sectors in Podravka from 2000 to 2024. Data: SiStat (n.d.). Accessed: March 2026.

While manufacturing remains Podravka's largest source of employment and an important contributor to regional gross value added, both manufacturing's share of regional employment and its contribution to GVA have declined since 2000. This could point to an **ongoing structural shift in the regional economy** (SiStat, n.d.), potentially related to decarbonization pressures.

1.2.3 Decarbonization pressures

The **total stock of green-house gas (GHG) emissions** as well as GHG per capita emissions decrease in Eastern Slovenia and in Slovenia since 2014. Table 3 illustrates the sectoral shares contributing to Eastern Slovenia's GHG emissions (2013 and 2022) in comparison to Slovenia and the EU average (Eurostat, 2026b). In Eastern Slovenia, the **energy, industrial and transportation sector are particularly carbon-intensive**, contributing each about 25% to the regional emissions in 2022.

While energy emissions decreased significantly from 2013, industrial and transportation-related emission shares have increased. Shares of waste (2%) and infrastructure-related (7%) emissions remained constant since 2013. Compared to the Slovenian average emissions, agriculture, waste, and infrastructure shares remained similar. The **Eastern Slovenian energy sector, however, is well above the national average** (19% in 2022), whereas contributions from industrial and transportation-related emissions are just below national levels. Compared to the EU-average Eastern Slovenia shows well elevated proportions in transportation and energy-related emissions. Infrastructure and industry emissions are a similar level or just below the EU average (Eurostat, 2025c).

	Eastern Slovenia		Slovenia		EU average	
	2013	2022	2013	2022	2013	2022
Agriculture	11%	13%	10%	11%	10%	11%
Infrastructure	7%	7%	8%	9%	15%	14%
Energy	36%	26%	29%	19%	28%	24%
Industry	22%	25%	24%	28%	24%	25%
Transport	22%	27%	26%	30%	18%	21%
Waste	2%	2%	3%	3%	5%	5%

Table 3: Sectoral contributions to GHG emissions. Data Source: Eurostat (2025c).

Podravska is home to several energy-intensive industries, such as the production of iron, steel and aluminum, construction materials, chemicals, paper, automotive, batteries and waste treatment (RIS4Danu, 2023). As previously discussed, several regions in Slovenia rely more on traditional manufacturing industries than others (in terms of GVA contribution and employment), consequently national and supranational environmental protection laws impact Slovenian regions differently, **resulting in higher adjustment costs in regions with more energy-intensive industries**. Especially non-capital regions are expected to bear larger costs in transitioning to net zero, for example due to **infrastructure gaps (compared to Ljubljana) or faster changes in demography** (OECD, 2026).

1.2.4 Innovation capacities

Lastly, the report takes a closer look at the region's innovation capacities. Transformative innovation for climate adaptation requires a strong enabling environment in which innovations can be conceived, financed, and implemented. According to a recent EU report (European Commission, 2025), Vzhodna Slovenija (NUTS 2), is considered **a moderate innovator**. Importantly, this overview **only outlines traditional economic indicators for innovation**, currently measured with statistical indicators by the European Union. For a more comprehensive understanding of innovation capacities in Podravje, see Chapter 3 of this report.

A detailed analysis of the Applied Innovation Index (see Figure 6) shows that Eastern Slovenia falls at or below the European average across most indicators (European Commission, 2025). Particularly relevant in the context of climate adaptation are the region's **low public-sector R&D expenditure** and the **declining levels of firms' R&D expenditures and Non-R&D innovation expenditures** (compared to 2018) Another cause for concern is the **decrease of collaboration between innovative SMEs** - something that has been consistently brought up as a major weakness of Podravje's innovation system in the interviews (see Chapter 3 of this report).

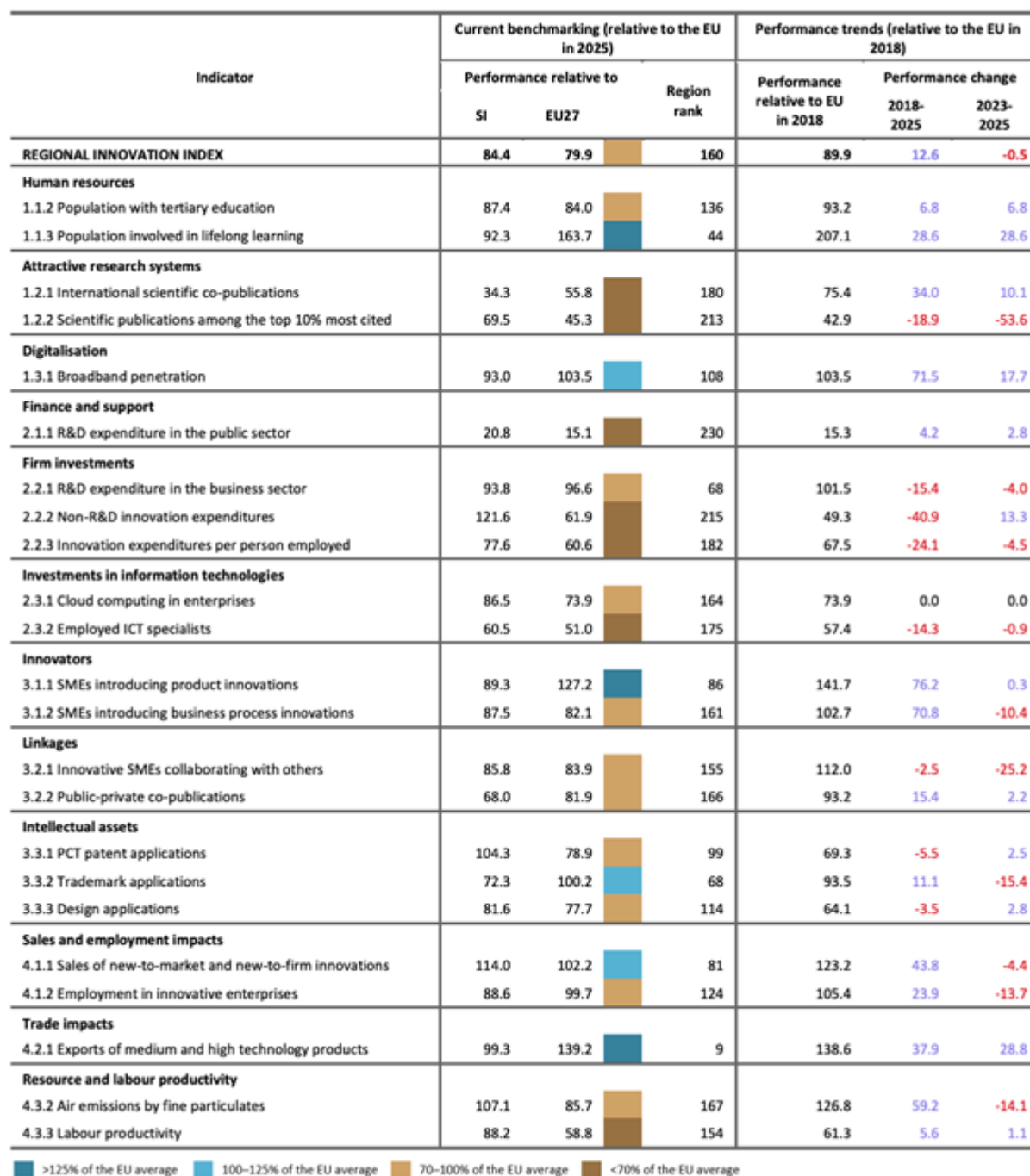


Figure 6: Regional innovation indicators for Vzhodna Slovenija. Source: European Commission (2025).

Zooming out to the national level, several factors help explain these numbers. Osrednjeslovenska is Slovenia's top-spender in R&D expenditure (58,4% in 2023) and hosts most of the country's major universities, research centres, etc., increasing its attractiveness towards foreign investments, and actors (RIS4Danu, 2023). Podravska, despite **hosting the second-largest university** in Slovenia and other relevant research institutes, on the private sector side Podravska does not host advanced technologies departments, but rather branch plants and lower-tier suppliers. As a result, Podravska is locked in low added value activities and is hit hard by an outflow of skilled labourers towards Slovenia's economic centre (RIS4Danu, 2023). According to a recent OECD (2026) report Slovenia faces intensifying regional economic disparities, in result of concentrating its economic activities around Ljubljana.

However, the region also has **several strengths that could be leveraged to support innovative climate adaptation**. Among the strongest increasing indicators since 2018 and representing relative strengths are: **SMEs introducing product innovations** and broadband penetration. **Broadband penetration** facilitates communication with and access to the population during climate-related emergencies - a factor identified as relevant for effective disaster response (Sanders, 2026). Although the indicator “**SMEs introducing business process innovations**” took a slight dip between 2023 and 2025, the overall trend since 2018 is among the strongest increases. This suggests firms’ openness to invest in process improvement that could potentially support the development and uptake of more climate-resilient production processes. Additionally, the region scores high regarding the share of the **population involved in lifelong learning**, which offers opportunities for skills-building and community-led adaptation projects.

1.2.5 Synthesis: Socio-economic risk profile

Overall, Podravska remains Slovenia’s **second-largest economic center** in absolute terms and has shown resilience in recovering from the economic effects of the COVID-19 pandemic. However, compared with Osrednjeslovenska, Podravska experiences **higher unemployment and poverty risks**, and has more **limited research and innovation capacities**. This reflects the broader concentration of high-value activities, investment, and labor in and around the capital region. **Podravska’s economic strengths in manufacturing and energy-intensive industrial activities** are among the sectors most exposed to reaching future climate targets, rising carbon prices, or energy-price volatilities. The regional industrial restructuring in the region is therefore likely to entail adjustment costs, notably firms and workers.

Regarding social vulnerabilities, Podravska has an **ageing population, a shrinking working-age population**, a relatively **high risk of poverty**, and – in the wider region (NUTS2) - comparatively poor housing and energy-affordability conditions. Poor-quality and energy-inefficient housing can intensify vulnerability to climate risks, particularly during heatwaves and intense cold periods, increasing the risk of heat-related illness, energy poverty, or social exclusion. The demographic shift has direct implications for CCA. Older residents are generally more vulnerable to heatwaves, reduced air quality, or disruptions to health and care services due to climate emergencies. Meanwhile, a decreasing working-age population potentially constrains financial, administrative, or labor capacities for implementing adaptation measures, e.g., in health care, emergency response, or municipal services. Similarly, migrations towards the urban areas affect smaller municipalities and rural areas simultaneously - cities by increasing density, rural areas by declining administrative and financial capacities to maintain infrastructure and provide emergency services.

This interacts with increasing **challenges to adapt to the impacts of climate change**. Estimates suggest that 23% of Podravska’s population is expected to be exposed to potentially harmful climate impacts (e.g., river floods, windstorms, water shortage, etc.), on the national level this share lays just under 28%. Compared to the average European regional population (19,61%), Slovenian rates are markedly higher, pointing to an increased vulnerability to climate change impacts (Eurostat, 2025d).

Eastern Slovenia accounts for 70% (i.e., 4555 ha) of Slovenia’s total irrigated surfaces (i.e., 6414 ha), with 2376 ha alone in Podravska (SiStat, n.d.). In this line, drought events may cause substantial damages if no adaptation measures in agriculture are taken (RIS4Danu, 2023), posing a threat to the regional agricultural sector, which contributes slightly above national average to Podravska’s GRP (SiStat, n.d.; Ris4Danu, 2023). Similarly, sewage overflow due to heavy rain events may cause serious damage. Podravska has the longest sewage system in Slovenia, accounting for 30% of the Slovenian total length (SiStat, n.d.). To decrease vulnerability, investing in adaptation measures, e.g., for river regulation in prevention of flooding, becomes inevitable in affected areas. As of now, Podravska allocated only **around**

0.2% of its regional GDP to gross fixed capital formation for **environmental protection**² in 2024, substantially below the Slovenian average of approximately 0.5%, **placing it among the regions with the lowest relative levels of environmental-protection investment in Slovenia** (SiStat, n.d.).

Given the intersection climate change mitigation challenges (driven by industrial decarbonization pressures), social inequalities and climate challenges, adaptation measures should not be treated as stand-alone environmental investments, but as part of a broader strategy paying attention to climate mitigation and regional development.

2 Regional risks to climate change

Risk assessments are critical for understanding the potential impacts of natural hazards and climate extremes to people and their (built) environment. The United Nations office for Disaster Risk Reduction (UNDRR, 2009) defines risk as a function of three key components, namely hazard, exposure, and vulnerability. Here, **hazard** refers to a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, destruction or degradation of infrastructure, or social and economic disruption or environmental degradation. These hazards can be natural, such as floods and earthquakes, or human-made, such as industrial accidents and cyber-attacks. The remainder of this document will focus on natural hazards. Secondly, **exposure** refers to the presence of people, assets, or critical infrastructure (CI) in areas that are prone to natural hazards, such as floods, earthquakes, tropical cyclones. Lastly, **vulnerability** refers the characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard, which is the result of the range of economic, social, cultural, institutional, political and psychological factors that shape people's lives and the environment they live in.

The risk framework is applied to assess the potential impacts of natural hazards and climate change in the Podravje region using spatial analysis. Such an assessment requires geospatial information on the extent and severity of natural hazards, including historical hazard data or information on the statistical likelihood of occurrence. The spatial extent of a hazard is overlaid with data on population distribution, land use, or infrastructure to assess exposure. For drought and landslides, our analysis focuses primarily on exposure, whereas for flooding and extreme heat, exposure is complemented with information on social vulnerability through the Social Vulnerability Index (SoVI), which is used to identify population groups that may be more susceptible to adverse impacts.

2.1 Flooding

2.1.1 Flooding in Podravje region

Flooding can occur through several mechanisms, including pluvial (surface), fluvial (river), and coastal flooding. Historical flood events were examined using the HANZE dataset (Paprotny, 2025). Figure 7 presents flood events recorded between 1870 and March 2025, covering the different flood types and their underlying causes. The HANZE historical flood records for Podravje indicate that river floods dominate the documented events, with 14 recorded occurrences compared with four flash floods. River flooding is primarily associated with heavy rainfall, which accounts for ten events, while several additional events are linked to particularly intense rainfall episodes, including totals exceeding 200 mm within 12 hours and up to 539 mm over three days. Flash floods are instead associated with extreme rainfall, including events with very high short-duration precipitation intensities, such as up to 141 mm within one hour.

² Even though this indicator does not specifically target adaptation, some areas intersect, including wastewater management or protection of green spaces.

Overall, the historical record highlights intense and prolonged rainfall as the principal reported trigger of flooding in the region, while differences between river and flash floods reflect variations in rainfall characteristics and flood response. The remainder of this section focuses on fluvial flooding, defined here as flooding that occurs when rivers exceed their channel capacity and overflow into surrounding areas, due to constraints in the availability of consistent hazard data for other flood types.

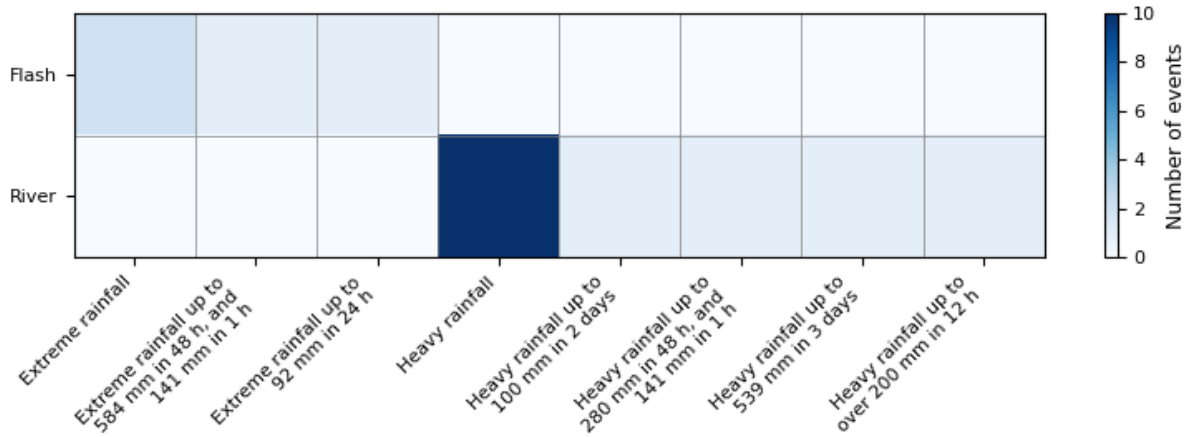


Figure 7: Historical flood events affecting Podravje, categorized by flood type and reported cause, based on the HANZE dataset for the period 1870-2025.

The figure summarizes the number of recorded river and flash flood events associated with different rainfall-related triggers and provides an overview of the dominant historical flood-generating processes in the region.

2.1.2 Exposed population to fluvial flooding

For the fluvial flood exposure analysis, the 1-in-100-year flood event was selected as a representative high-impact scenario that is commonly used in flood-risk assessment and planning (see Appendix 8.1 for hazard information). Such an event corresponds to an annual exceedance probability of 1%, meaning that a flood of this magnitude or greater has a 1% chance of occurring in any given year. Across Podravje, 167 settlements (24.6%) show some degree of population exposure to this flood scenario (Figure 8). In total, an estimated 11,224 residents are exposed, corresponding to 3.4% of the regional population. The highest absolute exposed populations are found in Maribor, Ptuj, and Spodnji Duplek, with approximately 2,652, 1,367, and 409 exposed residents, respectively. In relative terms, the highest exposure occurs in Sturmovci, Skorba, and Popovci, where an estimated 49.3%, 42.4%, and 42.4% of the settlement population is exposed.

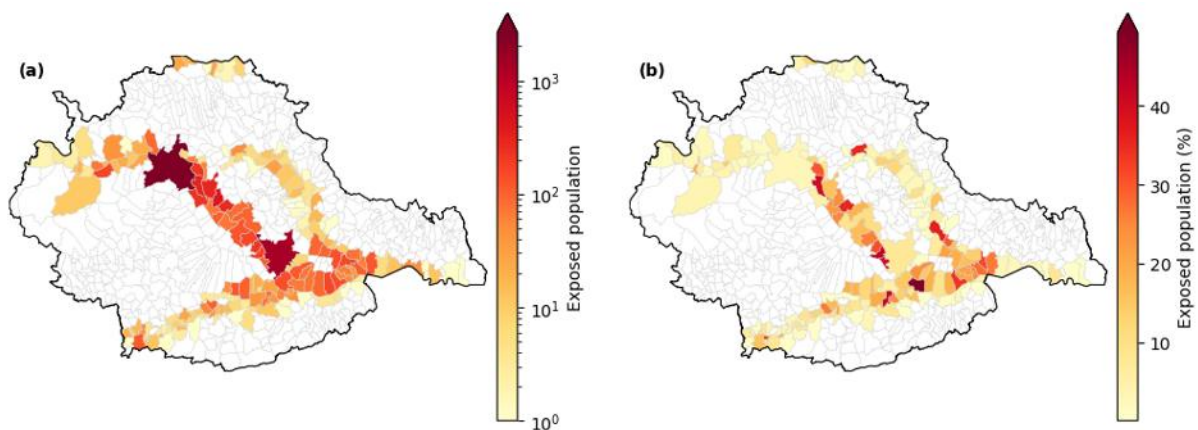


Figure 8: Settlement-level population exposure to the 1-in-100-year fluvial flood in Podravje.

Panel (a) shows the estimated absolute number of exposed residents per settlement, while panel (b) shows the exposed population as a percentage of the total settlement population. Settlements with no estimated exposure are shown in white.

The distribution of exposed population varies considerably across inundation-depth classes. The largest share of exposed residents is found in the 2-5 m class, which accounts for 3,470 people or 30.9% of the total exposed population, followed by the 1-2 m class with 2,712 people (24.2%). Together, inundation depths above 1 m account for more than half of the total exposed population. The settlements with the highest absolute exposure are generally the larger settlements, particularly Maribor and Ptuj, which appear repeatedly among the five most exposed settlements across several depth classes. However, the spatial pattern differs when exposure is considered relative to settlement population. Smaller settlements such as Popovci, Šturmovci, Zabovci, and Skorba show some of the highest relative exposure, indicating that a substantial share of their residents could be affected even where the absolute number of exposed people is comparatively low.

Inundation depth	Exposed population in Podravje	Share of exposed population in Podravje	Settlements with highest absolute exposure	Settlements with highest relative exposure
0-0.5 m	1,741	15.50%	Maribor (189); Ptuj (169); Gorišnica (107); Spodnji Duplek (75); Lovrenc na Dravskem polju (64)	Popovci (19.8%); Mostje (18.3%); Trnovec (13.3%); Formin (11.5%); Gorišnica (11.4%)
>0.5-1 m	1,861	16.60%	Maribor (231); Ptuj (139); Spodnji Duplek (113); Miklavž na Dravskem polju (84); Dvorjane (55)	Šturmovci (17.5%); Mostje (15.1%); Osluševci (14.3%); Gajevci (12.3%); Podboč (10.8%)
>1-2 m	2,712	24.20%	Ptuj (460); Maribor (371); Spodnji Duplek (153); Dvorjane (121); Zabovci (111)	Zabovci (22.9%); Šturmovci (19.8%); Podboč (16.9%); Dvorjane (16.2%); Spodnja Hajdina (13.6%)
>2-5 m	3,471	30.90%	Maribor (1,106); Ptuj (582); Skorba (138); Dogoše (136); Zrkovci (126)	Skorba (33.0%); Zrkovci (17.7%); Dogoše (17.2%); Spodnja Hajdina (15.9%); Hajdoše (12.9%)
>5 m	1,439	12.80%	Maribor (755); Ruše (85); Kamnica (68); Zgornji Duplek (54); Zrkovci (40)	Fala (13.7%); Malečnik (6.8%); Loka (6.6%); Nova vas pri Markovcih (6.0%); Zrkovci (5.6%)

Table 4: Population exposure to the 1-in-100-year fluvial flood in Podravje by inundation-depth class. Including the total and relative share of exposed population and the five settlements with the highest absolute and relative exposure within each depth class.

2.1.3. Social Vulnerability Index

The Social Vulnerability Index (SoVI) was developed to represent spatial variation in social vulnerability across Podravje based on five demographic and socioeconomic indicators: the proportion of elderly residents, the proportion of children, low educational attainment, unemployment, and median net earnings. The indicators were normalized, oriented so that higher values correspond to greater vulnerability, and combined using the assigned weights. Full details on indicator selection, normalization, weighting, and sensitivity testing are provided in Appendix 8.2.1. Figure 9 presents the SoVI and the dominant contributing indicator for settlements exposed to the 1-in-100-year fluvial flood.

Figure 9a shows that Zamarkova, Zgornje Poljčane, and Srednje are among the exposed settlements with the highest SoVI values, reaching 0.61, 0.59, and 0.57, respectively. However, their absolute population exposure is relatively limited, with approximately 51, 116, and 8 exposed residents. This illustrates that high social vulnerability does not necessarily coincide with high absolute population exposure. Figure 9b further shows that the dominant contributors to social vulnerability differ spatially across the exposed settlements. Low earnings are the most frequently dominant indicator, accounting for 61 settlements (36.5%), followed by the proportion of elderly residents in 44 settlements (26.3%) and low educational attainment in 37 settlements (22.2%). Unemployment is dominant in 23 settlements (13.8%), while the proportion of children is dominant in only two settlements (1.2%). These results highlight that the underlying drivers of social vulnerability vary considerably among flood-exposed

settlements and are most commonly associated with economic capacity, ageing, and educational attainment.

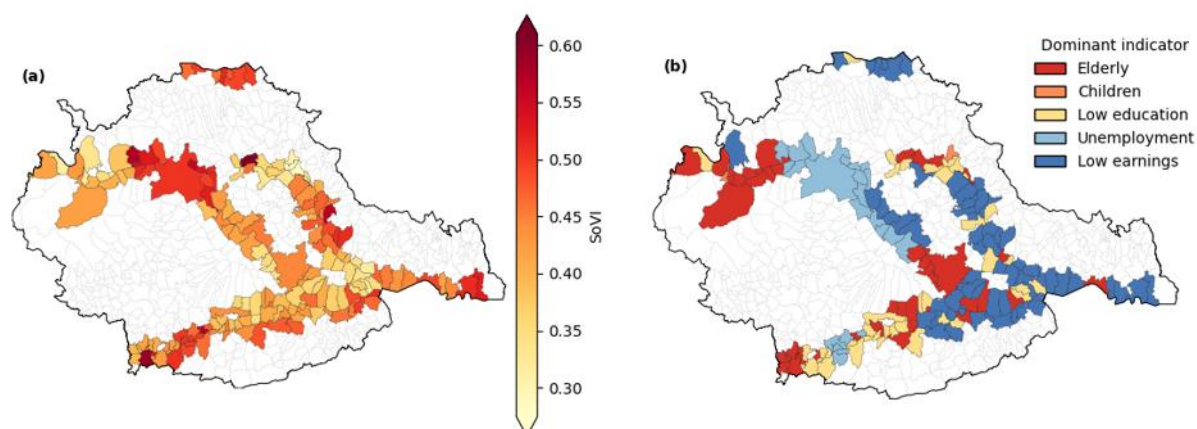


Figure 9: Settlement-level Social Vulnerability Index (SoVI) and dominant contributing indicator for flood-exposed settlements in Podravje.

Panel (a) shows SoVI, whereas panel (b) shows the indicator with the largest contribution to the SoVI in each exposed settlement.

The relationship between social vulnerability and inundation depth is further illustrated in Figure 10. For interpretation, SoVI values were grouped into five equal-width classes across the normalized 0-1 scale, ranging from class 1 (lowest) to class 5 (highest social vulnerability). Equal intervals were used rather than quantiles to avoid forcing an equal number of observations into each class. Most of the exposed population falls within SoVI class 3 across all inundation-depth categories, accounting for approximately 71.1% of the total exposed population, while 28.5% falls within class 2 and only 0.5% within class 4. The dominance of class 3 becomes more pronounced with increasing inundation depth, accounting for 52.7% of exposed residents at depths of 0-0.5 m, 69.0% at 1-2 m, 80.6% at 2-5 m, and 90.7% at depths exceeding 5 m. Conversely, the share of exposed population in class 2 decreases with increasing inundation depth. No exposed population falls within classes 1 or 5.

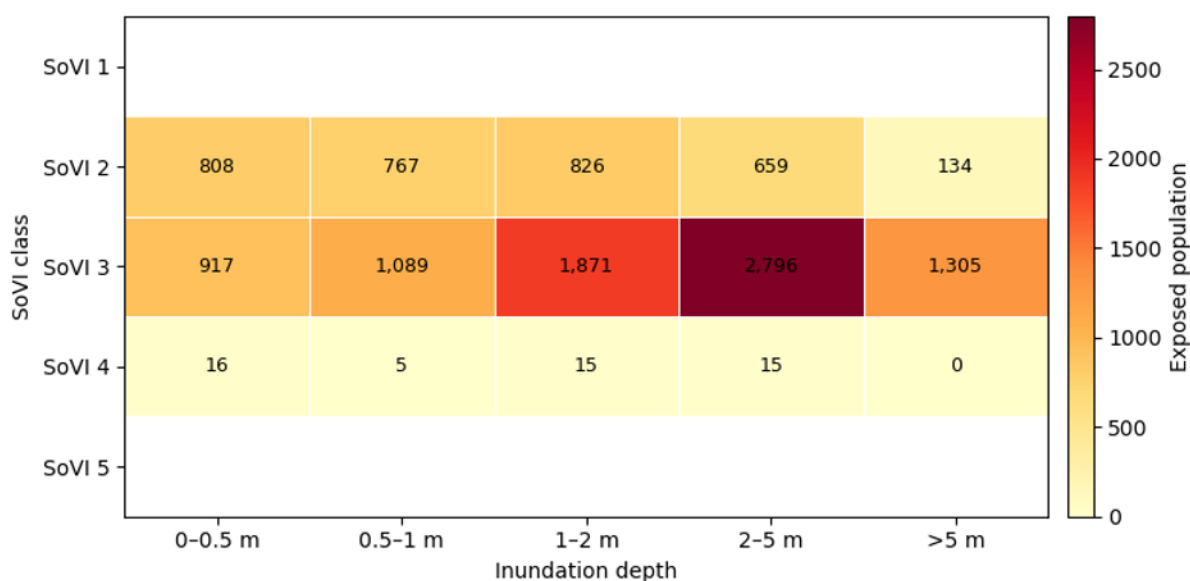


Figure 10: Distribution of flood-exposed population across Social Vulnerability Index (SoVI) classes and inundation-depth categories for the 1-in-100-year fluvial flood in Podravje.

Cell values indicate the estimated number of exposed residents in each combination of SoVI class and inundation depth. SoVI classes are based on equal-width intervals across the normalized 0-1 scale: class 1 = 0.00-0.20, class 2 = >0.20-0.40,

class 3 = >0.40–0.60, class 4 = >0.60–0.80, and class 5 = >0.80–1.00, ranging from lowest to highest social vulnerability. Blank cells indicate that no exposed population falls within the corresponding SoVI class.

2.2 Extreme heat

2.2.1 Extreme heat in Podravje region

Extreme heat represents an important climate-related hazard in the Podravje region, with potential implications for population well-being, infrastructure, and overall regional resilience. To characterize changes in extreme heat, three complementary temperature indicators were analyzed for the period 1990–2025 (Appendix 8.3). The annual number of days with daily maximum temperature above the 95th-percentile threshold (TX95p_days) was used to represent the frequency of unusually hot conditions, while TXx captures heat intensity through the annual maximum of daily maximum temperature. In addition, the annual number of tropical nights (TR), defined as nights with minimum temperature above 20°C, was used to represent persistent nighttime heat. Together, these indicators provide a broader picture of extreme-heat conditions by capturing their frequency, intensity, and nighttime persistence across Podravje.

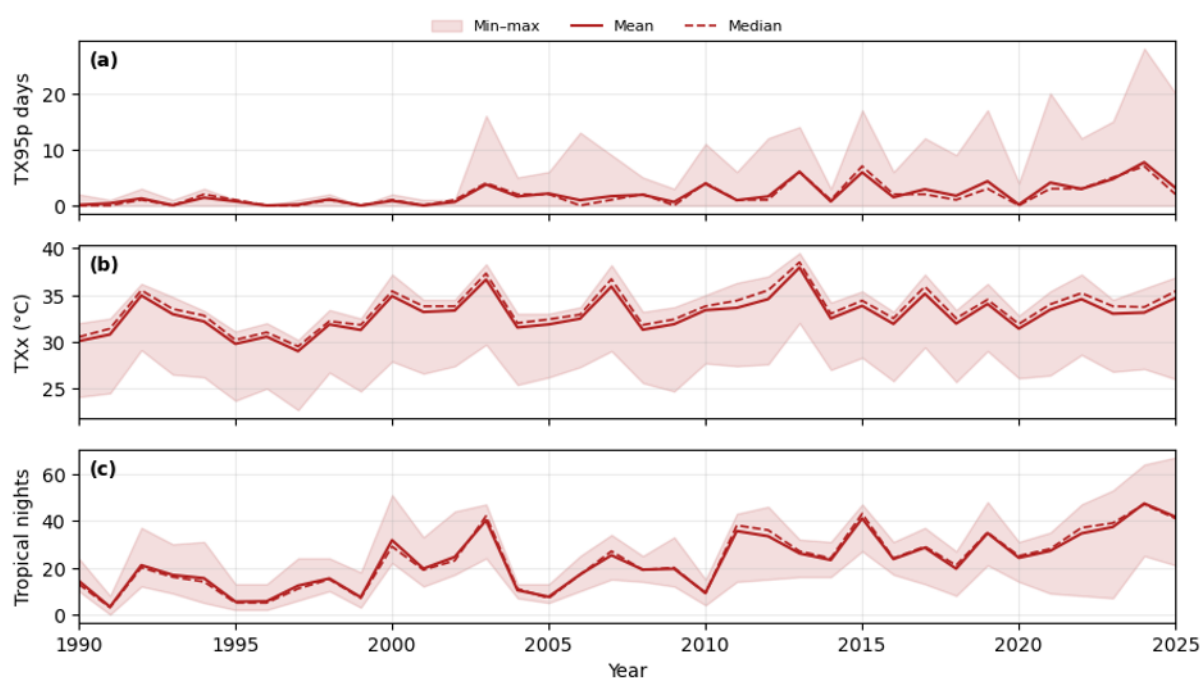


Figure 11: Annual variation in extreme-heat indicators across Podravje from 1990 to 2025, derived from the EMO-1 dataset. Panel (a) shows the annual number of days with daily maximum temperature exceeding the 95th-percentile threshold (TX95p_days), panel (b) shows the annual maximum value of daily maximum temperature (TXx), and panel (c) shows the annual number of tropical nights (TR), defined as nights with minimum temperature above 20°C. Solid and dashed lines represent the spatial mean and median across Podravje, respectively, while the shaded area indicates the annual minimum-to-maximum range across the region.

Extreme-heat conditions in Podravje show a clear increase over the 1990–2025 period across all three indicators (Figure 11). The regional mean number of days exceeding the 95th-percentile threshold (TX95p_days) increased from 0.5 days per year during 1990–1999 to 3.3 days during 2016–2025, corresponding to a significant linear trend of +1.18 days per decade ($p < 0.001$). The highest regional mean occurred in 2024, with 7.7 days. Annual maximum temperature (TXx) also increased, from an average of 31.3°C in the first decade to 33.3°C in the most recent decade, with a significant trend of +0.69°C per decade ($p = 0.024$); the highest regional mean TXx of 37.9°C occurred in 2013. The strongest change is observed for tropical nights, which increased from an average of 11.7 nights per year during 1990–1999 to 31.9 during 2016–2025, representing an increase of approximately 20 nights and a significant trend

of +7.58 nights per decade ($p < 0.001$). The annual regional mean peaked at 47.3 tropical nights in 2024. Mean and median values are generally similar across the time series, with average absolute differences of only 0.41 days for TX95p_days, 0.57°C for TXx, and 1.02 days for tropical nights. This indicates that the regional central tendency is relatively consistent regardless of whether the spatial mean or median is used. At the same time, the annual minimum-maximum ranges reveal considerable spatial variability within Podravje, with maximum differences between locations reaching 28 days for TX95p_days, 10.9°C for TXx, and 46 days for tropical nights in individual years.

Figure 12 presents the spatial distribution of mean annual extreme-heat indicators across the Podravje region, revealing clear contrasts among the three indicators. For 2016-2025, the mean annual number of TX95p days across municipalities was 3.41 days, ranging from 0.97 days in Oplotnica to 10.16 days in Kungota. The highest values were concentrated in northern municipalities, including Kungota, Šentilj, Sveta Ana, Pesnica, and Benedikt. Tropical nights show a distinctly different spatial pattern, with a municipal mean of 31.59 nights per year and values ranging from 20.69 nights in Sveta Ana to 37.18 nights in Ormož. The highest frequencies occurred in Ormož, Središče ob Dravi, and Sveti Tomaž, whereas several northern municipalities recorded comparatively fewer tropical nights. TXx shows a different spatial distribution again. The municipal mean annual maximum temperature was 33.63°C, ranging from 30.18°C in Lovrenc na Pohorju to 34.60°C in Središče ob Dravi. The highest mean annual maximum temperatures were found in Središče ob Dravi, Gorišnica, Markovci, Hajdina, and Starše, while lower values occurred primarily in the western part of the region. Overall, these contrasting spatial patterns indicate that municipalities experiencing the most frequent locally unusual daytime heat are not necessarily those experiencing the highest absolute temperatures or the greatest frequency of tropical nights.

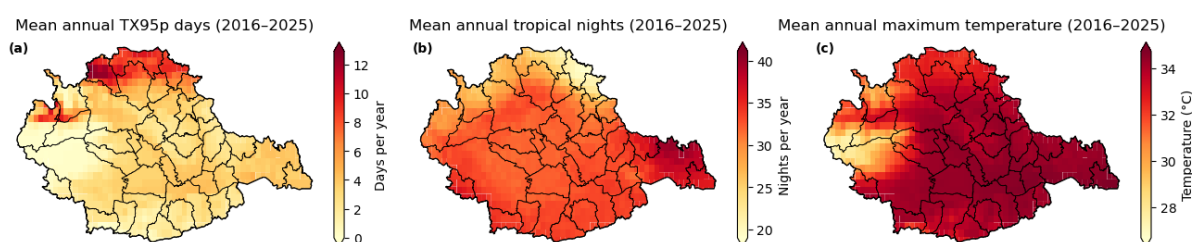


Figure 12: Spatial distribution of mean annual extreme-heat indicators across Podravje for the period 2016-2025, derived from the EMO-1 dataset.

Panel (a) shows the mean annual number of days with daily maximum temperature exceeding the 95th-percentile threshold (TX95p_days), panel (b) shows the mean annual number of tropical nights (TR; minimum temperature >20°C), and panel (c) shows the mean annual maximum daily maximum temperature (TXx). Municipal boundaries are shown as solid black lines.

2.2.2 Exposed population to tropical nights

For the population exposure analysis, tropical nights were selected as the primary heat indicator because they are defined using a fixed and readily interpretable threshold of minimum temperature above 20°C, allowing direct comparison across the region. Unlike percentile-based indicators, tropical nights provide an absolute measure of persistent nighttime heat. Elevated nighttime temperatures can limit physiological recovery from daytime heat stress and are associated with increased heat-related health risks, particularly among vulnerable groups such as older adults, young children, and people with pre-existing health conditions. They can also impair sleep quality, further increasing the impacts of prolonged heat events.

Across the Podravje region, exposure to frequent tropical nights is widespread. An estimated 303,518 residents, corresponding to 91.5% of the regional population, live in areas experiencing more than 30 tropical nights per year on average during 2016-2025. Most of this population falls within the >30-35 nights per year class, accounting for 288,902 residents (87.1%), while 14,616 residents (4.4%) are exposed to more than 35 tropical nights per year.

Exposure to lower frequencies is comparatively limited, with 18,904 residents (5.7%) exposed to >25-30 nights per year and 9,393 residents (2.8%) to 15-25 nights per year; no population falls within the <15 nights per year class.

Figure 13 illustrates how this exposure varies across municipalities, both in relative and absolute terms. The highest relative exposure to more than 35 tropical nights per year occurs in Središče ob Dravi, where the entire population falls within this class, followed by Ormož (81.3%) and Sveti Tomaž (79.5%). Several municipalities, including Oplotnica, Cirkulane, Destrižnik, Dornava, and Duplek, have their entire population exposed to more than 30 tropical nights per year. In absolute terms, the largest exposed populations occur in the most populous municipalities, led by Maribor with approximately 114,301 residents, followed by Slovenska Bistrica (26,265), Ptuj (23,920), Hoče-Slivnica (11,913), and Ormož (11,849).

Figure 13 shows how tropical-night exposure varies across municipalities in both relative and absolute terms. The highest relative exposure to more than 35 tropical nights per year occurs in Središče ob Dravi, where the entire population falls within this class, followed by Ormož (81.3%) and Sveti Tomaž (79.5%). More than half of the municipalities (21 of 41) are entirely exposed to >30-35 tropical nights per year. In absolute terms, the largest exposed populations occur in the most populous municipalities, with Maribor accounting for approximately 114,301 residents, followed by Slovenska Bistrica (26,265), Ptuj (23,920), Hoče-Slivnica (11,913), and Ormož (11,849).

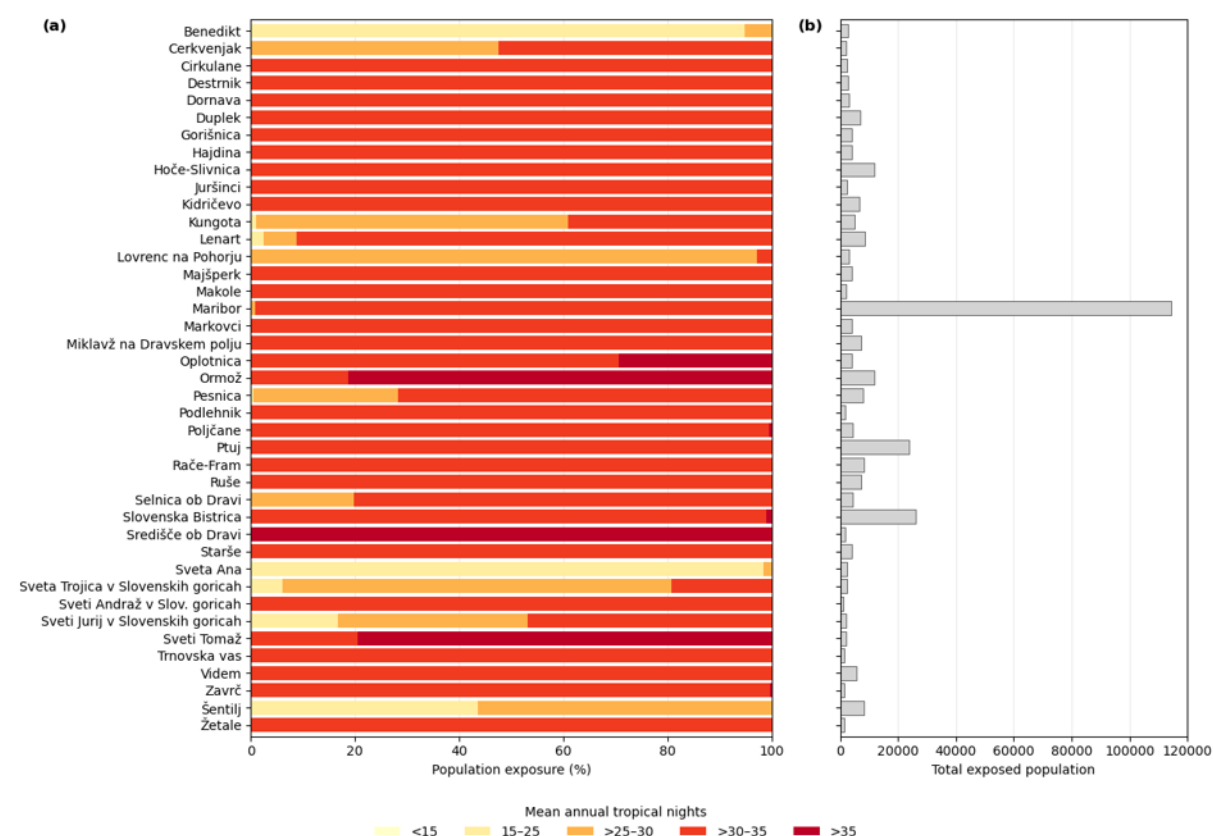


Figure 13: Municipal-level population exposure to mean annual tropical-night frequency in Podravje for the period 2016-2025.

Panel (a) shows the percentage distribution of each municipality's exposed population across five tropical-night frequency ranges: <15, 15-25, >25-30, >30-35, and >35 nights per year. Panel (b) shows the total exposed population per municipality. Because the tropical-night hazard layer covers the entire study area, the total exposed population corresponds to the total municipal population.

2.2.3 Social Vulnerability Index

At settlement level, social vulnerability in Podravje is concentrated mainly in the middle range of the SoVI distribution (Figure 14a). A total of 413 settlements (60.8%) have SoVI values between >0.40 and 0.60 , while 262 settlements (38.6%) fall between >0.20 and 0.40 . Only three settlements (0.4%) have values between >0.60 and 0.80 , and one settlement (0.1%) falls within the $0-0.20$ range. No settlements have SoVI values above 0.80 . The highest SoVI values occur in Sejanči (0.641), Juršinci (0.633), and Zamarkova (0.610), for which the elderly population is the dominant contributor to social vulnerability (Figure 14b). Other settlements with relatively high SoVI values show different dominant contributors, including unemployment in Zgornji Slemen - del and Srednje, and low education in Paradiž and Zgornje Dobrenje. At the lower end of the distribution, Požeg has the lowest SoVI (0.195), followed by Cezlak (0.215) and Morje (0.231). Overall, the results indicate that intermediate levels of social vulnerability are widespread across Podravje, whereas the highest SoVI values are concentrated in only a small number of settlements.

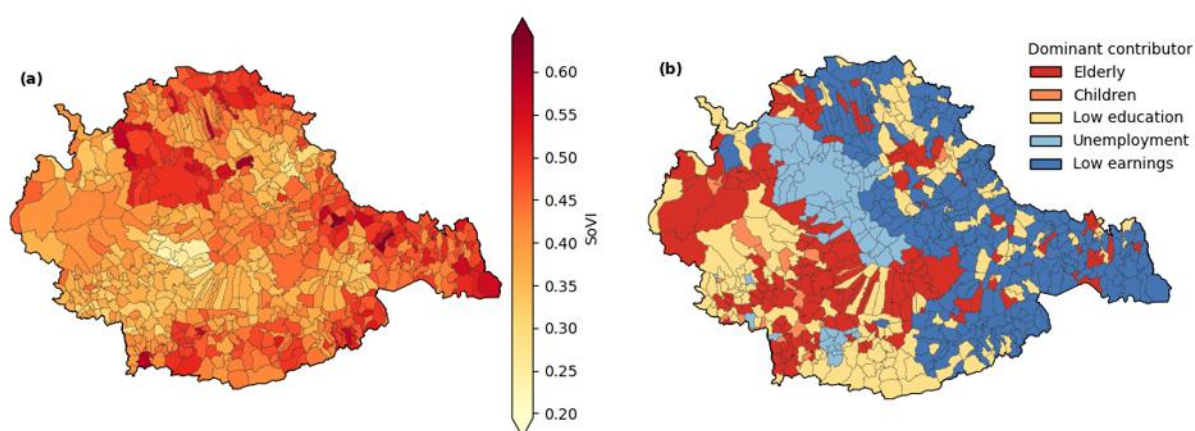


Figure 14: Settlement-level Social Vulnerability Index (SoVI) and dominant contributing indicator for tropical night-exposed settlements in Podravje.

Panel (a) shows SoVI, whereas panel (b) shows the indicator with the largest contribution to the SoVI in each exposed settlement.

The distribution of population across tropical-night exposure and SoVI categories shows that most heat-exposed residents live in settlements with intermediate social vulnerability. No population is exposed to fewer than 15 tropical nights per year. Among residents exposed to 15-25 tropical nights annually, 79.5% live in settlements with SoVI values between >0.40 and 0.60 , while 20.5% fall within the $>0.20-0.40$ range. For exposure to $>25-30$ tropical nights, these shares are 58.4% and 41.6%, respectively. The largest population group occurs in the $>30-35$ tropical nights category, comprising approximately 288,902 residents; of these, 66.5% live in settlements with SoVI values between >0.40 and 0.60 and 33.2% in settlements with values between >0.20 and 0.40 . Among the 14,616 residents exposed to more than 35 tropical nights per year, 88.9% live in settlements with SoVI values between >0.40 and 0.60 , while 10.9% live in settlements with values between >0.20 and 0.40 . Only a very small proportion of residents exposed to more than 30 tropical nights live in settlements with SoVI values above

0.60, indicating that high nighttime-heat exposure in Podravje is concentrated predominantly among populations living in settlements with intermediate levels of social vulnerability.

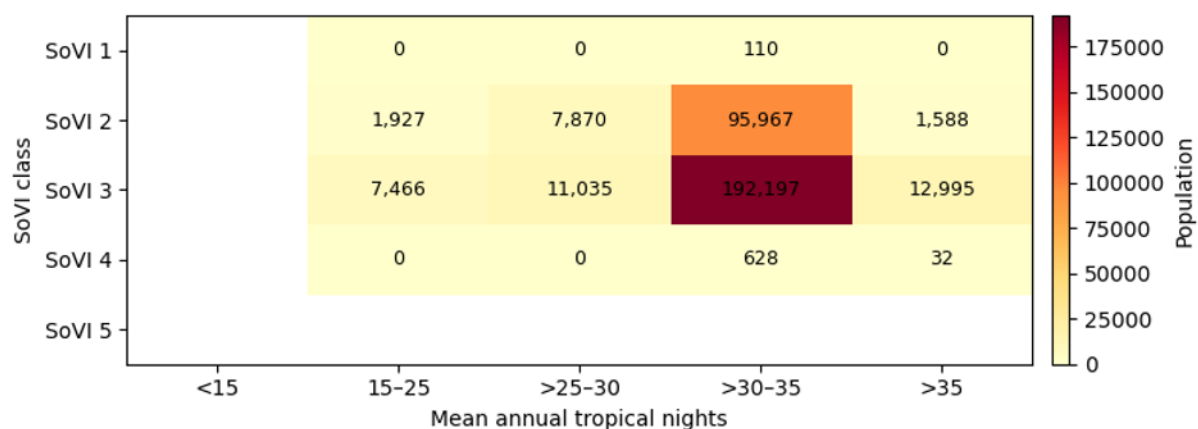


Figure 15: Distribution of the exposed population across Social Vulnerability Index (SoVI) classes and mean annual tropical-night frequency classes in Podravje for the period 2016-2025.

Cell values indicate the number of residents in each combination of SoVI class and tropical-night exposure class. SoVI classes are based on equal-width intervals across the normalized 0-1 scale: class 1 = 0.00-0.20, class 2 = >0.20-0.40, class 3 = >0.40-0.60, class 4 = >0.60-0.80, and class 5 = >0.80-1.00, ranging from lowest to highest social vulnerability.

Across the Podravje region, exposure to frequent tropical nights is substantial across all population groups considered. Among residents exposed to 15-25 tropical nights per year, an estimated 1,860 elderly residents and 1,394 children are exposed, corresponding to 19.8% and 14.8% of the population in this exposure class, respectively. These proportions increase for elderly residents at higher heat levels, reaching 22.9% in the >30-35 nights class and 24.5% among those exposed to more than 35 tropical nights per year, while the share of children decreases slightly from 14.8% to 12.8%. Overall, 69,670 elderly residents and 40,624 children are exposed to more than 30 tropical nights per year, representing 23.0% and 13.4% of the population in this exposure range. Social vulnerability is also pronounced within the most heat-exposed groups: 205,852 residents exposed to more than 30 tropical nights per year, or 67.8% of this population, live in settlements with SoVI values above 0.40. This share rises to 89.1% among residents exposed to more than 35 tropical nights per year.

Tropical nights	Population	Elderly	Elderly (%)	Children	Children (%)	Population SoVI >0.40	Population SoVI >0.40 (%)
15-25	9393	1860	19.8	1394	14.8	7466	79.5
>25-30	18904	4146	21.9	2621	13.9	11035	58.4
>30-35	288902	66089	22.9	38752	13.4	192825	66.7
>35	14616	3581	24.5	1872	12.8	13028	89.1
>30 total	303518	69670	23	40624	13.4	205852	67.8

Table 5: Population exposure to mean annual tropical-night frequency classes in Podravje for the period 2016-2025, including the estimated number and share of elderly residents and children exposed, as well as the population living in settlements with SoVI values above 0.40. Estimates of elderly and child exposure are based on the demographic composition of the underlying population units.

2.3 Drought

2.3.1 Drought in Podravje region

Drought is a complex hazard that can be expressed through different components of the hydrological cycle, including meteorological, agricultural, hydrological, and socioeconomic drought (Van Loon, 2015). In this study, the analysis focuses specifically on meteorological drought, referring to periods of anomalously low precipitation, potentially compounded by increased atmospheric evaporative demand. Meteorological drought is commonly characterized using standardized drought indices that allow dry conditions to be compared across locations and time periods. Meteorological drought conditions in Podravje were assessed using annual drought severity derived from the 3-month Standardized Precipitation Index (SPI3) and Standardized Precipitation Evapotranspiration Index (SPEI3). SPI3 characterizes precipitation deficits over a three-month period, while SPEI3 additionally accounts for potential evapotranspiration.

Annual drought severity indicates moderate or more severe drought conditions for each year, which was computed by summing the absolute values of monthly SPI3 or SPEI3 values below -1 . The indicator therefore captures both the intensity and persistence of drought conditions: higher annual drought severity can result from more severe drought conditions, a greater number of drought-affected months, or a combination of both. Figure 16 shows the temporal evolution of meteorological drought in Podravje between 1990 and 2025. SPI3- and SPEI3-based drought severity generally follow a similar temporal pattern, although differences occur in individual years (Figure 16a). For example, SPI3 indicates higher drought severity in 1992, whereas SPEI3 is higher in 2022. The highest median annual drought severity occurred in 2011, reaching 8.98 for SPI3 and 9.14 for SPEI3. The close agreement between SPI3 and SPEI3 suggests that precipitation deficits were the dominant driver of drought variability in most years, while the differences between the two indices indicate years in which evaporative demand may have intensified the drought signal. Drought severity was particularly high in 2011 and 2022. In 2011, maximum local drought severity reached 18.9 for SPI3 and 16.3 for SPEI3, while in 2022 the corresponding maxima were 12.8 and 14.8. Figure 16b shows the spatial extent of meteorological drought across Podravje. In general, years with higher annual drought severity also show a larger affected area, indicating that the most severe drought years were typically widespread rather than spatially confined. Over the 36-year record, the entire Podravje region experienced meteorological drought in approximately 39% of the recorded years according to SPI3 and 42% of years according to SPEI3.

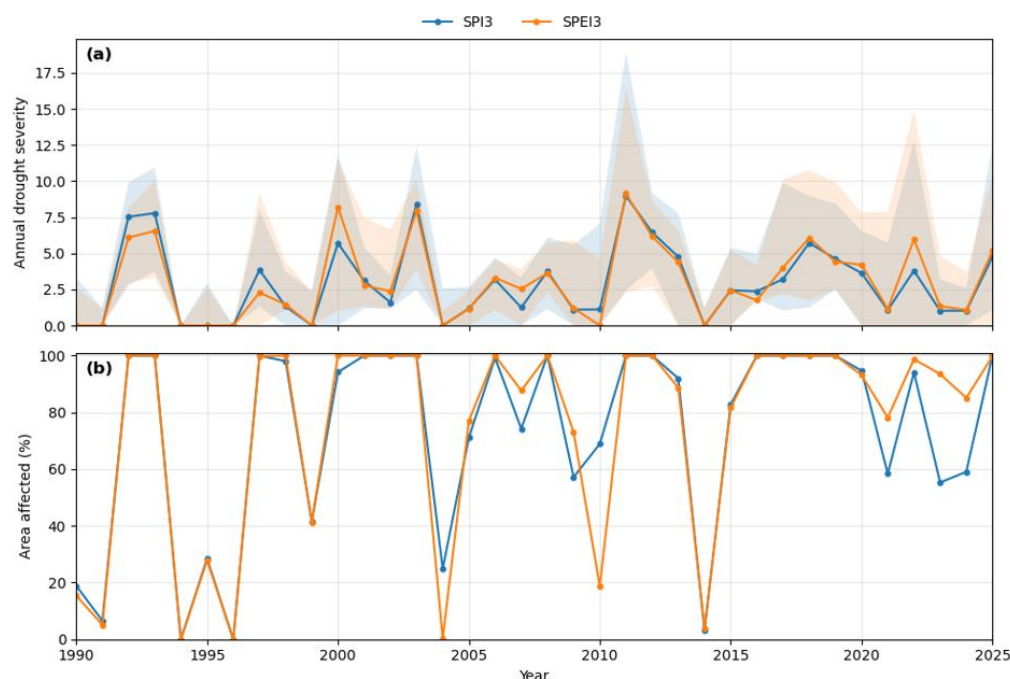


Figure 16: Temporal evolution of meteorological drought in Podravje between 1990 and 2025 based on EMO-1. Panel (a) shows the median annual drought severity derived from SPI3 and SPEI3, together with the spatial minimum and maximum annual drought severity across the region. Panel (b) shows the percentage of the Podravje region experiencing at least one month with SPI3 or SPEI3 below -1 .

Figure 17 illustrates the spatial variation in meteorological drought characteristics across Podravje between 1990 and 2025. Median annual SPEI3 drought severity ranges from approximately 1.2 to 3.5, with the lowest values occurring predominantly in the northern part of the region (Figura xa). Drought frequency is highest in central Podravje and generally lower in the north, indicating that drought conditions occurred more regularly in the central municipalities (Figure 17b). However, a higher drought frequency does not necessarily correspond to greater drought severity. This is particularly evident in Starše and Duplek, where drought occurred in approximately 77.8% and 76.5% of the observed years, respectively, despite both municipalities having among the lowest municipality-averaged maximum drought severity values (8.3 in Starše and 8.4 in Duplek). This suggests that drought conditions in these municipalities were relatively frequent but generally less severe and/or covered a short timespan. The spatial pattern of cumulative drought severity differs from that of drought frequency, with the highest cumulative drought severity observed in southern Podravje, Podlehnik municipality in particular, and lower cumulative drought severity toward the northeastern part of Podravje. These contrasting patterns highlight that areas experiencing drought most frequently are not necessarily those accumulating the greatest drought severity over 1990-2025.

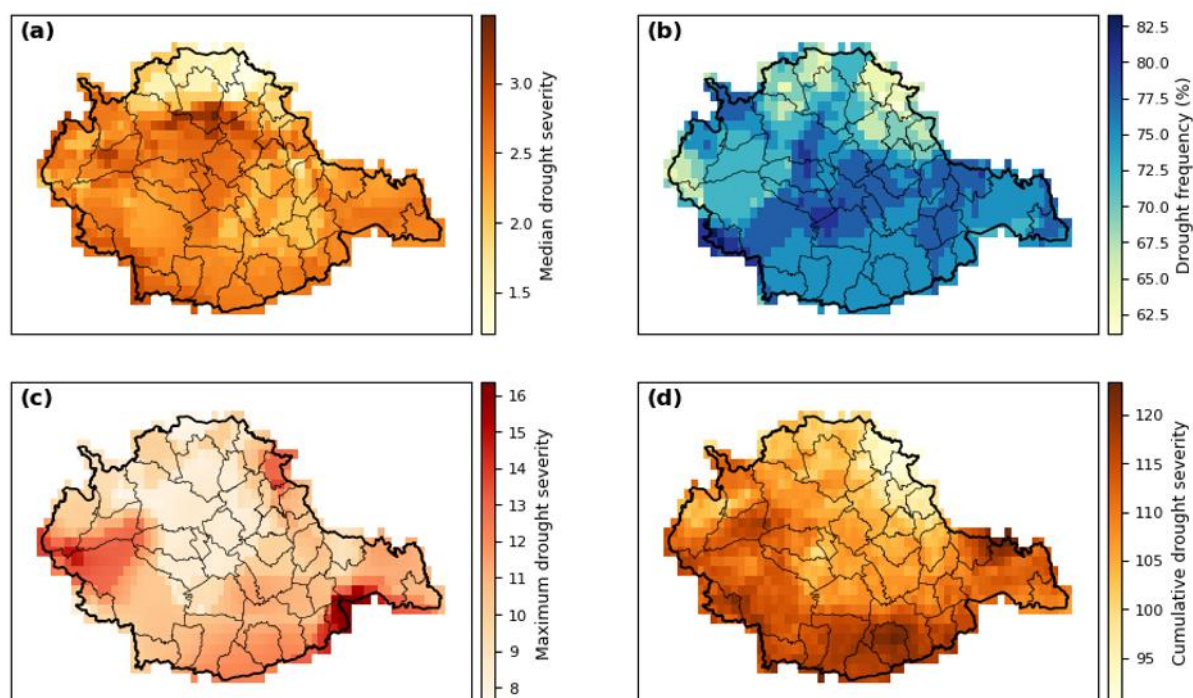


Figure 17: Spatial characteristics of meteorological drought in Podravje based on EMO-1 SPEI3 drought severity for 1990–2025.

Panel (a) shows the median annual drought severity, panel (b) the frequency of drought occurrence expressed as the percentage of years with at least one month below SPEI3 = -1, panel (c) the maximum annual drought severity over the observed period, and panel (d) the cumulative drought severity over 1990–2025. Municipality boundaries are shown for spatial reference.

2.3.2 Agricultural drought exposure

Agricultural land use in Podravje was characterized using the RABA dataset, which maps the land-use in Slovenia. From the available RABA classes, land-use types representing agricultural production were selected for the exposure analysis; the complete selection and rationale for inclusion or exclusion of individual classes are provided in Appendix 8.4.3. The selected agricultural classes cover approximately 97,308 ha in Podravje. Arable land is the dominant class, accounting for almost half of the selected agricultural area, followed by permanent grassland. Arable land represents areas used predominantly for the cultivation of non-permanent crops and is therefore directly relevant to the assessment of drought exposure. Permanent grassland was included because it represents an important agricultural land use associated with grass and forage production, which can likewise be affected by prolonged water deficits through reduced vegetation growth and productivity. The RABA dataset reflects observed land use but does not necessarily indicate that every mapped parcel is actively cultivated or managed.

Figure 18 shows agricultural exposure to cumulative SPEI3 drought severity across municipalities in Podravje for 1990–2025. Figure 18a indicates that agricultural land in 13 municipalities falls within the highest cumulative drought-severity class (≥ 118). The largest share of agricultural land within this class is found in Podlehnik (88%), followed by Oplotnica (28%) and Sveti Tomaž (23%). Figure 18(b) shows substantial differences in the absolute extent of agricultural land exposed to drought across municipalities. Slovenska Bistrica has the largest exposed agricultural area (9,363 ha), followed by Ormož (8,236 ha), Pesnica (4,891 ha), and Maribor (4,556 ha). A further breakdown of agricultural drought exposure by sector and municipality is provided in Figure 19. Unsurprisingly, arable land and permanent grassland account for the largest exposed areas and are widely distributed across municipalities. Extensive orchards represent the third-largest exposed agricultural land-use class, with the

greatest exposed areas found in Maribor (591 ha), Pesnica (403 ha), and Slovenska Bistrica (354 ha). Intensive orchards show a similar spatial pattern, with the largest exposed areas in Maribor (176 ha), Slovenska Bistrica (139 ha), and Pesnica (100 ha). Vineyard exposure is highest in Ormož (962 ha), followed by Maribor (340 ha) and Kungota (262 ha). In contrast, hop fields are spatially more limited and occur in only eight municipalities, with the largest exposed areas located in Dornava (51 ha), Ormož (46 ha), and Videm (45 ha). Appendix 8.4.2 provides a detailed overview of the distribution of agricultural drought exposure by sector and municipality across the three cumulative drought-severity classes presented in Figure 18a.

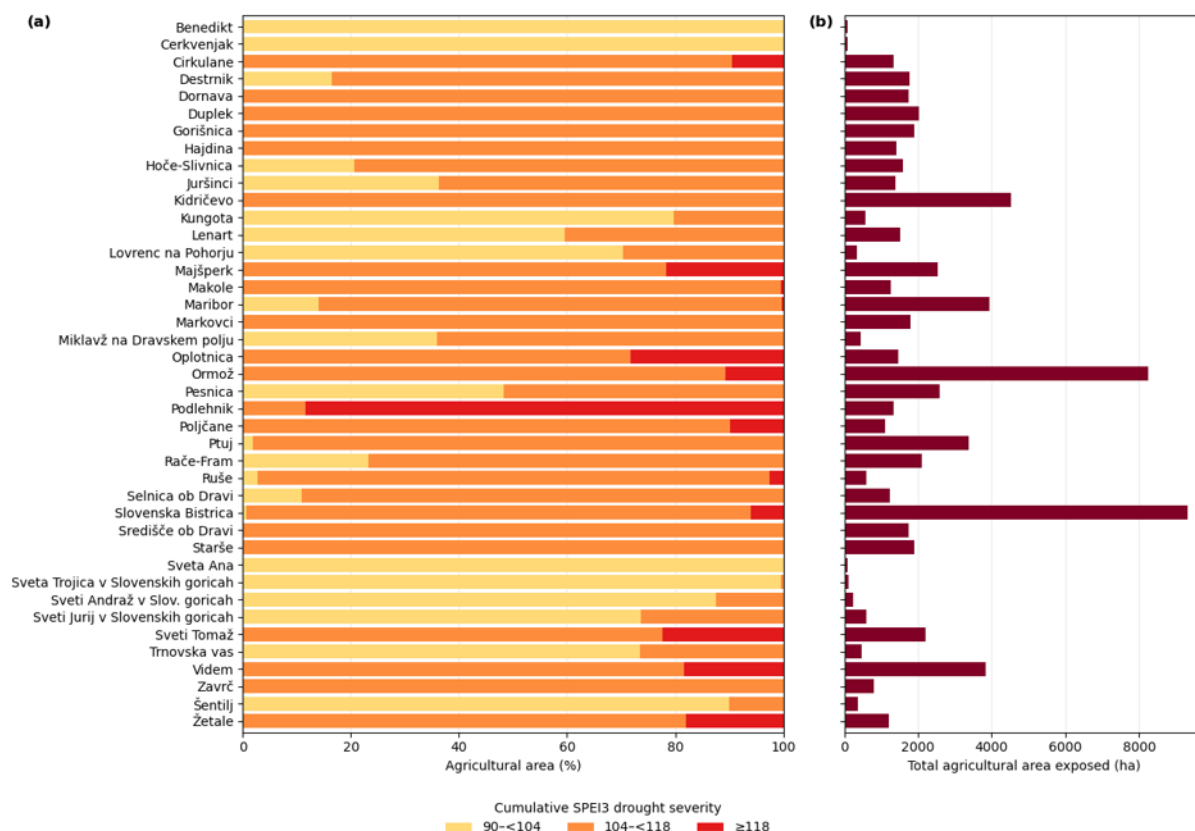


Figure 18: Agricultural exposure to cumulative SPEI3 drought severity across municipalities in Podravje for 1990–2025. Panel (a) shows the percentage of agricultural land within each municipality falling into three cumulative SPEI3 drought-severity classes. Panel (b) shows the total agricultural area included in the drought exposure assessment for each municipality, expressed in hectares.

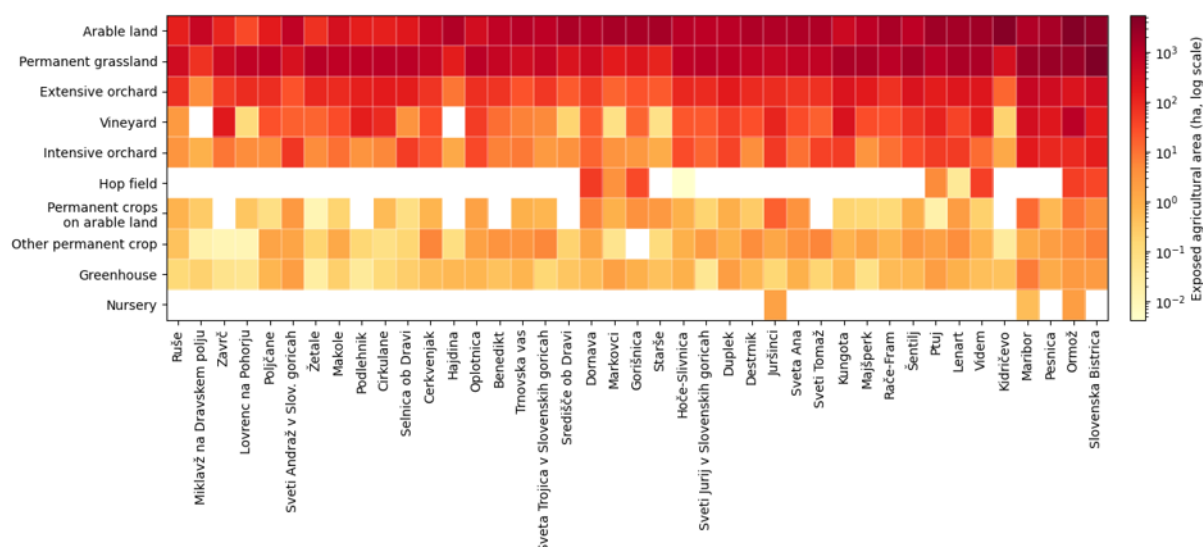


Figure 19: Agricultural drought exposure by sector and municipality in Podravje for 1990–2025.

The heatmap shows the total area, in hectares, of each agricultural land-use class located within areas with cumulative SPEI3 drought severity ≥ 90 . Municipalities are ordered by total agricultural area, with the largest agricultural areas shown on the right, while agricultural sectors are ordered by total exposed area, with the largest sectors shown at the top. Color intensity represents the exposed agricultural area and is displayed on a logarithmic scale to facilitate comparison between land-use classes with substantially different spatial extents.

Overall, the results show that agricultural drought exposure in Podravje is highly uneven across both municipalities and land-use classes. Municipalities with large agricultural areas account for much of the absolute exposure, while others contain a comparatively high share of agricultural land within the upper cumulative drought-severity classes. This distinction is important for adaptation planning, as different areas may require different priorities. The sectoral differences further suggest that adaptation strategies should account for the spatial distribution and characteristics of individual agricultural land uses rather than applying uniform measures across the region. These results can therefore help identify priority municipalities and sectors for more detailed assessments of drought vulnerability, water availability, irrigation needs, and crop-specific adaptation options. It should be noted, however, that the analysis represents exposure to meteorological drought and does not directly quantify agricultural losses or vulnerability.

The present analysis complements the ENERGA (2024) assessment by providing a different perspective on agricultural drought in Podravje. While ENERGA (2024) primarily assesses future changes in drought-related climatic conditions using projections of precipitation, evapotranspiration and water deficit, the analysis presented here focuses on the observed 1990–2025 period and applies a spatially explicit cumulative SPEI3 drought-severity indicator. This enables drought conditions to be differentiated across municipalities and directly combined with detailed agricultural land-use data to quantify the area and proportion of individual agricultural sectors exposed to different levels of cumulative drought severity. ENERGA (2024) highlights lowland agricultural areas and crop production on arable land as potentially sensitive to increasing water deficits and longer drought periods. These findings provide useful context for the present exposure assessment, in which arable land represents a large share of the agricultural area exposed to drought.

2.4 Landslides

2.4.1 Landslides in Podravje region

Landslide susceptibility in Podravje was assessed using the GeoZS warning map, which provides spatial classes of the probability of landslide initiation (DRSV, 2026a-c). Although the GeoZS datasets are formally described as warning maps of the probability of occurrence, the

mapped classes are derived from weighted combinations of spatial conditioning factors (e.g., lithology, land-use and slope) and are not associated with a defined temporal probability or return period. The warning maps are therefore interpreted here as relative susceptibility classes for landslides, rockfalls and debris flows. The GeoZS warning map is available for 15 municipalities within the Podravje region, and the analysis is consequently limited to these areas.

To complement the susceptibility assessment, field-verified landslide observations from GeoZS are used to characterize the spatial distribution of previously recorded landslide occurrences (DRSV, 2026d; Figure 20) and to provide historical context for the subsequent assessment of road susceptibility. The GeoZS inventory contains previously occurring slope mass movements that were field-verified during preparation of the warning maps (Jež et al., 2025). The recorded survey month and year refer to the timing of field verification rather than the date on which the event occurred, and the inventory should therefore not be interpreted as a complete chronological record of past events. Figure 20 shows three types of recorded slope mass movements: landslides, involving the downslope movement of soil or rock along a failure surface; rockfalls, involving the detachment and rapid fall of rock from steep slopes; and debris/mass flows, in which water-saturated sediment and debris move rapidly downslope. In total, 1,068 field-verified events were identified across 14 of the 15 participating municipalities in Podravje, comprising 1,045 landslides, 21 rockfalls, and two debris/mass flows. Šentilj, Slovenska Bistrica, and Maribor together account for 52.7% of all recorded events. The two debris/mass-flow observations occurred in Slovenska Bistrica and Ruše, while Ruše also accounts for 43% of all recorded rockfall events. The inventory does not identify the triggering mechanism of individual landslides. Landslides can be triggered by both earthquakes and intense rainfall, although the triggering mechanism is not recorded in the GeoZS inventory. Historical earthquakes in Slovenia have generally not been strong enough to trigger widespread landsliding, whereas rainfall-induced landslides are considerably more common (Mikoš et al., 2013).

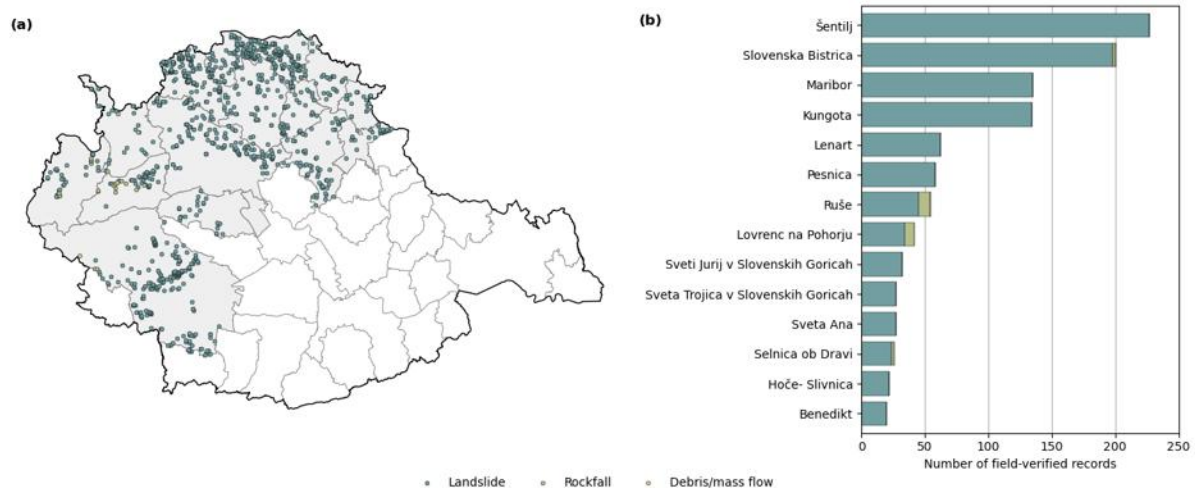


Figure 20: Spatial distribution of field-verified landslides, rockfalls, and debris/mass flows in Podravje. Panel (a) shows the locations of recorded slope-instability phenomena, with shaded municipalities indicating areas covered by the GeoZS field surveys. Panel (b) shows the number of field-verified records by municipality and event type. The inventory represents phenomena identified during GeoZS field verification and should not be interpreted as a complete historical record of all events.

2.4.2 Road susceptibility

The municipalities in Podravje covered by the GeoZS field surveys (DRSV, 2026d) contain approximately 5,404 km of roads, with a breakdown by road type provided in Appendix 8.5.2. Around two-thirds of the regional road network (64.0%) lies within areas classified as

susceptible to landslide occurrence. Of this exposed road length, 87.1% falls within the medium, high, or very high susceptibility classes. A similar share of the road network (64.0%) is located within areas susceptible to debris flows; however, most of this exposure (95.4%) is concentrated in the very low and low susceptibility classes. In contrast, exposure to rockfall susceptibility is much more limited, with only about 0.5% of the regional road network intersecting mapped rockfall-susceptible areas. The susceptibility classes provide an indication of how favorable local conditions are for the occurrence of landslides, but they do not quantify the actual likelihood or frequency of an event. To estimate the probability of landslide occurrence, for example as an annual frequency, the spatial conditioning factors represented by the susceptibility classes would need to be combined with information on relevant triggering processes (Palau et al., 2023), such as extreme precipitation. Additionally, a landslide could also be initiated in proximity to a road segment, which could still potentially affect this road segment. Additionally, slope failures may initiate upslope or otherwise in close proximity to a road and subsequently affect the road through downslope movement or runout. Such indirect exposure is not captured in the present analysis, which considers only road segments that directly intersect mapped susceptibility areas.

Figure 21 presents the distribution of road susceptibility across municipalities in Podravje for landslides, rockfalls, and debris flows, while panel (d) provides the total road-network length in each municipality for context. Slovenska Bistrica, Maribor, and Lovrenc na Pohorju show the largest absolute road exposure to landslide susceptibility, with approximately 739 km, 555 km, and 451 km of roads exposed, respectively. The same municipalities also record the largest absolute road exposure to debris-flow susceptibility, with very similar exposed road lengths of approximately 739 km, 554 km, and 451 km. However, the distribution across susceptibility classes differs markedly between the two hazard types. Landslide-exposed roads are predominantly located in areas classified as medium to high susceptibility, whereas debris-flow exposure is concentrated mainly in the very low and low susceptibility classes. Furthermore, rockfall exposure is much more spatially limited than landslide and debris-flow exposure, with Selnica ob Dravi, Lovrenc na Pohorju, and Ruše ranking highest in terms of road exposure to rockfall susceptibility.

Municipalities with extensive road networks may rank highly in terms of absolute exposed road length simply because they contain more road infrastructure overall. The percentage of the municipal road network exposed therefore provides an important complementary measure, as it indicates the relative scale of exposure within each municipality and facilitates comparison between municipalities with different network sizes. A high proportional exposure may suggest that disruption could affect a substantial share of the local road system, even where the absolute exposed length is comparatively small. However, this does not directly indicate network redundancy or accessibility, which would require further analysis of road connectivity, alternative routes, road hierarchy, and the location of critical links. Ten municipalities have more than 50% of their road network exposed to landslide susceptibility, while four municipalities exceed 75% exposure (Figure 21a and c). A similar pattern is observed for debris-flow susceptibility. In relative terms, Lovrenc na Pohorju ranks highest for both landslide and debris-flow susceptibility, with approximately 91% of its road network exposed in each case. Ruše and Selnica ob Dravi also rank among the three municipalities with the highest proportional exposure, with around 86% and 80% of their road networks exposed to landslide susceptibility, respectively, and similarly high shares for debris-flow susceptibility.

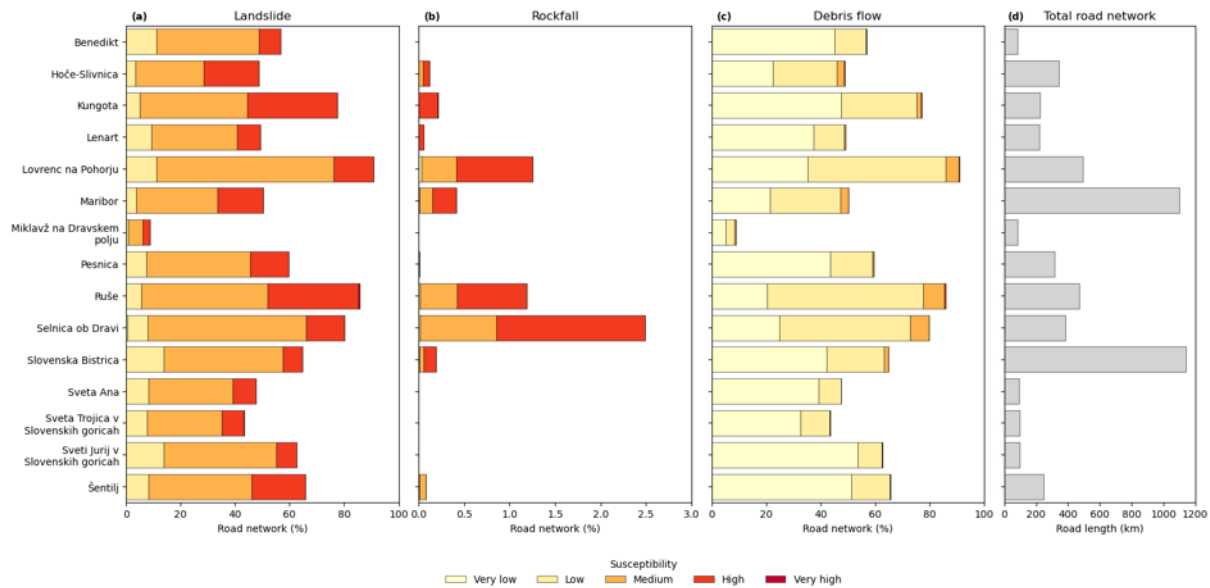


Figure 21: Road susceptibility to slope mass-movement hazards across municipalities in Podravje.

Panels (a)-(c) show the share of each municipality's total road network exposed to very low, low, medium, high, and very high susceptibility classes for landslides, rockfalls, and debris flows, respectively. Panel (d) shows the total road-network length in each municipality. Percentages in panels (a)-(c) are calculated relative to the full municipal road network, so any unfilled portion represents roads outside susceptibility classes 1-5.

The road network was grouped into four broader functional categories: major roads, comprising motorways, trunk roads, and primary roads that mainly support longer-distance through traffic; regional/local roads, comprising secondary and tertiary roads that connect towns and settlements; local access roads, consisting primarily of residential roads that provide direct access to homes and properties; and tracks, representing minor agricultural, forest, or other access routes. The main distinction between regional/local roads and local access roads is therefore functional, with the former serving primarily a connector role and the latter an access or destination role. Generally, the road susceptibility exposure is mainly driven by tracks, which constitute by far the largest share of the road network, at 69.5% (Figure 22). Figure 22a and c further shows that 13.1% of major roads are exposed to both landslide and debris flow susceptibility, whereas the relative exposure of regional/local roads and local access roads is considerably higher, reaching up to 39.2% and 38.2%, respectively, for both hazards.

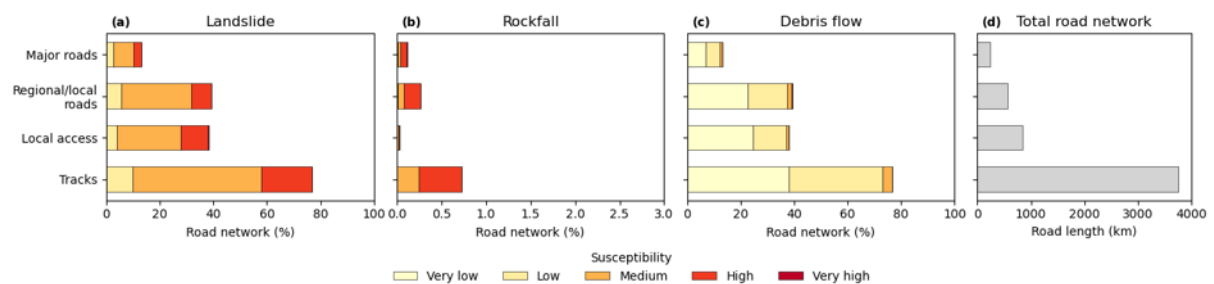


Figure 22: Road susceptibility by functional road type in Podravje.

Panels (a)-(c) show the share of each road category intersecting very low, low, medium, high, and very high susceptibility areas for landslides, rockfalls, and debris flows, respectively. Percentages are calculated relative to the total length of each road category. Panel (d) shows the total road-network length represented by each functional road type. Road categories comprise major roads (motorway, trunk, and primary), regional/local roads (secondary and tertiary), local access roads (residential), and tracks.

Differentiating between infrastructure types is important for adaptation planning because different road categories serve different functions and therefore have different consequences

when disrupted. Exposure of major or regional/local roads may have broader implications for connectivity between settlements, access to services, freight movement, and emergency response, whereas exposure of local access roads may primarily affect access to individual communities or properties. Tracks may account for a large share of exposed road length, but their disruption may not have the same system-wide consequences as disruption of higher-order roads. Distinguishing road types therefore helps move beyond simply identifying where exposure is highest and supports prioritization of adaptation measures according to both the level of susceptibility and the functional importance of the affected infrastructure.

2.5 Labor market outcomes in Podravska: levels, trends, and gaps

To identify the socio-economic effects, three indicators are analyzed (employment, wages, number of firms). These indicators are drawn from two official sources. The employment rate is taken from the SURS Municipal Labour Force Survey and measures the proportion of the working-age population that is employed, expressed in percentage points. Real wages are calculated using the SURS's gross monthly earnings, deflated using the Consumer Price Index (base 2015 = 100) and expressed in constant euros. The number of firms is taken from the AJPES commercial register and indexed to 2008=100 so that trends are comparable across regions of different economic size. The panel covers 213 municipalities over the period 2005–2024, with coverage varying slightly depending on the source.

Figure 23 shows the trend for the three indicators analysed. As regards the employment rate, Podravska started in 2005 at a level below the national average (around 54 per cent compared with 58 per cent), and the gap remained virtually stable until 2016. From then on, both Podravska and the national average recover steadily, but the national average records stronger growth, reaching almost 70 per cent in 2024, compared with 67 per cent in Podravska. As for real wages, the two trajectories move more or less in parallel during the first half of the period, although Podravska consistently lags behind the national average. The sharp contraction between 2013 and 2015 was more pronounced in the region, and convergence with the national average did not occur until around 2021. The number of businesses shows the most consistent pattern: both Podravska and the national average grow almost continuously from 2008 onwards, accumulating an increase of approximately 55 per cent by 2024 at an almost identical rate. This suggests that business creation in the region kept pace with the country as a whole, in contrast to the persistent gaps observed in employment and wages.

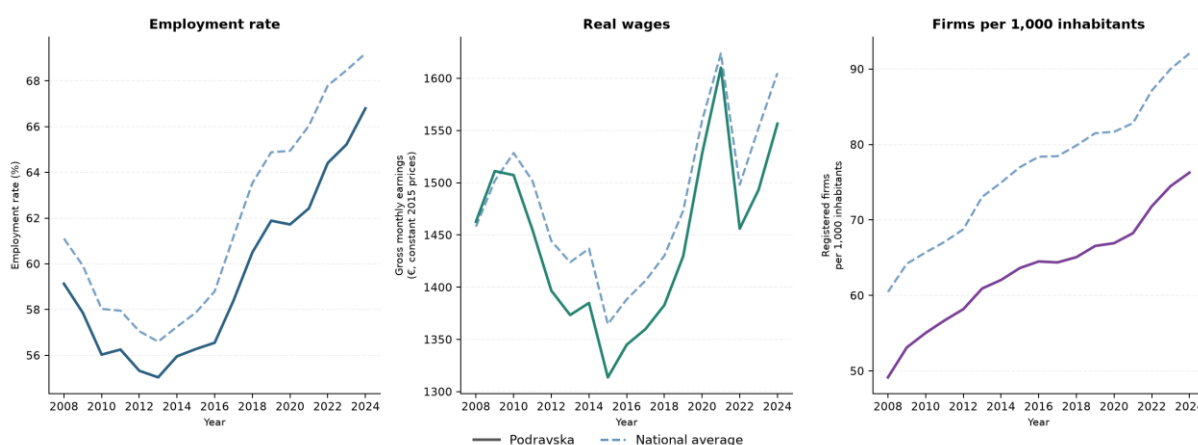


Figure 23: Labor market outcomes. Source: SURS/AJPES.

2.5.1 Analytical approach

The analysis of hazards in Podravska (river flooding, extreme heat, drought and windstorms) is particularly complex, because no single hazard occurs as a discrete, one-off event. These recur regularly with varying intensity. In this context, the policy question is whether years of abnormal exposure leave a lasting mark on the regional labour market, and whether that mark fades quickly or persists.

Answering this question requires a method that compares each municipality to its own history, rather than to other places. What we seek to isolate is the effect of years that are exceptionally severe by local standards. For example, a summer hotter than what Maribor normally experiences, a drought more intense than what the Drava valley has historically recorded, or a flood season that far exceeds the local historical average.

In this context, we employ the methodological framework of Dell, Jones and Olken (2012), a framework developed to analyse continuous and recurrent exposure. Specifically, the model analyses how the labour market of each municipality grows or contracts from one year to the next, and assesses whether that trajectory is altered when climate conditions deviate significantly from the local historical norm.

The model measures abnormal exposure, not average exposure. For each climate hazard, we subtract from the observed value in each year the corresponding municipal mean for the period 2001-2010. What enters the model is therefore the deviation: how much worse than usual a given year was for that specific municipality. For example, in 2023 the municipalities of Podravska recorded nearly 20 additional days of extreme river discharge relative to their historical baseline; it is that deviation, and not the absolute number of flood days, that drives the estimates.

The model allows effects to unfold over time through a distributed lag structure spanning three consecutive years. The year of the event (t), the following year ($t+1$), and two years after ($t+2$). This design rests on two assumptions: first, that the economic response to a climate shock begins in the same year it occurs and may continue to propagate over subsequent years; and second, that by the end of the third year the effect has either dissipated or stabilised into a new equilibrium. The cumulative coefficient (the sum of the three annual responses) captures the total impact once two years have elapsed, and is the primary measure reported throughout Section 3.2. It allows us to determine whether the local economy managed to recover or whether the damage had lasting consequences.³

The model distinguishes the regional story from the national one. By including an interaction term for Podravska, it simultaneously estimates the average effect of each climate hazard across all Slovenian municipalities and determines whether Podravska's labour market responds differently from that national pattern. In this way, the analysis identifies what is specific to this region, beyond what any Slovenian municipality might experience.

The analysis covers three labour market outcomes: the municipal employment rate, real wages, and the number of registered firms. Table 6 summarises which combinations of climate hazards and outcomes yield a statistically significant cumulative effect for Podravska.

³ No assumption is made about the direction or monotonicity of the response: the effect may build gradually, peak in year two, or partially reverse, as indeed occurs in some of the hazards analysed.

Climate hazard	Employment rate	Real earnings	No of firms
Extreme river flooding	↓	↓	
TX95p heat days			↓
Drought			
Extreme wind speed		↓	

Table 6: Climate hazard effects on Podravska's labour market.

Note: Arrows indicate the direction of the statistically significant cumulative effect ($\beta + \delta_1 + \delta_2$) estimated using the Dell-Jones-Olken (2012) distributed lag panel model with municipality and year fixed effects and standard errors clustered by municipality (↑ positive or ↓ negative). Blank cells indicate no statistically significant cumulative effect at the 10% significance level. The cumulative effect sums the response in the year of the event and the two subsequent years. It captures the total impact after three years have elapsed, but does not imply a uniform or monotonic trajectory, individual annual responses may differ in sign or magnitude. Detailed year-by-year estimates are presented in the figures in Section 2.5.2

2.5.2 Results by type of climate hazard

The figures below present the total effect of each climate hazard on Podravska's labour market, estimated separately for the year of the event, one year later, two years later, and as a cumulative total. This structure allows us to distinguish between hazards whose effects appear immediately and then dissipate, and those whose impacts accumulate or intensify over time. The cumulative bar is the most policy-relevant measure, as it summarises the total impact over the three-year window spanning the event and the two subsequent years. Asterisks indicate statistically significant results at conventional levels.

Extreme river flooding

Flooding leaves a statistically significant mark on both employment and real earnings in Podravska. In years of extreme river discharge, the employment rate falls by approximately 0.065 percentage points relative to the national trend over the three-year window. The impact on wages is larger and more precisely estimated: real earnings decline in the same year (-0.042%), again one year later (-0.103%), and once more two years after the event (-0.048%), generating a cumulative loss of -0.193%⁴. The number of firms does not respond significantly in any period. This pattern suggests that flooding compresses wages and reduces employment along the intensive margin (hours worked or wage rates) while formal firm structures prove more resilient to short-term disruption. The persistence of the wage effect across all three periods indicates that recovery is not immediate and that the labour market absorbs the shock gradually.

⁴ A cumulative earnings loss of 0.193% implies a total shortfall of roughly €46 per worker over the three-year window. Aggregated across approximately 134,000 employed residents in Podravska, this corresponds to a total wage loss of approximately €6.2 million per flood episode of this severity.

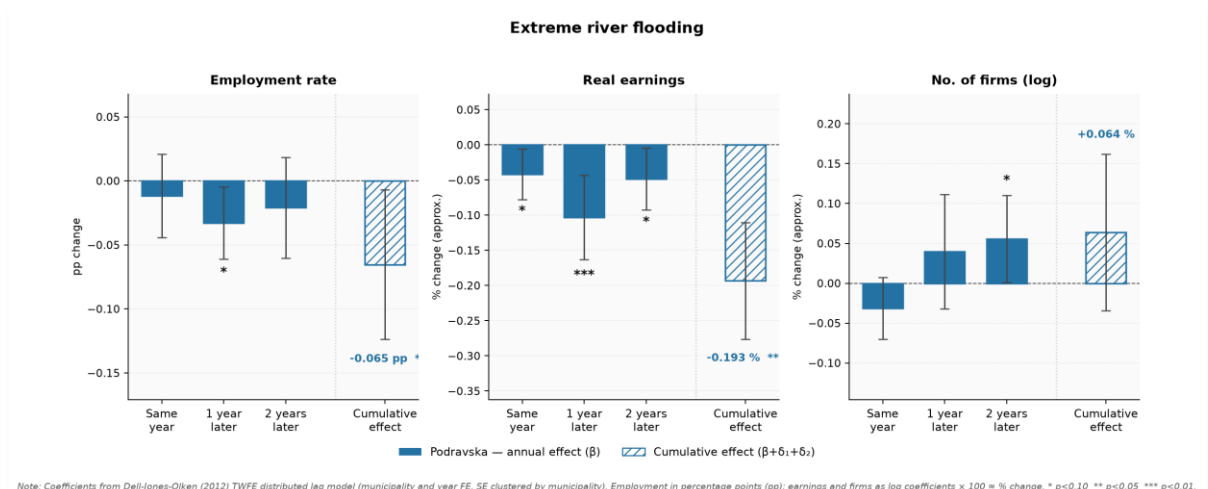


Figure 24: Cumulative labour market effects of extreme river flooding in Podravka, 2005-2024.

Note: Bars show the total effect of each climate hazard on Podravka's labour market ($\beta + \delta_1 + \delta_2$), estimated using the Dell et al. (2012) panel framework with municipality and year fixed effects and SE clustered by municipality. The cumulative effect (hatched bar) sums the contemporaneous and two lagged annual responses. Standard errors clustered by municipality. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Heat days (TX95p)

Anomalous heat, measured as days above the local 95th percentile of maximum temperature relative to the 1991-2020 reference period, does not produce statistically significant effects on employment or earnings in Podravka. The cumulative employment effect is -0.054 pp and the cumulative earnings effect is -0.326%, but neither reaches conventional significance levels given the precision of the estimates. The exception is the number of firms: the cumulative effect is -0.489%, driven primarily by a negative response two years after the heat episode (-0.220%). This delayed signal is consistent with a mechanism in which heat stress gradually erodes the profitability of smaller enterprises (particularly in agriculture, construction, and outdoor services) leading to exit or consolidation in the years following an extreme heat year rather than immediate closure.

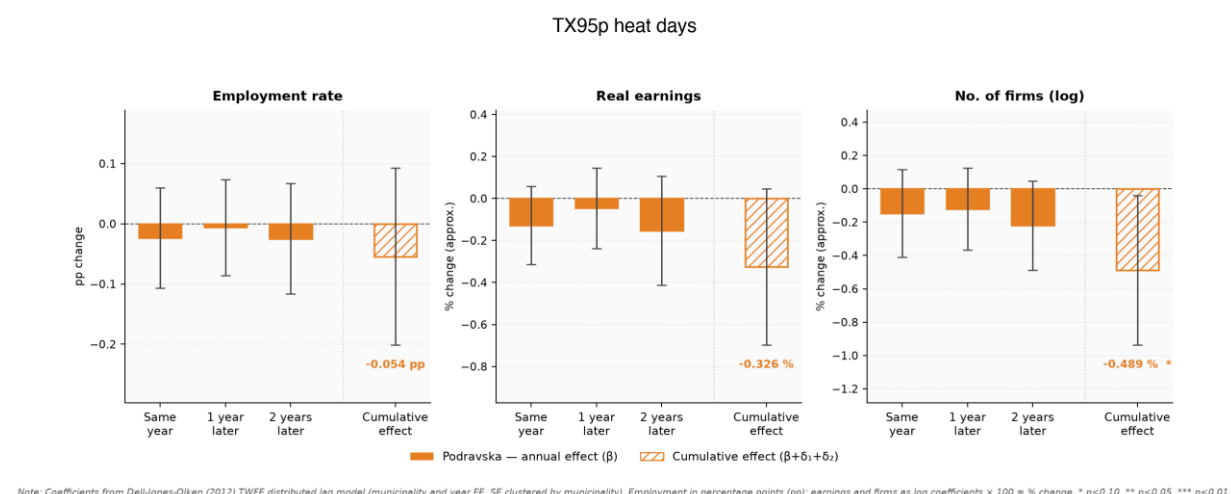


Figure 25: Cumulative labour market effects of heat days in Podravka, 2005-2024.

Note: Bars show the total effect of each climate hazard on Podravka's labour market ($\beta + \delta_1 + \delta_2$), estimated using the Dell et al. (2012) panel framework with municipality and year fixed effects and SE clustered by municipality. The cumulative effect (hatched bar) sums the contemporaneous and two lagged annual responses. Standard errors clustered by municipality. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Drought (SPEI-3 index)

Drought, measured as the annual minimum of the three-month Standardised Precipitation-Evapotranspiration Index (SPEI-3), does not produce statistically significant effects on any of

the three labour market outcomes over the three-year window. The point estimates are large in magnitude, the cumulative employment effect is -1.013 pp and the cumulative firms effect is +1.379%, but confidence intervals are wide, reflecting the limited variation in severe drought years within Podravska's 41 municipalities. These results should be interpreted cautiously: the absence of statistical significance does not rule out economically meaningful effects, and longer panels or higher-resolution drought indicators may yield more precise estimates in future work.

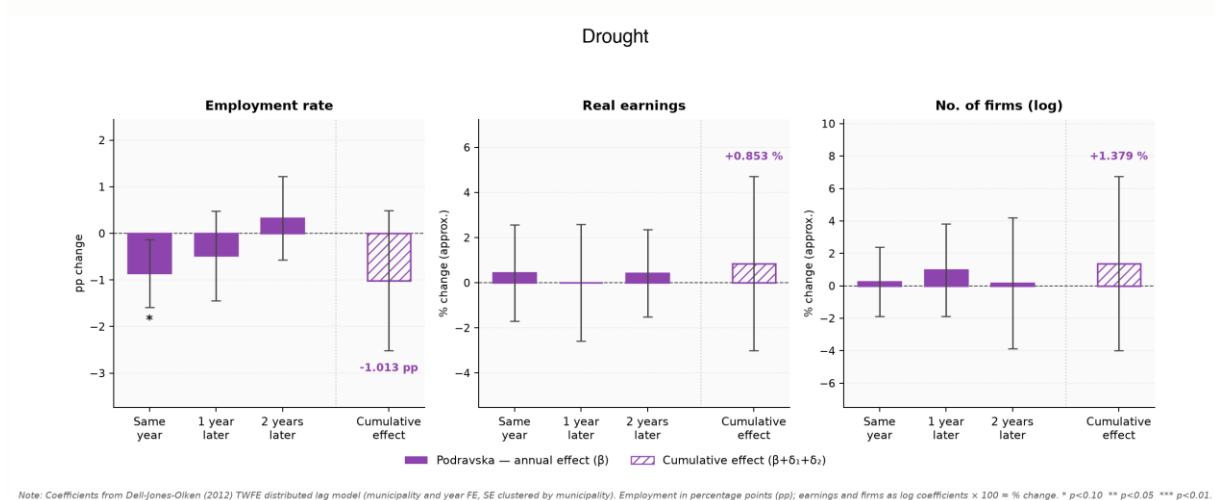


Figure 26: Cumulative labour market effects of drought in Podravska, 2005-2024.

Note: Bars show the total effect of each climate hazard on Podravska's labour market ($\beta + \delta_1 + \delta_2$), estimated using the Dell et al. (2012) panel framework with municipality and year fixed effects and SE clustered by municipality. The cumulative effect (hatched bar) sums the contemporaneous and two lagged annual responses. Standard errors clustered by municipality. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Extreme wind speed

Wind speed produces the most concentrated and precisely estimated effect on earnings. In the year of the event, real earnings in Podravska fall by - 2% relative to the national trend, and the effect persists in the two subsequent years, generating a cumulative loss of -4.5%. Employment and the number of firms do not show statistically significant responses. The wage effect is striking in magnitude: a one-unit increase in annual maximum wind speed is associated with a cumulative earnings loss approaching 4.5%. One interpretation is that wind events damage productive infrastructure and disrupt activity in exposed sectors (i.e. forestry, outdoor manufacturing, transport) in ways that compress wages without immediately triggering formal unemployment or firm closure.⁵

⁵ A cumulative earnings loss of 4.493% implies a total shortfall of approximately €1,073 per worker over the three-year window. Aggregated across approximately 134,000 employed residents in Podravska, this corresponds to a total wage loss of roughly €144 million per episode.

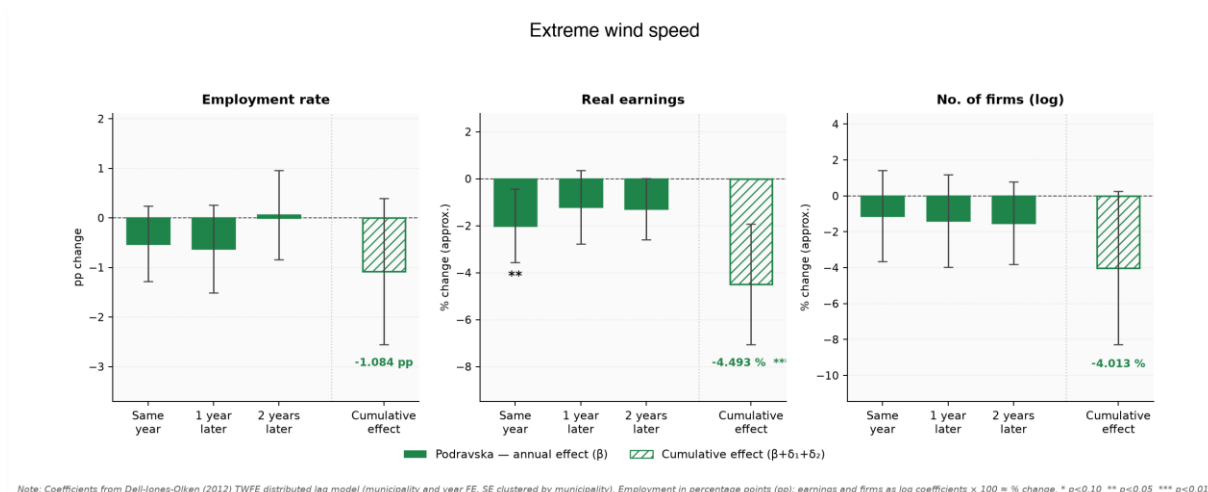


Figure 27: Cumulative labour market effects of extreme wind speed in Podravska, 2005-2024.

Note: Bars show the total effect of each climate hazard on Podravska's labour market ($\beta + \delta_1 + \delta_2$), estimated using the Dell et al. (2012) panel framework with municipality and year fixed effects and SE clustered by municipality. The cumulative effect (hatched bar) sums the contemporaneous and two lagged annual responses. Standard errors clustered by municipality. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

2.5.3 Heterogeneous effects by historical exposure

The main analysis presented in Section 2.5.2 estimates the average labour market response of Podravska's municipalities to each climate hazard, treating the region as if all municipalities were equally sensitive to a given climatic shock. Whilst this assumption is useful as a first approximation, it may conceal an important source of variation: municipalities that have been repeatedly exposed to a particular hazard over decades may respond very differently from those that have experienced it less frequently. This section tests that possibility directly, drawing on the methodological framework of Kalkuhl and Wenz (2020) and Dong, Tol and Wang (2025), who develop a formal test to evaluate whether a longer history of exposure to a hazard makes a municipality more or less vulnerable when a new shock occurs.

The exercise is conducted for the same four climate hazards and three labor market outcomes analysed throughout Section 2.5.⁶ Formally, the model extends the baseline specification by incorporating an interaction term between the current-year climatic deviation and the municipality's long-run historical mean of that same variable, computed over the reference period 2001-2010. A positive interaction coefficient indicates adaptation, whilst a negative coefficient reflects damage accumulation.

The results reveal two distinct patterns. In the case of extreme river flooding, the interaction with historical exposure is positive and statistically significant for both employment (+0.014) and real earnings (+0.040%), indicating a clear adaptation effect: municipalities where flooding has historically been more frequent absorb new flood episodes with smaller employment and wage losses. This finding suggests that repeated exposure fosters institutional capacity, infrastructure investment, or sectoral adjustment that attenuates subsequent damage. For the number of firms, however, the interaction turns negative and significant (-0.0002), consistent with a long-run process of business attrition in chronically flood-prone municipalities.

For TX95p heat days, the interaction with historical exposure is negative and highly significant for the employment rate (-0.074), reflecting a process of damage accumulation rather than adaptation: municipalities that have historically experienced more anomalous heat episodes

⁶ Consider two municipalities in Podravska experiencing an exceptionally severe drought in the same year. If one of them has lived for decades with conditions of scarce rainfall and the other has not, one would not necessarily expect both to suffer identical consequences.

suffer proportionally larger employment losses when new heat events occur. This finding suggests that repeated heat stress progressively erodes the productive capacity of the local labour market (particularly in outdoor and heat-sensitive sectors) without triggering sufficient adaptive responses to offset the cumulative burden.

No statistically significant interaction is found for drought or extreme wind speed under any of the three labour market outcomes, nor for earnings and firms under heat exposure. These null results suggest that the heterogeneous dynamics observed for flooding and heat employment are hazard-specific and do not generalise uniformly across all dimensions of the regional labour market.

2.5.4 Distributional effects of climate hazard exposure

The analyses presented in Sections 2.5.3 and 2.5.4 estimated the average labour market response of Podravška's municipalities to each climate hazard and examined how that response varied according to the degree of historical exposure. This section addresses a complementary question: do the areas most intensely exposed to climate hazards also coincide with those where the resident population exhibits higher levels of socioeconomic vulnerability?

The analysis moves to a finer spatial resolution, using the 2,048 populated cells of the Eurostat Census Grid 2021 as the unit of observation, with each cell covering one square kilometre. For each cell, hazard intensity is related to two demographic characteristics drawn from the 2021 Census: the local employment rate and the share of the population aged 65 and over. The central objective is to establish whether the spatial distribution of each hazard overlaps with population groups that are inherently less resilient to economic shocks.

Figure 28 presents four maps showing the spatial distribution of climate hazard intensity across Podravška at a 1 km² resolution. Each cell corresponds to a one-square-kilometre area containing at least one resident, yielding 2,048 populated cells covering the region's 344,260 inhabitants. For extreme river flooding, cell-level exposure is drawn from the official flood hazard layer, which identifies cells located within flood-prone zones based on a return period of ten years or less; 184 cells (9% of the total, covering approximately 8% of the regional population) fall within this category. For TX95p heat days, drought severity, and wind speed, the intensity measure corresponds to the average annual value of the respective climate indicator over the period 2005 - 2024, calculated at the municipal level using the same panel dataset employed in the econometric analysis and subsequently assigned uniformly to all grid cells within each municipality⁷.

The purpose of mapping exposure at this resolution is to move beyond the municipal level of analysis and examine the internal geography of climate risk within Podravška. Municipal averages conceal considerable variation. By overlaying the intensity of each climate hazard with the demographic characteristics of each grid cell, it is possible to identify which segments of the population bear the greatest physical burden of exposure.

⁷ In all cases, cells with exposure levels below the threshold defined in the flood hazard layer are displayed in grey and classified as not exposed. For hazards assigned at the municipal level, within-municipality spatial variation in exposure is not captured.

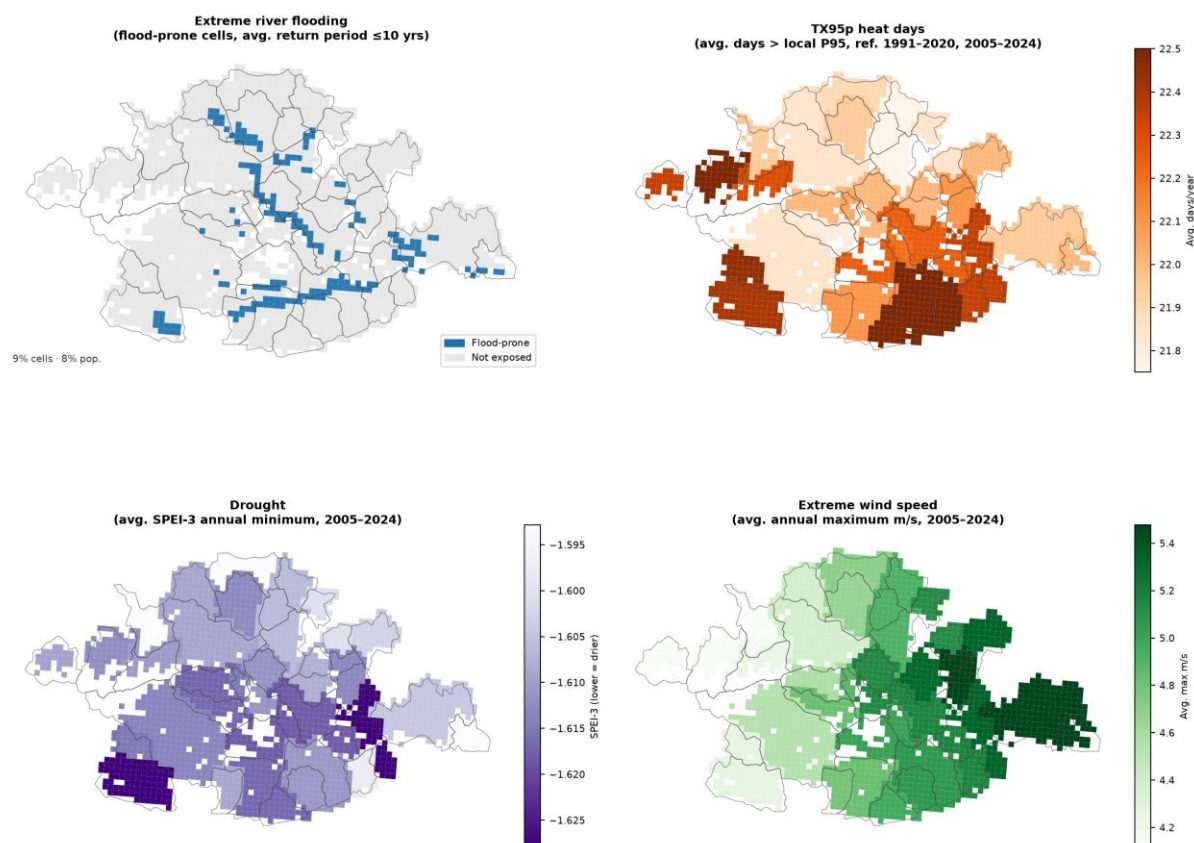


Figure 28: Climate hazard exposure across Podravska's territory.

Note: Each cell covers one square kilometre and contains at least one resident (2,048 populated cells, 344,260 inhabitants). For extreme river flooding, shading identifies cells within the official flood-prone zone (return period ≤10 years); grey cells are not exposed. For TX95p heat days, drought, and wind speed, the value displayed is the average annual indicator over 2005 - 2024, calculated at the municipal level and assigned uniformly to all cells within each municipality. Darker shading indicates higher hazard intensity; for drought (SPEI-3), lower (more negative) values indicate more severe dry conditions.

Figure 29 presents two maps showing the spatial distribution of the employment rate and the population aged 65 and over, both drawn from the 2021 Census. The left panel shows the employment rate, with a population-weighted mean of 44.5% across Podravska, and considerable variation across cells: the lowest employment rates tend to be concentrated in peripheral rural areas and along the outer edges of municipalities. The right panel shows the share of the population aged 65 years and over, with a population-weighted mean of 21.6%. The age structure displays a more spatially continuous pattern, with the northern municipalities and the rural periphery concentrating the highest shares of older residents.

To examine the relationship between socioeconomic indicators and climate hazards, an OLS regression was estimated for each hazard-outcome combination at the grid-cell level, controlling for cell population size. The results provide limited evidence of a systematic spatial overlap between climate exposure and socioeconomic vulnerability in Podravska. For extreme river flooding, TX95p heat days, and extreme wind speed, no statistically significant association is found between hazard intensity and either the employment rate or the share of older residents. In the case of flooding, the limited number of flood-prone cells (184 of 2,048) constrains statistical power, so the absence of significance should not be interpreted as evidence of no distributional concern.

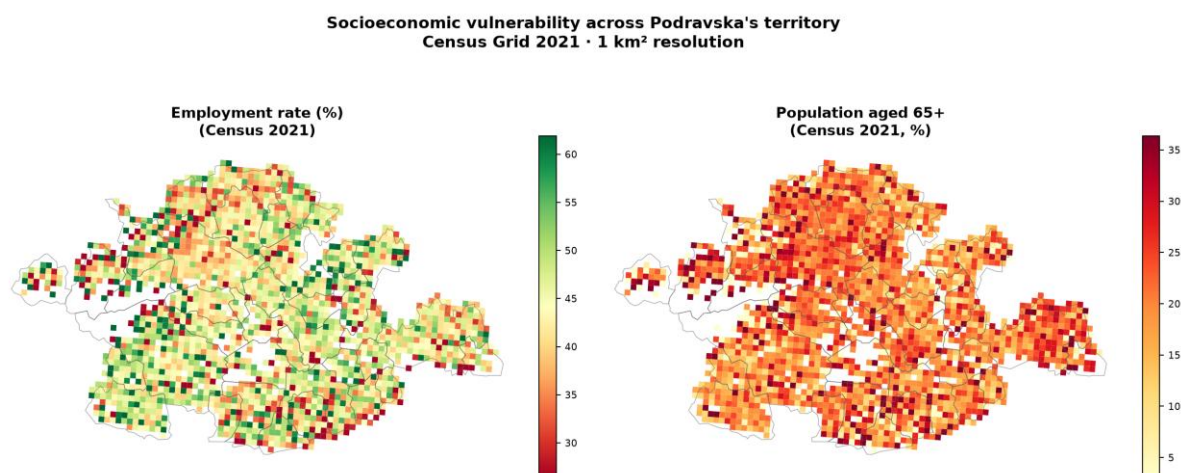


Figure 29: Socioeconomic vulnerability across Podravska's territory.

Note: Each cell covers one square kilometre and contains at least one resident (2,048 populated cells, 344,260 inhabitants). The employment rate is defined as the share of the working-age population in employment. The share of population aged 65 and over is calculated as a proportion of total cell population. Both indicators are drawn from the 2021 Population and Housing Census. Cells with suppressed values due to statistical confidentiality are excluded. Population-weighted regional means: employment rate 44.5%; population aged 65+ 21.6%.

The only statistically significant distributional pattern is found for drought: cells located in municipalities historically more affected by dry conditions exhibit lower employment rates. This result should nonetheless be interpreted with caution. The variation in drought severity across Podravska's municipalities is narrow. The region is sufficiently compact that differences in chronic drought exposure are small, which amplifies the estimated coefficient and limits its economic interpretability. The distributional analysis does not reveal a systematic pattern of double burden, high climate exposure concentrated among the most economically or demographically vulnerable population groups, within Podravska at this spatial resolution.

2.5.5 Climate scenarios and projected business losses

The previous sections analysed four climate hazards. However, for the forward-looking scenario analysis, we focus on temperature. This decision is based on the available evidence. Temperature is the climate variable that can be projected with the greatest degree of confidence. The IPCC Sixth Assessment Report (2021) assigns a high level of confidence to temperature projections for Central Europe, whereas projections of extreme precipitation, drought, and wind carry medium to low confidence at the regional scale, owing to the greater influence of internal climate variability and model uncertainty for these variables (Hawkins and Sutton, 2011; IPCC AR6, Working Group I, Chapter 4). This is not a limitation specific to the present report: the leading studies in the climate economics literature focus their forward-looking analyses on temperature for precisely this reason (Dell et al., 2012; Burke et al., 2015).

Temperatures in Podravska have increased steadily over the past two decades, and the pace of warming continues to accelerate. An analysis of twenty years of climate records (ERA5-Land, 2005–2024) confirms that TX95p heat days⁸ have trended upward at a rate of approximately 0.66 additional days per year, with the pace accelerating from +0.45 days per year before 2014 to +0.74 days per year thereafter. The baseline over the most recent five-year period (2020–2024) stands at 26.6 TX95p days per year on average across Podravska's municipalities, well above the theoretical reference-period mean of 18.25 days (5% of 365

⁸ Defined as days exceeding the local 95th percentile of maximum temperature relative to the 1991–2020 reference period.

days). Figure 30 illustrates this trend, with years of particularly intense heat anomalies visible in 2012, 2015, 2017, and 2024.

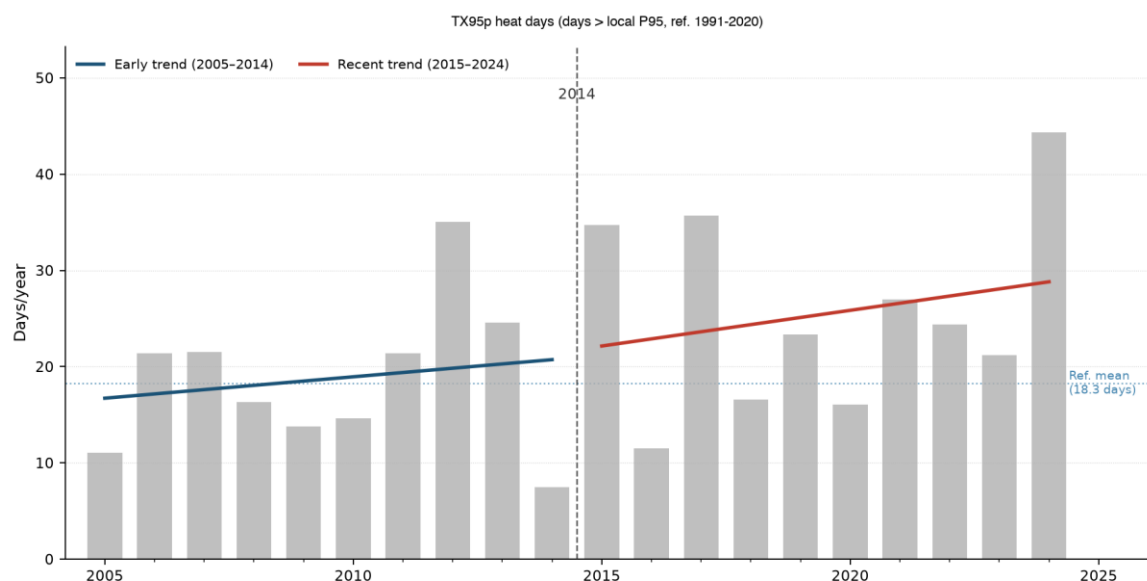


Figure 30: TX95p heat days Podravka, 2005–2024.

Figure note: Annual count of TX95p heat days (days above the local 95th percentile of daily maximum temperature, reference period 1991–2020) averaged across 41 municipalities in Podravka, 2005–2024. Structural break date (2014) identified using the Bai & Perron (1998) sequential breakpoint test. Trend lines are OLS estimates fitted separately to each sub-period. Source: ERA5-Land reanalysis (Copernicus Climate Change Service, ECMWF), authors' calculations.

To assess the economic impacts of continued warming, this section develops two prospective scenarios based on official temperature projections from the IPCC Sixth Assessment Report for the Central Europe region and translates them into concrete labour market and firm-level outcomes for Podravka. The projection methodology follows four explicit steps, set out here in full to allow replication and critical assessment.

S1. Baseline. The baseline values are five-year averages drawn from observed data over 2020–2024: 26.6 TX95p days per year (ERA5-Land), 30,623 registered firms (AJ PES), and €13,164M in total real firm revenue (AJ PES, deflated using the Slovenia GDP deflator, Eurostat).

S2. Temperature-to-TX95p conversion. An OLS regression of annual TX95p days on mean annual temperature over 2005–2024 yields a conversion factor of 5.75 additional TX95p days per +1°C of warming. This coefficient translates the IPCC temperature increments into projected changes in TX95p days under each scenario.

S3. TWFE coefficient. The Dell-Jones-Olken panel model estimated in Section 3.2 yields a cumulative effect of - 0.489% on the number of firms per additional TX95p day over a three-year window. Annualised across the three-year horizon, this implies - 0.163% per TX95p day per year. The same proportional effect is applied to regional revenue, under the assumption that the revenue-per-firm ratio remains constant.

S4. Scenario application. IPCC AR6 temperature increases for Central Europe of +0.7°C by 2030 and +1.0°C by 2040 under SSP2-4.5, and +1.0°C by 2030 and +1.6°C by 2040 under SSP5 - 8.5 are applied to the 2020 - 2024 baseline to obtain projected TX95p days at each horizon. The TWFE coefficient then translates the increment in TX95p days into projected annual firm and revenue losses. Cumulative losses are computed as the annual loss multiplied by the number of years from 2024 to the horizon, assuming a constant loss rate across the projection period.

Scenario	Horizon	ΔT	Projected TX95p days	Δ days	Firm change	Firms at risk (annual)	Revenue loss (annual)	Revenue loss (cumulative)
Central (SSP2-4.5)	2030	+0.7°C	30.6	+4	- 0.66%	201	€86M	€518M
Central (SSP2-4.5)	2040	+1.0°C	32.4	+5.8	-0.94%	287	€123M	€1,974M
Accelerated (SSP5-8.5)	2030	+1.0°C	32.4	+5.8	- 0.94%	287	€123M	€740M
Accelerated (SSP5-8.5)	2040	+1.6°C	35.8	+9.2	- 1.50%	459	€197M	€3,159M

Table 7: Projected business losses under IPCC AR6 climate scenarios.

Baseline (2020 - 2024): 30,623 firms · €13,164M real revenue · 26.6 TX95p days/yr. ΔT relative to 2020 - 2024 observed baseline (IPCC AR6, Central Europe). Conversion: 5.75 TX95p days per +1°C (OLS, ERA5-Land 2005 - 2024). TWFE coefficient: -0.163% per additional TX95p day per year (annualised cumulative effect, Dell-Jones-Olken model, lags=2). Revenue in constant prices (Slovenia GDP deflator, Eurostat)⁹

Under the central scenario, Podravska could lose around 201 firms per year by 2030 and 287 by 2040, with associated annual revenue losses of €86M and €123M respectively. Under the accelerated scenario, these figures rise to 287 firms and €123M by 2030, and 459 firms and €197M by 2040. Cumulated over the full period to 2040, total revenue losses could reach between €1,974M and €3,159M depending on the emissions pathway followed.

These figures should be interpreted in light of the highly unequal spatial distribution of economic activity within the region. Total annual revenue in Podravska averaged €13,164M over 2020–2024, but this aggregate is heavily concentrated: Maribor alone accounts for nearly half of regional revenue (48.5%), and the five largest municipalities (Maribor, Slovenska Bistrica, Ptuj, Hoče-Slivnica, and Kidričevo) together represent 78.2% of the total. The median municipality generates only €38M per year. This concentration has important distributional implications: the projected losses in absolute terms will fall disproportionately on the larger urban municipalities, whilst smaller rural municipalities, though individually less exposed in revenue terms, may face proportionally greater difficulties in absorbing the loss of even a small number of firms given their limited economic base.

Several caveats apply. The temperature-to-TX95p conversion factor is estimated from a twenty-year historical window and carries uncertainty; longer series would improve precision. The TWFE coefficient for TX95p days on firm numbers is estimated over a sample of 41 municipalities, and given the limited number of clusters the projections should be read as indicative order-of-magnitude estimates rather than precise forecasts. Finally, the scenarios assume that the structural relationship between heat anomalies and firm dynamics estimated over 2005–2024 remains stable over the projection horizon, which may not hold if firms adapt or if the sectoral composition of the regional economy changes materially.

⁹ The projected losses are derived in three steps. First, the historical sensitivity of TX95p days to mean temperature is estimated from the ERA5-Land series (2005–2024), yielding 5.75 additional TX95p days per degree of warming. Second, temperature increments for 2030 and 2040 are taken directly from IPCC AR6 regional projections for Central Europe under SSP2-4.5 (central scenario) and SSP5-8.5 (accelerated scenario), applied relative to the 2020–2024 observed baseline. Third, the resulting increase in TX95p days is multiplied by the annualised cumulative TWFE coefficient estimated in Section

3 Governance Structures

This chapter maps the governance of climate adaptation in the Podravje region, identifying the key actors and the ways they interact. The analysis draws on fifteen semi-structured interviews with officials and practitioners from municipalities, regional institutions, non-governmental organizations (NGOs), and emergency services, complemented by a survey of forty-six quadruple-helix stakeholders.¹⁰ Section 3.1 outlines competences and cooperation across municipalities, agencies, firms, research bodies, and civil society. Section 3.2 examines the adaptation-oriented regional innovation system, detailing prevailing adaptation visions and measures, and how innovation for adaptation is understood and supported. The challenges section (3.3) highlights system-level barriers - such as fragmented mandates, capacity constraints, and funding gaps - as well as specific problems of smaller-sized municipalities. The chapter concludes with an outlook on opportunities on how to move forward (3.4).

3.1 Stakeholder Landscape

Stakeholder Map — Climate Change Adaptation, Maribor / Podravje Region

X-axis: Interaction/Cooperation (Q14 mean) | Y-axis: Perceived Influence (Q15 mean) | Dividing lines = overall means



Figure 31: Stakeholder Map - Climate Adaptation Governance in Maribor and Podravje Region. Influence-Interaction Matrix.

As part of a survey among key organizations involved in climate adaptation in Podravje, we examined their interactions with other stakeholder organizations and how they perceive their influence over decision-making. Figure 31 summarizes the results by showing an influence-interaction matrix that places stakeholders in four sections. Perceived influence over decision-making is highest for **national ministries, municipal governments, and international organizations**, highlighting the multilevel nature of adaptation governance. Several groups cluster around the interaction/influence mean (e.g., **academics, regional institutions, NGOs**), suggesting they could become “Key Actors” with targeted engagement. Currently not included in the matrix, **local environmental agencies** were mentioned in the interviews as potential actors who could support municipalities in their future adaptation efforts. At present, these agencies are primarily focused on mitigation. **Workers’ unions** and the **private sector** are perceived as least engaged and least influential in the context of climate adaptation in the Podravje-Region. The following describes how adaptation is governed at different governance levels, starting with the municipal level.

¹⁰ For more details on the survey, see Chapter 5.

Municipalities as key actors:

Podravje is characterised by a **predominantly small-municipality structure**; divided into 41 municipalities, of which 29 (71%) have fewer than 5,000 inhabitants and 36 (88%) have fewer than 10,000. Smaller municipalities often only have small administrative units with around 5 to 15 employees.

Approaches to govern adaptation varies in each municipality. In Maribor, the largest and most populous municipality in Podravje, adaptation is governed by cooperation between different departments, often project-based. As one interviewee describes the organization of adaptation in Maribor Municipality:

“Not really one person, but in several departments [...]. We have, for example, for greenery, they're doing their work and then we have environment protection and also the [EU] project office.” [Maribor Municipality]

In another smaller municipality, a **single employee informally coordinates** with others on all climate-related topics. Another small municipality reports to lack any formal strategies and **tackle adaptation on an ad-hoc basis**, identifying needs such as irrigation or heatwaves as they come up. Both report that the current approach is not sufficient enough to handle climate challenges (see more in Chapter 3.3.1).

Another municipality governs climate adaptation primarily by **mainstreaming it across all municipal departments**, rather than relying on one dedicated specialist:

“everyone working in the municipality should understand what does it mean [and] how they can contribute from their specific [area] [...] to look every project really from the point of how we are resilient to future change.” [Municipality in Podravje]

The aim is for staff responsible for areas such as schools, farming, water, or wastewater to **recognize how specific climate risks affect their own area of work**. This approach is **considered effective** by the employee because adaptation becomes part of **routine decision-making** rather than “something special”, with staff themselves identifying solutions to problems such as groundwater decline, heatwaves or biodiversity loss affecting their areas of work. The interviewee stresses that this requires knowledge-building for employees and dedicated leadership in the municipality.

(Cross-)regional institutions:

The NUTS3 level ‘Podravje’ or ‘Podravksa’ is a **statistical region without formal powers or elected officials**. Nevertheless, some Podravje regional institutions exist that aim for better cooperation between the municipalities: Most importantly for climate adaptation are: Regional Development Agency (RDA Maribor-Podravje) and the Energy and Climate Agency Podravje (ENERGAP). Additionally, some formal institutions for cooperation exist even though their well-functioning is questioned due to the lack of regional administration by one interviewee (see more on the challenges in Chapter 3.3):

*“So there is the **regional council with 41 mayors of the municipalities** [emphasis added] established. But they are always seeing especially their municipality, not the region.” [Regional institution]*

Next to regional institutions focused on the Podravje region, several cross-regional institutions exist, comprising larger territories than Podravje. Most importantly, the **Association of Municipalities and Towns of Slovenia (SOS)** has established a **“Climate Office”** that plays a crucial role in providing knowledge, training, and support for climate adaptation and resilience in municipalities. The SOS also works as a bridge between the national and local level.

National and EU level:

The national level is most frequently **referred to for strategic direction, planning, and funding**. A recent national mandate requires regional development agencies to oversee and develop regional climate change adaptation and mitigation strategies:

“It was top-down from the national government. The initiative was given to the regional development agencies. It’s one of the required documents. It’s also for getting the new EU funding.” [Regional institution]

The EU is mentioned often as central to funding and priority-setting, i.e., by illustrated by the following quote:

“Without EU funding, almost nothing could get done [...]. It shapes the strategic positioning, because we know what the EU is funding. So we also try to align the strategic documents in a way to show that we are doing this.” [Regional institution]

This is also criticized by one interviewee, notably because EU projects are short-termed:

“The money for the nature-based solutions [...]. It shouldn’t come only from European projects. It should come from the government or some municipality funding. [Cross-regional institution]

National and Regional Emergency Response Structures:

Emergency responses, such as civil defense in case of disasters, are primarily national, with regional branches acting as first responders. Municipalities also have their own local divisions. There is no regional division but multi-municipal divisions. For Podravje, one is located in Ptuj and the other one is in Maribor, which covers a bit more than half of the municipalities. They operate under a national hierarchy, which can sometimes be inflexible and impractical for specific local disaster situations, according to an interviewee:

“They have some rules that sometimes don’t make sense when the disaster happens in one or the other municipality. And some municipalities are trying to adapt some of those rules in order to serve better to the people.” [Regional institution]

Rigid rules here, e.g., refer to strict hierarchies down from the national levels and difficulties in cooperation across administrative boundaries. However, there is an ongoing project by the Red Cross actively seeking to connect municipalities for disaster preparedness, by building a region-wide alliance of municipalities to operate as a single team. Given limited volunteers, they argued, a broader regional approach enables joint mobilization and more effective assistance.

3.2 Adaptation-oriented innovation system

3.2.1 Visions of adaptation and dominant measures

Climate change adaptation in my region...

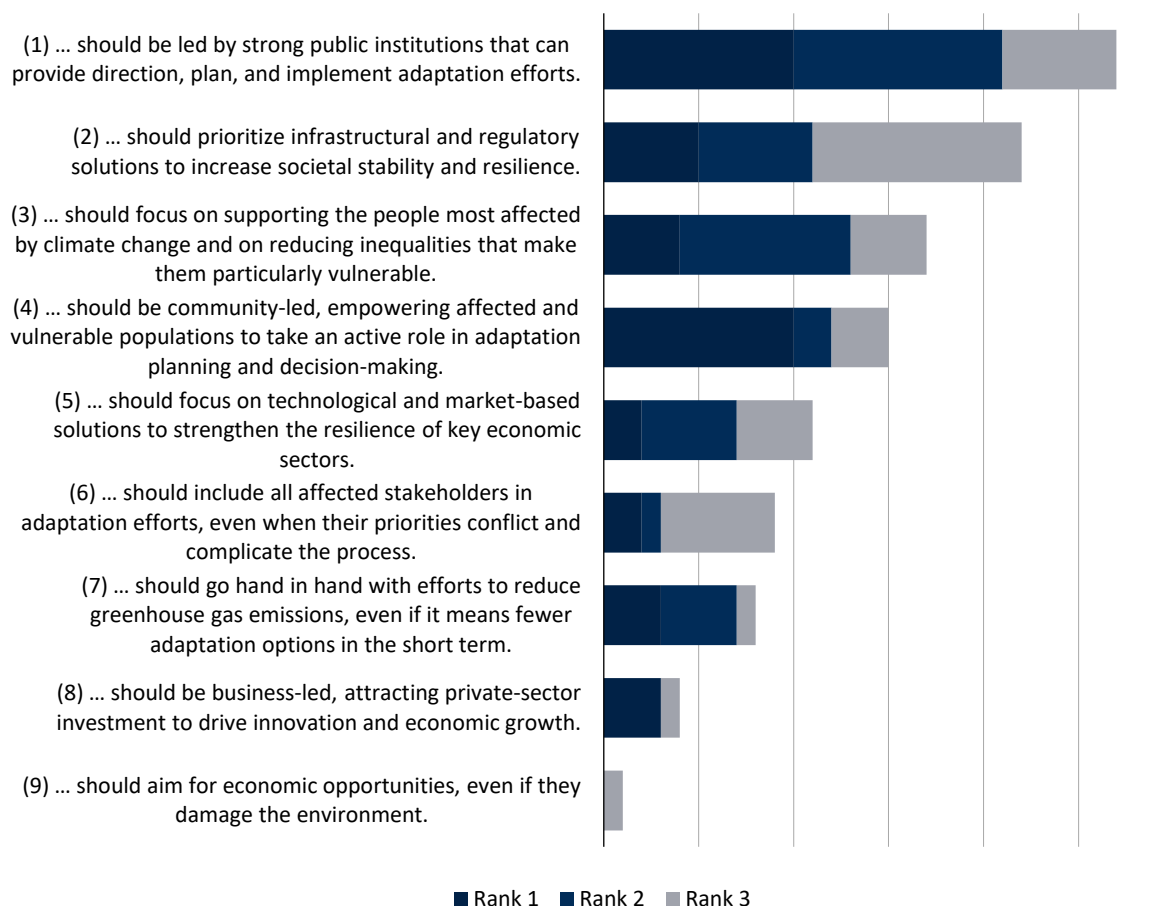


Figure 32: Visions on climate change adaptation in the Podravje Region.

Survey question: “Finally, we would like to hear your views on climate change adaptation in your region. From the list below, please select the three statements that are most important to you and rank them according to the extent to which you agree with them.”, n=42.

This section examines how people envision adaptation in Maribor-Podravje and which type of adaptation measures are currently being implemented. In the survey, we asked participants to select and rank the three most important statements about adaptation in their region. The statements reflect different visions for adaptation governance (see, e.g., Kanarp et al., 2025). Overall, Figure 32 shows that while every statement received at least one vote, responses cluster around a public-institution-centered and equality-oriented vision of adaptation.¹¹

Governing adaptation through an eco-modern state

The two most strongly supported statements, (1) and (2), align with an adaptation vision of the “eco-modern state”, relying “on **centralized planning and expert knowledge**” and an efficiently working public sector (Kanarp et al. 2025, p. 531). Consistent with Kanarp et al.’s observation that this vision is the most dominant one in policy documents, practitioners in

¹¹ With a modest sample size (n = 42), these results should be read as indicative rather than definitive. Still, the pattern is consistent with interview material and provides a coherent picture of how adaptation is framed locally.

Maribor-Podravje appear to see public institutions as the leading actors to aim for regulatory and infrastructural measures as the main objective of adaptation.

This emphasis also shows in practice, i.e., an increased focus on the **development of adaptation strategies** across different governance scales. Regional agencies are preparing comprehensive plans - mandated nationally - that cover climate mitigation and adaptation across the entire Podravje region and involve all municipalities and relevant stakeholders:

“based on the new Climate Act that was adopted last year, the regional development agency and climate agencies have to prepare regional [climate] action plans.” [Regional institution]

Municipalities are likewise required to prepare their own climate and energy adaptation strategies. Many are delayed, and interviewees noted that progress often correlates with the frequency or severity of recent impacts such as heat waves, flooding, or drought.

Advancing adaptation through climate justice¹²

Second, statements (3) and (4) reflect elements of the **“just adaptation”** vision: prioritizing vulnerable people who are most affected by climate change and empowering them to participate in decision-making. These adaptation measures are supposed to be more transformative and inclusive, even though it is still blurry how this can be best achieved (Kanarp et al., 2025). While Kanarp et al. (2025) find this narrative more common in academic discourse than in policy and grey literature, the survey indicates that local practitioners see justice and community leadership as important to successful climate adaptation. The following quotes from two different municipalities illustrate how they implement their vision of “just adaptation”:

“So I divided my municipality not only by elderly and small children, but also depending on the risk. For example they live in quite remote areas so they are as a group, they're a quite vulnerable group because in the case of road destruction or they have a bad internet connection, they don't have a telephone...” [Municipality in Podravje]

“We invited a lot of also nursery homes, so a lot of people who are working with the vulnerable groups to prepare the measures and the measures are from raising awareness to investment projects, greening projects...” [Maribor Municipality]

As **examples of how a justice-oriented vision of adaptation translates into practice on the national level**, interviewees pointed to Eko Sklad's state program targeting energy poverty by financing upgrades such as better windows, roofs, and facades, with local NGOs assisting residents with the paperwork. **At the municipal level**, actions include heat-preparedness newsletters for pregnant people and young children; sector-specific support such as drought-focused workshops for farmers; and cooling/greening initiatives in schools and kindergartens, for example vegetated pergolas over playgrounds.

Although inclusion and improvements for vulnerable groups are often emphasized in the interviews, **most measures remain incremental**. NGOs also criticize the limited support for intersectionally marginalized groups, noting that many low-income older adults still go to shopping malls to cool down on hot days because they have nowhere else to go. Municipal employees, on the other hand, also tell of the difficulties involved with just adaptation, notably in reaching a wide range of stakeholders, illustrated by the following quote:

“It was tough because we had to cooperate with all departments and especially also NGOs and also with people who are not employed by the municipality so we have tried to make a consensus with other associations, handicapped people, we have searched for example pensioners, elderly people who are living alone at home and also kindergartens.” [Maribor Municipality]

Accelerating adaptation through markets and technology

Market- and technology-led framings are much less prominent in the survey. Although statement (5) - support for technological and market-based solutions - can be found mid-range

¹² A detailed analysis of this particular vision and of the inclusion of justice dimension in Podravje's current adaptation system can be found in Chapter 4.

in figure 33, only five participants think businesses should lead adaptation (statement (8)). Likewise, the growth-first framing that accepts environmental damage for economic gain (statement (9)) received minimal acceptance. Together, these results suggest that green-growth or high-tech innovation visions are not very dominant in Maribor-Podravje, suggesting that private investment is seen as complementary at best. In interviews, the main example of company-led adaptation that was mentioned was the installation of nature-based solutions (e.g., green roofs) on corporate grounds.

Differences between actor groups

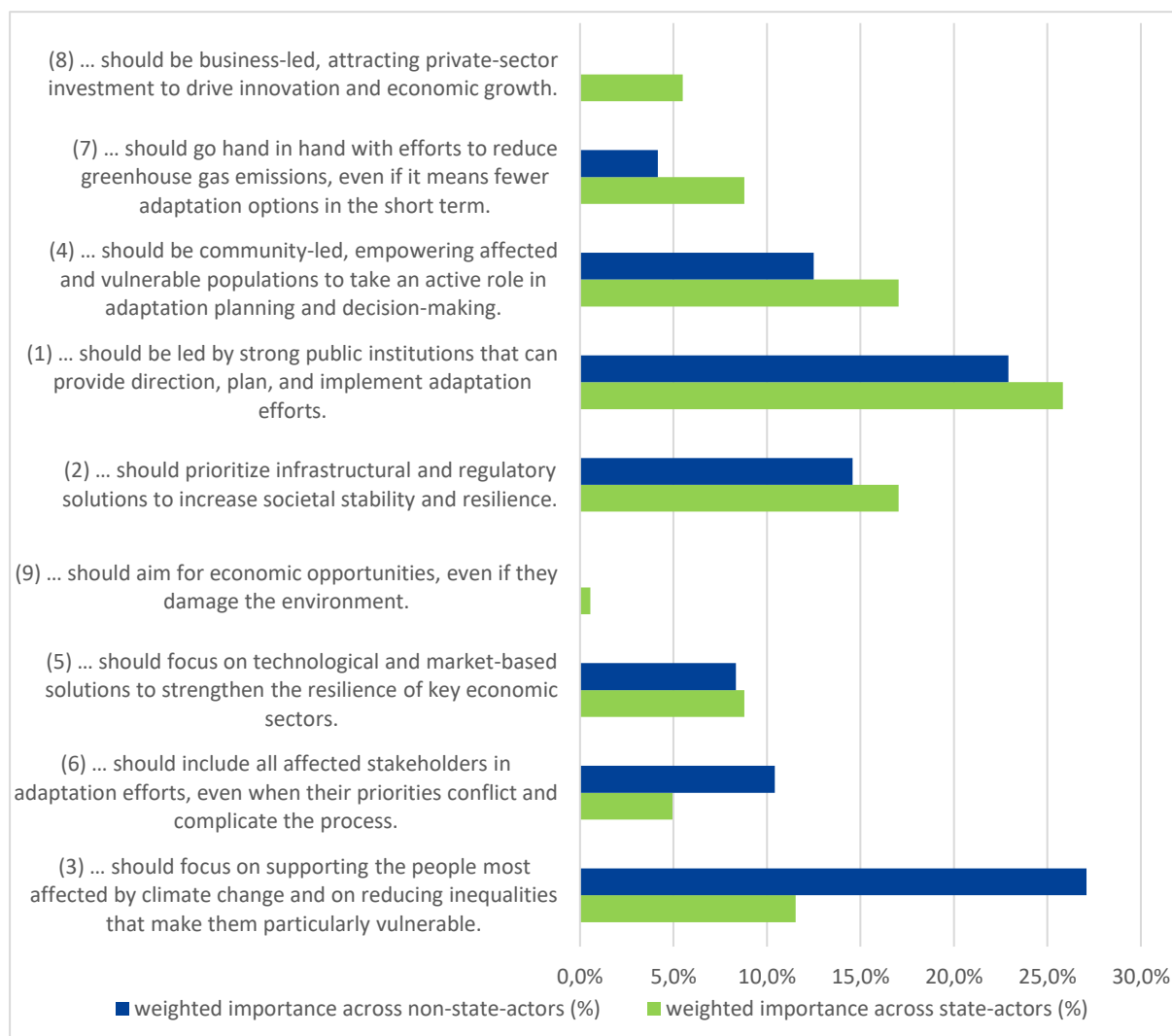


Figure 33: Difference on climate adaptation visions between state- and non-state stakeholders (in %).

To compare how different actor groups perceive adaptation priorities, we grouped survey respondents according to their self-identified affiliation: “government/administration,” “economic actor,” “academic actor,” “civil society,” or “other.” Because 32 respondents identified as government or administrative actors, compared with only 14 respondents across the four non-state categories - despite extensive outreach to relevant organizations - we combined the latter categories into a single non-state actor group for the analysis. We aim to answer the following question: **How is the relative importance of these priorities distributed among state versus non-state actors?**

The comparison between state and non-state respondents reveals several differences in the relative importance assigned to these adaptation narratives. State respondents place slightly greater emphasis on business-led approaches, simultaneous emissions reduction, and strong public institutions. In contrast, non-state respondents attach greater importance to supporting

people most affected by climate change and reducing inequalities (-15.5 percentage points) and to including all affected stakeholders (-5.5 percentage points). An inconsistency is observed regarding community-led approaches (Statement 4), which conceptually align with stakeholder inclusion (Statement 6) and vulnerability reduction (Statement 3): While the two latter statements are clearly prioritized by non-state actors, community-led approaches are more important to state-actors. This pattern cannot be explained by the available material; however, it reflects, at least to some extent, the diversity of narratives among state actors.

Overall, the results suggest that **state actors tend to place relatively greater weight on institutional and economic, whereas non-state actors place greater emphasis on social vulnerability, inclusion, and the needs of affected populations.**

3.2.2 Conceptions of innovation in the adaptation context

This section examines dominant understandings of innovation in the adaptation context and how they relate to the adaptation visions above.



Figure 34: Word cloud of interviews coded as “understanding of innovation” (and sub-codes), MaxQDA.

Overall, interviewees referred to four main types of innovation: As a first and most prominent type, **organizational, governance or institutional innovations** are mentioned. As such, innovation is about “*new ways of doing things*,” including “*how one reacts, [...] how one plans*” for climate risks [Interview with a rural municipality]. In this view, better organization, cross-sectoral governance, and collaboration are seen as particularly important, as emphasized by the following quote:

“So if we can find an instrument that would force our people to collaborate more, I think that would be the most innovative.” [Regional institution]

Secondly, **nature-based innovations** are mentioned often as concrete innovations for climate adaptation. Especially in smaller municipalities with less concrete expertise on CCA, NBS are viewed as central to adaptation, sometimes as the dominant understanding of what adaptation is, as the following interviewee criticizes:

“They think [...] only green areas are adaptation. Because this is how our Slovenian government is presenting it.” [Regional institution]

Concrete solutions driven by municipal initiative and funded through EU projects: greening bus stops and depaving to plant trees to creating green islands. Other examples also came up combining nature-based solutions and the vision for just adaptation, when nature-based

solutions are specifically targeted at places where vulnerable groups of the populations live (e.g., in kindergartens).

Thirdly, **social or behavioral innovations** were sometimes mentioned, often connected with an emphasis on more public engagement in adaptation policy processes. Importantly, innovative solutions should connect to people's values, identity, and emotions to shift behavior, as emphasized by the following quote:

"If people don't find this as part of their identity, they don't change their behavior, you did nothing." [Research & policy institute]

While this type of innovation is recognized as important, no concrete examples were provided in the context of adaptation.

Last, **technological innovation and private-sector roles**: When asked directly about innovation for adaptation, technological tools and business involvement emerge more strongly than the analysis of the survey alone would suggest. Some interviewees state the need for more innovative technologies to monitor landslide or fire risks also in areas that are difficult to reach. The view on technological innovation also shows implicitly. One interviewee - when asked about innovation in a public utilities company - seems to be skeptical about potential innovations due to the structure of the company:

"[a company] which deals with transport, bus services and so on. They already have electric buses and things like that – what further innovations could they come up with?" [Public utilities company]

Another interviewee - when asked about innovation for adaptation in the business context replied:

*"if it's **real** [emphasis added] innovation, they will put a patent on it, and they will not show it to the general public"* [Cross-regional institution]

Both quotes suggest an implicit narrowing of innovation to technology in business contexts, which can obscure organizational and social dimensions that interviewees otherwise value.

In **summary**, there is broad support for innovation as collaboration and social change, consistent with the "eco-modern state" plus "just adaptation" mix identified above, while the private-sector/technology track is viewed as helpful but not leading. Current adaptation initiatives are mostly institution-driven, reflecting the dominant role of public actors and the constrained capacity of firms. NbS and institutional innovation are most prominent locally, while technology or company-based innovation for climate adaptation remains sectoral and not very frequent. As for civil society actors and NGOs: They engage in different kind of innovative practices, e.g., social innovation, but also report difficulties:

"Well, we're always limited with open calls, you know. So, you can get as creative as the open call allows it. That's a very big limitation [for innovation], I think, for the NGO sector." [NGO]

The following chapter examines these challenges in greater detail.

3.3 Key challenges

3.3.1 Governance challenges in the regional innovation system

Nearly all interviewees mention that a **lack of cooperation** hinders climate adaptation across governance levels in Podravje. "Everyone works on their own... we're not really connected, and no one can bring us together," an NGO representative observed. Many trace this to **the region's status as a mere statistical unit** without *real* authority or dedicated funding. Interviewees criticize that the council of mayors for the region still tends to prioritize local agendas because no external pressure "*is forcing*" the municipalities "*to cooperate*" [Interview with a regional institution]. Consequently, as one regional representative put it, there is "*a lack of understanding of what is the regional priority and what are the municipal priorities,*" a problem magnified by the large number of very small municipalities in Podravje.

"We should set up a region, like in Austria, and all that, because with so many municipalities, it's very difficult to get anything done." [NGO]

While some interviewees mention examples of collaboration, e.g., in the area of essential utilities like freshwater supply, **cooperation rarely extends to climate adaptation**. Fragmentation and a preference for local control hinder regional projects, and unilateral measures can even shift risk to neighboring areas, for example, riverbank works that protect one municipality but worsen flooding in another municipality.

The interview material points to similar **structural weaknesses in the regional innovation system**, most prominently **fragmentation and a weak regional governance system**. This frustration was captured particularly clearly by one interviewee:

"I wouldn't say that there is any innovation system for the region of Podravje. What is done [at this level] is done by the Development Agency, Energy Agency, and some agencies that work at the level of this statistical region." [Research & policy institute]

Companies, universities, and research institutes often work in isolation, with few spin-offs and weak links between research and practice. *"We've got a faculty here, we've got lots of good companies here, but we're not connected,"* observed an NGO representative. This is also hindered by a political landscape where long-serving officials may **prioritize established networks over new initiatives**. Prescriptive funding schemes, particularly for NGOs, restrict innovative potential. The broader environment **lacks clear priorities for long-term investments**. There is a perceived disconnect between innovative ideas and their practical implementation.

Funding constraints and misaligned incentives reinforce this fragmentation. Most resources come from national or EU programs, while local budgets - especially outside Ljubljana and Maribor - are thin. Additionally, according to one interviewee, **national climate finance remains heavily focused on climate change mitigation** (about 90%), leaving adaptation underfunded [Interview with a cross-regional institution]. The financial crisis and the COVID-19 pandemic have also reduced national co-financing, shrinking innovation funds, and increasing institutional burdens [ibid].

The same holds for companies in Podravje: Small and medium-sized companies struggle to survive economically, **leaving little budget for innovation**. As one interviewee put it:

"We have a lot of also startups here. But I don't know, mostly companies here are trying to survive this time of period. And it's not so about innovative stuff. It's more about survival stuff." [Cross-regional institution]

In the innovation context, the **Stajerska chamber of commerce is an important player in the Podravje region**, the largest regional commerce chamber in Slovenia - primarily supporting SMEs and not directly engaging with municipalities. They are also coordinating the "Strategic Research and Innovation Partnerships" (SRIPs) in the context of climate and sustainability transitions, but they often involve companies from other regions than Podravje that have better socio-economic indicators, drawing attention to the **spatial unevenness between the eastern and western cohesion regions in Slovenia**.

While there are **some programs dedicated to fund projects in the eastern cohesion region**, this is sometimes circumvented by institutions situated in the eastern cohesion region but taking the money for national research projects. Related problems with funding are **short-term project cycles** that sometimes lead to new infrastructure that lacks money after the end of the project and is abandoned subsequently.

Next to this, interviewees mentioned they perceive **conceptual confusion** about what counts as adaptation. **Shifting terminology and a narrow view of what counts as "adaptation"**

make it harder to find the right funding streams and to build a common agenda, as one interviewee notes:

“People will understand [...] heat waves, [...] droughts, [...] floods, [...] landslides. But they will not understand this umbrella word.” [Regional institution]

This lack of clarity worsens both other issues: funding and a lack of cooperation. It limits what people might think of as suitable funds for adaptation and weakens a shared understanding.

3.3.2 The challenges of smaller, rural municipalities:

Given the structure of Podravje consisting of predominantly small and rural municipalities, a focus in this report is placed on their role in adaptation efforts. Overall, smaller rural and more urban municipalities report similar challenges. However, without a regional authority to align adaptation priorities, redistribute funds, or “force cooperation,” many interviewees highlight how the large number of predominantly small, rural municipalities of Podravje face them more severely.

These municipalities often operate with **limited staff**, **limited access to expertise**, and **constrained capacities**. In many smaller municipalities, only four to ten people work in the administration which makes it difficult to gather the expertise. Officials describe being largely reactive, lacking the resources to plan and implement larger-scale measures.

“We’re still at the stage where we’re just reacting. It is very difficult to plan and carry out anything on a larger scale with the resources we have” [Rural municipality in Podravje].

While local actors recognize changing climatic patterns, they lack the means to map or forecast them. They have less access to expertise, e.g., in the form of research institutes or universities in their areas, this leads to knowledge gaps. A municipal expert cited recurring landslides *“in an area where there were actually hardly any landslides - in the past”* [Small rural municipality]. This **knowledge gap also hinders collaboration** in that area, as practitioners feel uncertain about appropriate adaptation measures and therefore struggle to coordinate across stakeholder groups and governance levels.

“There is cooperation, but not in this area. I get the feeling here that nobody really knows yet how to adapt properly. [...] So there can’t be any cooperation between the two either, because we actually don’t yet know what we’re supposed to do.” [Rural municipality in Podravje]

Financial constraints deepen capacity gaps. Limited local revenues and weak economies hinder innovation - and limited expertise applications for additional EU funds more difficult. Costs are pushed higher by **extensive infrastructure per capita** and mountainous terrain in some municipalities: “We have more metres of infrastructure per capita [...] costs are much higher than in flat areas” [Small, rural municipality in Podravje].

“Municipalities are really poor. [...] Innovation in municipalities is not funded by any funds. [...] They are not financed by the economy, because the economy does not exist in these small municipalities. So they have no money.” [Research & policy institute]

“I mean national funding is spread throughout the country but if you look on the funding on local levels of course funding in Maribor and Ljubljana it’s much higher than in some small village. So the organizations being placed in smaller towns or villages have much fewer opportunities of reaching local funds.” [NGO]

Some participants, however, also contest the idea that smaller municipalities just face disadvantages compared to more urban municipalities. Instead, they point to **the advantages of smaller sized municipalities** - especially when there is strong local leadership. Smaller municipalities can **move quickly** on low-cost, incremental measures, **face fewer bureaucratic steps in decision-making**, and can easily **reach and involve residents for co-creation**. Additionally, one interviewee believes that people in a rural environment are very self-reliant and embedded in community structures:

“I think the people who live here are actually very adaptable. I believe they’ll adapt, but we don’t yet know how. [...] Here, you won’t get very far with global politics and that sort of thing. They’ll

do what's best for them. And they'll adapt to everything. They'll do it the way they think is best.[...] Ever since the break-up of Yugoslavia [...] People have adapted. It's a poor region, but people don't live badly." [Rural municipality in Podravje]

3.4 Opportunities & Way forward

Despite the challenges and problems, interviewees pointed to concrete solutions they already implemented or suggested concrete ways to move forward. Several concrete solutions are suggested, including the **need for constant awareness-raising campaigns**, as there is much room for improvement in public understanding. Participants also propose **supporting or incentivizing local residents in maintaining public green spaces**, even if municipally-owned, due to their positive impact on cooling the city. In the recommendations, a strong emphasis is placed on the **funding of nature-based solutions**, which should come from government or municipal budgets rather than solely from European projects. Even though municipal actors also emphasized that EU projects are useful for piloting, demanding measures that are hard to implement, **using them to engage stakeholders and build momentum for change**. Additionally, an interviewee calls for more national projects for innovation in nature-based solutions for SMEs, as companies are quick to react when funding is available:

"If there is money and there is a project proposal to be written, the companies react really fast. So, if there would be a national funding for innovation in climate change, the companies would react. But now, I don't think there is. And climate change is always just a part of project proposals." [Cross-regional institution]

In terms of innovation, interviewees also see a gradual mindset shift, **with younger generations more open to innovation**. Policy design is beginning to rebalance regional opportunities:

"Now you get more points if one of the consortium partners is from this part of Slovenia... companies from the west are intensively looking for partners here to get more points" [Cross-regional institution].

Regarding the specific challenges of smaller municipalities, one municipality is suggesting all to pursue an **adaptation mainstreaming approach** - integrating climate resilience into every decision. As the official explained, for small administrations *"it is an illusion to say that I will have one person to cover this [...] everyone working in the municipality should understand what it means and how they can contribute from their specific"* field [Interview with a small municipality]. This model aligns with the challenges of tight budgets and hiring constraints. At the same time, internal knowledge and leadership on adaptation can be built. For better inter-municipal coordination on adaptation, it would also be helpful - as one interviewee suggested - to **designate a contact person for all climate-related topics in each municipality** who can then distribute the knowledge within the municipality.

Lastly, it is recommended in a political context to frame adaptation as a way to make it better for the people:

"They have to understand that in the end this is the citizens, this [is about] the voters [...] It's not about the road, about the rain, about the droughts but about the people." [Municipality in Podravje]

4 Justice Dimensions in Adaptation Planning

Justice is a malleable term which can mean different things to different people at different times, and people often disagree about when a situation or event is just. Justice is often thought of having distinctive “forms”, all of which are important but may take on different degrees of importance to groups or individuals depending on what they value. For climate adaptation a typical breakdown of these “forms” are:

Form	Description
Distributive Justice	justice in the way that the risks of climate change, and the costs and benefits of adaptation are distributed within a social context.
Procedural Justice	justice in the processes which are used to come to decisions, including who has a say in decisions, the degree of influence they have, and the rules which govern these interactions.
Recognition Justice	justice in whose needs, desires, and interests are accounted for in adaptation planning and governance, including the differences in the ability and needs of different social groups in adaptation.
Restorative/Transitional Justice	justice in the way in which existing or previous injustices are accounted for and rectified.

Table 8: Forms of justice in climate adaptation

Within **distributive justice** specifically people can also have different answers to what kind of distribution of costs and benefits are just – and how we answer this question will impact what we see as just or unjust, how we expect public finances to be spent, how we expect costs and risks to be shared.

In this section we use these categories of justice considerations to explore (potential) justice considerations in Maribor municipality, drawing from:

- A review of the strategic planning context for CCA at the National and Municipal Level utilizing the Adaptation Justice Index.
- Issues identified through the semi-structured interviews conducted with stakeholders in CCA planning and implementation in Maribor/Podravje municipality and district.

4.1 Strategic Planning Context

Implementation of CCA planning on the city and regional level is shaped by national and city level strategic planning, and how well indicators of justice are incorporated into the planning phase sets the conditions for achieving just adaptation.

The Adaptation Justice Index (AJI) is a tool for examining how well indicators for each of the four forms of justice (Recognition, Distributional, Procedural, Restorative) are incorporated into CCA planning across scales, including the national, regional, and municipal. It contains sets of 3-5 indicators for each form of justice, which can be achieved on a scale of 0-3. The highest score a plan can achieve is 48. The list of indicators and the scoring methodology is detailed in the appendix to [The Guidance on Just and Transformative Adaptation](#) and in the original paper by [Juhola et al \(2022\)](#).

Indicator	Distributive Justice (D)	Procedural Justice (P)	Recognitional Justice (R)	Restorative/Corrective Justice (C)
1	A risk mapping/assessment has been conducted.	Adaptation strategy details who participates in the strategy process.	The strategy acknowledges that adaptation needs are different across groups in society.	The strategy acknowledges the need to compensate for the diverging impacts of climate change
2	There is a process for identifying vulnerable groups.	The adaptation strategy has involved participation during different phases of the process.	The strategy acknowledges the impact of existing societal structures on vulnerable groups in adapting to the impacts of climate change.	The strategy has compensation measures to deal with maladaptation.
3	There is a process that assesses the distribution of benefits.	The strategy allocates responsibility to adaptation.	The strategy acknowledges adaptation as a way to secure basic human rights.	The unequal distribution of resources for adaptation is compensated for by redistribution.
4	There is a process that assesses the distribution of costs.	The adaptation strategy has a structured plan for implementation.		
5	The strategy identifies the possibility of a distribution of negative impacts (e.g., maladaptation).	The adaptation strategy has a plan for updating and evaluating the strategy.		

Table 9: Justice Indicators based on the Adaptation-Justice Index

At the national level Slovenia's Climate Change Adaptation strategy is being prepared in accordance with the Guidelines on EU Member States' adaptation strategies and plans (2023/C 264/01). This is due to be completed in 2028. At present Risk and Vulnerability assessments have been completed for 8 key strategic sectors (Energy, Economy, Agriculture, Cultural Heritage, Traffic, Urban Settlements, Waters, Health). The authors state that:

"The preparation of the climate change adaptation strategy will take place in 4 steps:

1. Establishing an institutional framework and ensuring stakeholder support.
2. Preparation of climate vulnerability and risk assessments for ten priority sectors (water resources and water management, nature and cultural heritage conservation, agriculture, forestry, energy, infrastructure and buildings, public health, economy and settlement - cities and other urban settlements).
3. Preparation of adaptation guidelines.

4. Monitoring and evaluation.

The preparation of the Climate Change Adaptation Strategy has been conceived from the very beginning as a consultative process, in which representatives of stakeholders from all levels of decision-making, the scientific research field, the private sector, the Climate Council, the human rights ombudsman, and non-governmental organizations will participate.” ([Ministry of Environment and Spatial Planning 2026](#))

The in-development Climate Change Adaptation strategy supersedes two documents:

- [The Slovenian Strategic Framework for Climate Change Adaptation](#) (Dec 2016)
- [The Expert Basis for preparing an assessment of the risks and opportunities posed by climate change in Slovenia](#) (2014)

Also of relevance is the:

- [Resolution on the national programme of protection against natural and other disasters for the years 2024 to 2030](#)

The most appropriate of these documents for assessment with the Adaptation Justice Index is the Slovenian Strategic Framework for Climate Change Adaptation (SSF-CCA). However, as a short (16 page) strategic framework, it lacks sufficient depth needed for a complete assessment against all the AJI indicators. It is also noted that the recommendations of this framework are in the process of being superseded. Therefore, the score given in this analysis should be taken as provisional. It is hoped that an analysis of the full or draft version of the upcoming strategy can be included in the Justice Analysis which forms TiCCA4Danu Deliverable 4.3.

At the Regional or City level there is no comprehensive strategy documents dealing exclusively with Climate Adaptation. For Maribor a number of relevant documents were identified. Chiefly the Municipal Environmental Protection Program 2021-2030 is a comprehensive program detailing a number of actions for supporting environmental sustainability and climate mitigation/adaptation on a sector by sector basis. Section 3.2 of this report specifically deals with climate adaptation actions and challenges faced by Maribor. This strategy was created in alignment with the Environmental Protection Act (2020). Additionally, Maribor was the first city in Slovenia to develop a dedicated Heat Action Plan developed in association with [Interreg Ready4Heat](#). While heat is far from the only climate adaptation risk, this is a unique for of targeted adaptation planning.

Other key strategies and plans include:

- The Local Energy & Climate Concept
- Climate Change Vulnerability Assessment ([Interreg Mission CE Climate](#))
- Strategy for the Transition to a Circular Economy
- Sustainable Urban Strategy
- Social Welfare Strategy
- Smart City Maribor Strategy
- Comprehensive Logistics Strategy
- Vulnerability and Risks Study Maribor/Podravje Region (Energap 2024).

As with the national level framework, the lack of a comprehensive/dedicated climate adaptations strategy for the city/region the assessment with the AJI is based on analysis of the Municipal Environment Protection Program (MEPP), the Heat Action Plan (HAP), and the Climate Change Vulnerability Assessment (CCVA) and aggregated. This is a limitation of the analysis and limits comparability with assessments of dedicated city/regional level adaptation plans; such as those prepared in Juhola et al (2022)’s original paper on the AJI tool. However, it is helpful to get an overview of how justice is integrated into the planning processes of Maribor municipality.

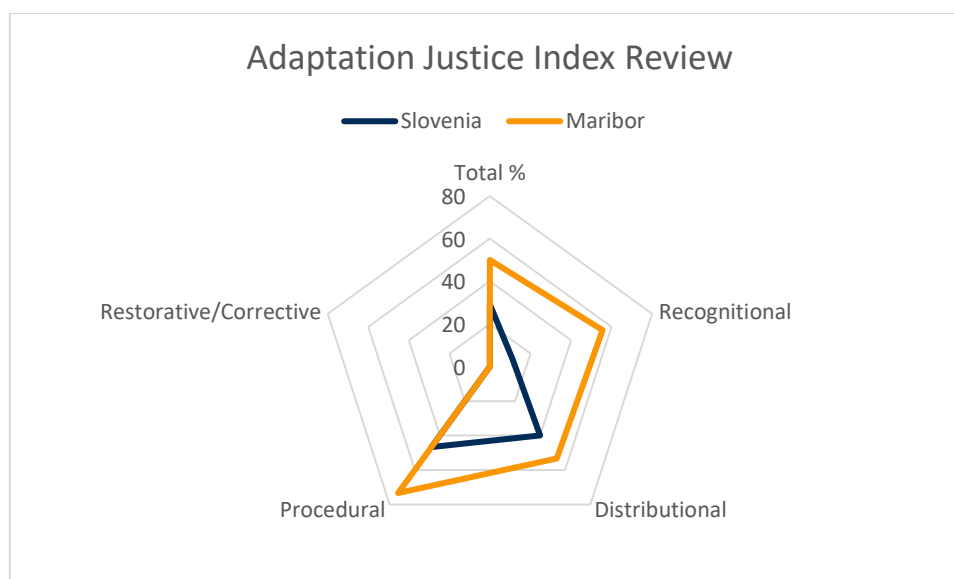


Figure 35 Assessments of Slovenian National and Maribor Municipal adaptation strategies with the adaptation justice index, showing achieved score as a percentage of the total possible across indicators of distributinal, procedural, recognitional, and restorative/corrective justice.

For methodology please see Section 8.7

4.1.1 Distributive Justice Indicators

- On the national scale a risk assessment study has been conducted that identifies key climate risks for Slovenia and links these to the measures and policies detailed in the report. In Maribor a risk assessment was conducted as part of MISSION CE CLIMATE, and was disaggregated by geographical region (lowland and highland), climate scenario (RCP4.5 & 8.5), and then by sector. Key risks are identified but these are not yet clearly linked to specific actions leading to a score of 2.
- In Maribor a vulnerability assessment was also conducted as part of the MISSION CE CLIMATE project. This analyzed sectoral vulnerability and exposure to different climate hazards, and identified in general terms the proportions of Maribor's population with common markers of increased vulnerability to climate change (e.g., the old and young, employment status, possession of home insurance, a selection of health issues, etc). To go further, repeated vulnerability assessments might take a bottom up approach and allow citizens to identify to planners how vulnerability is lived in practice, such as how these factors intersect to create novel vulnerability.
- At both the national and municipal level there is a general discussion of the benefits that successful adaptation and making investments into adaptation can bring. For example, at the municipal level MEPP states that:

"Implementing adaptation activities and measures undoubtedly yields savings [to public finances], reduces damage during disasters, protects public health, and enhances residents' safety, as well as creating new jobs, new business opportunities, and greater investment security while fully capitalizing on certain opportunities, particularly in the tourism, agriculture, and construction sectors"

In order to go further into assessing the distributive justice of climate adaptation measures in both contexts (and to achieve higher scores with the adaptation justice index), it is necessary to assess how the benefits of new (public or private) investments into agriculture will be shared between societies – for example looking at which neighborhoods benefit most from new public spending, and whether this is being shared equitably or in a way that is proportional to equalizing the

populations vulnerability to climate hazards (though be aware that different groups in society can have different views on how public funds should be spent fairly).

- At both the national and municipal level there is a lack of analysis of how the costs of adaptation are to be shared. At the national level there is a discussion of potential funding sources for adaptation actions, but this was not deemed as being sufficiently detailed to score higher than a 1 on the AJI. We were unable to identify an analysis of cost sharing for adaptation measures in the three documents analyzed for the municipal level, and this may reflect the fact that there is no comprehensive adaptation plan for Maribor at time of publication rather than an oversight. Nevertheless, it is important for administrations to understand how the costs of adaptation will be shared in order to make assessment of the distributive justice of their overall adaptation plans. Plans where costs are not shared equally, or in proportion to the extent that actors have contributed to causing hazards may be seen as unjust according to different theories of climate adaptation justice (thought again be aware that different groups can have different expectations of what a just distribution of costs are).
- Related to the distribution of costs, both reports implicitly mention the risk of maladaptation (unintended negative consequences of adaptation measures) in general terms. Maladaptation is mentioned in the Maribor CCVA implicitly as something that can happen with adaptation, but as the aim of the report is not to identify measures there is no specific discussion of possible impacts of different proposed adaptation options. Further iterations of these risk and vulnerability assessments should commit to following up on implemented measures to identify potential maladaptive effects.

4.1.2 Procedural Justice Indicators

- At the national level there was a low level of evidence of the Adaptation Justice Index indicators being met. At the municipal level however the results were mixed based on the particular strategy/plan being evaluated; with the Heat Action Plan demonstrating high standards of procedural justice based on the indicators from the AJI (albeit with some lack of detail about the precise engagement measures used).
- At the national level, the SSF-CCA involved the invited participation of expert non-governmental stakeholders at the sectoral level, who have identified some of their sectors needs to the government. However there was limited evidence of public engagement in the development of the strategy with input appearing to be limited to invited experts.
- The SSF-CCA also promises that these sectoral stakeholders will have a role in the planning and implementation of the measures identified in the plan: “the inclusion of stakeholders and the participation of the wider interested expert public in the development of policies and the planning and implementation of measures are guaranteed”. However from the planning document what kind of participation this would be, and likewise it was noted that the section of the plan detailing the plan for implementing the guidance there was no step requiring public engagement – procedural measures focused primarily on ensuring inter-ministerial cooperation.
- At the municipal level, the amount and depth of public engagement in the development of the strategies has varied between the plans. The Heat Action Plan scored very highly according to the AJI indicators as its measures were developed through close interaction with vulnerable groups who were able to make their specific needs identifiable to the local government in person; and were included in the working group responsible for implementing and evaluating the plan. A limiting

factor however was the lack of specificity within the planning document about what this working group would do and the role that public/vulnerable groups would play in it. By having clearly specified roles and responsibilities, this would ensure that the involvement of these groups in the working group was substantive and meaningful (i.e., they had real prospects of changing what the city does and how the plan is implemented) rather than just being tokenistic.

4.1.3 *Recognitional Justice Indicators*

- At the municipal level, the MEPP had a strong human rights framing that clearly linked environmental protection in general to both international rights frameworks and the rights of Slovenes under their national constitution. Section 2.2 details the legal basis of the report and specifically notes how the environmental objectives laid out therein (including the climate adaptation objectives) are part of an effort to fulfil the State's obligations under article 72 which stipulates that:

“everyone has the right to a healthy living environment in accordance with the law; this is a right that the state must actively protect, and the law sets forth the conditions and methods for its implementation economic and other activities.

The Act also specifies the conditions and extent to which the party responsible for damage to the living environment is obligated to compensate for the damage caused.”.

The latter part of this also notes in general terms a theoretical basis for sharing the costs of adaptation – that those who have contributed the most to causing climate change ought to contribute to adaptation measures in proportion to the damage caused. However, while this high level discussion is included in the report, there is a lack of specific commitment to how the municipality intends to enact this through its adaptation planning (though again, this may be present when a full adaptation plan is drafted).

Further discussion focusses on Articles 70, 33, and 67 of the constitution, which contain provisions for regulating natural resources and public goods, private property, and inheritance. Article 70 and 72 establishes the state as the responsible actor with obligations for the management of public goods and natural resources; and the report notes that in the contexts of environmental/adaptation planning the state has to balance its obligations to protect the right to personal property. These are classic examples of the kinds of justice questions that administrations face when asked to protect the environment while also allowing individuals the right to use and dispose of their property how they see fit. While it is good to see these included in the report, there is little detail on how this impacts the municipalities adaptation planning.

- Indicator R1 of the AJI looks for evidence that climate adaptation plans recognize that the impacts of climate change are not shared equally amongst all individuals and groups in society. This point is also a core component in the EU definition of “[just resilience](#)” which requires policymakers and practitioners to:

“A: address the uneven impacts of climate change;

B: make sure that when developing adaptation responses to these impacts, individuals or social groups that are already vulnerable benefit fairly from these responses and are not disproportionately burdened ('leaving no one behind').”

At the national level, Slovenia's Strategic Framework for Climate Change Adaptation makes clear that all sectors are likely to experience impacts from climate change, but that agricultural and forestry sectors are the “most exposed” to climate change. The report also discuss adaptive capacity on a national and sectoral basis.

This implies some recognition that adaptive capacity might differ from sector to sector and therefore some sectors might have differing needs for support – however this is not made explicit. Vulnerability to climate change is discussed only at the state and sectoral level. To achieve a higher score on the AJI it would be expected that a plan should recognize that different groups in society have differing vulnerabilities and adaptive capacities, and that these should be factored into the measures that the plan will seek to implement.

At a municipal level, the CCVA notes that:

“All citizens are affected [by climate change], but the more socially disadvantaged and vulnerable groups in society are more affected, as they recover more slowly. Both socio-economic status and pre-existing chronic diseases increase inequalities between people. These are more pronounced among people living in urban and densely populated areas.”

However as the CCVA does not link to specific measures, a higher score could not be achieved at present.

- Not made explicit by the just resilience definition is the fact that both vulnerability to climate change and ability to adapt to it (adaptive capacity) are structured by social, cultural, historic, political, and economic factors; in addition to “natural” causes of vulnerability like hazard exposure. Indicator R2 asks adaptation planners to acknowledge the role that these “social structures” play in determining vulnerability to climate change; and to use this analysis as a basis for specific measures. In neither the national or the municipal level could this kind of analysis be identified.

4.1.4 Restorative/Corrective Justice Indicators

- As is expected, the restorative/corrective justice indicators were the least evidenced in the adaptation plans being reviewed, both at the national and the municipal levels. This is in line with adaptation justice index reviews of adaptation plans elsewhere.
- At neither the national or the municipal level there was there identifiable discussion of compensation for the impacts of climate change. The idea of compensating for harms caused by climate change in the context of adaptation links to the debate around “loss-and-damage” for climate change, and highlights a (moral, rather than legal) claim to compensation which might exist amongst communities who have experienced losses attributable to climate change for which they were not responsible for causing. While these claims have standing in the international sphere (through the UN Loss-and-Damage fund, established at COP28 in 2023— which Slovenia contributes too), there is no national or EU level legal basis for this at present. The Slovenian constitution (Article 72) does recognize that citizens have a “right to a healthy living environment” and this provision might provide a theoretical legal basis for compensation claims if it was argued that by failing to adapt to climate change the state had failed to fulfil its constitutional responsibilities to provide this. The MEPP makes some gestures in this direction when discussing the legal basis of the plan. Prioritization for new adaptation spending could be a way that municipalities as well as states could enact in-kind compensation, but these kinds of policies have rarely made there way into legislatures globally.
- More specific compensation claims might be generated by *maladaptation* – instances where adaptation measures have unintended negative consequences. Rather than the more speculative and moral arguments for a need to compensate

for the damages of climate change, which have been difficult to attribute, compensation for maladaptation might have more straightforward legal basis. Distributive justice indicator 5 asks whether a strategy identifies the possibility of maladaptation occurring; and as there was no identified recognition or discussion of unintended negative consequences at either the national or municipal level, there was also no further discussion of compensation either.

- Another case for compensation might arise from the inequality of resources between individuals and groups to devote to adaptation – their *adaptive capacity*. In the AJI indicator C3 asks to see states/municipalities take measures to reduce this disparity of resources through redistribution. To an extent, all states/municipalities that have progressive taxation measures that they use to fund adaptation measures are doing this, by collectivizing resources and then (ideally) allocating them to adaptation measures on a fair basis. On the municipal level, the Maribor Heat Action plan achieves this to a limited extent by targeting city level investment towards vulnerable groups with limited ability to adapt for themselves owing to socio-economic factors such as “Inadequate living conditions, limited access to healthcare services, low incomes, and lack of social support further exacerbate their vulnerability”. The higher scores might require administrations to explicitly link climate adaptation to policies for reducing economic inequalities and thereby raising the adaptive capacities of all groups.

4.2 Justice Considerations Identified in Interviews

4.2.1 Procedural and Recognitional Justice

We conducted semi-structured interviews with stakeholders in Maribor/Podravje CCA governance and implementation system, including stakeholders from governing institutions and from civil society to identify further insights into how Climate Adaptation Justice was understood in the Maribor/Podravje City/Regional context. Relevant responses which brought up justice considerations thematically coded according to the “form” of justice being discussed. Further discussion on the role that the structure of governance and administration, and public/stakeholder engagement may be found in Section 3 of this report.

Owing to the structure of the interviews (primarily focused on CCA governance; and with participants from the governance system) many participants discussed points that are relevant to procedural justice or recognitional justice.

Several interviewees **identified vulnerable groups** in their interviews and acknowledged how their conditions generated specific or diverging needs, preferences in CCA contexts. Groups frequently identified were young people and youth organisations/schools and the elderly.

Rural communities were also frequently identified as being highly vulnerable, especially montane communities. In these occasions **interviews discussed how vulnerabilities intersected** – particularly with elderly residents of rural areas. A number of interviewees noted the impacts of demographic shifts in rural areas that mean that rural populations are increasingly isolated, increasingly elderly, and with less people living in the locality the council receives less resources to plan for climate adaptation. A number of ongoing projects and initiatives were highlighted: including physical adaptation measure (planning roads around landslide risks, utilising erosion maps), EU funded projects including “MountAdapt” on strengthening healthcare access for rural communities, and local council provision of car transport for bringing elderly people to doctors appointments (etc).

Agricultural communities were also identified as being vulnerable, including for the reasons of isolation and councils having a lower resource base to draw on to meet their needs. Interviewees highlighted the impacts of both drought and flooding on rural and agricultural communities. Some interviewees highlighted an additional risk that some of these communities faced additional exposure to hazards owing to the quality of their buildings and their proximity

to rivers and flood risks. A number of interviewees noted potential conflicts between the needs/interests of agricultural communities and ongoing initiatives to promote biodiversity. We heard from two interviews that a regional EU Life project which involved allowing the river Savinja to flood naturally – which impacts farmers affected by the floods.

“there are some examples where the logic isn't in place because it happens that, for example, for the sake of preserving some kind of a bird species in an area, [the national government] will not address some challenges that are endangering people and what is more important to preserve a bird or to save people [by modifying the environment]... It's out of your hands... This is something that is decided on a higher level. And even municipalities are fighting this, the mayors also, but they cannot do anything if this is decided on some higher level that they cannot fight.”

The impact of rurality on vulnerability was not uncontested. One interviewee noted that in their opinion rural communities could rely on **informal support networks** that people in the city (of Maribor, and in Ljubljana) did not have. They told us that:

“When the big center big city is struck with a national disaster the support mechanisms are even weaker than in the general population because the system of self support that we work intensively on it is not established”

Likewise another interviewee emphasised the experience of people in the region with adapting to uncertainty in the past.

“I think the people who live [in a rural district] are actually very adaptable. I believe they'll adapt, but we don't yet know how... They're so spontaneous, and they can adapt to almost anything... since the break-up of Yugoslavia and so on. People have adapted. It's a poor region, but people don't live badly. Most of them, anyway. There are certainly people who are quite badly affected socially, but most aren't.”

Ethnic minorities were also noted as being especially vulnerable. In particular issues facing the Roma population were highlighted to us by an NGO who amongst their activities work to support the Roma population (and especially Roma women). They noted that, in their opinion, the Roma population was not as vulnerable as they are in other parts of Slovenia – in Maribor/Podravja the population often live in formal settlements, receive social welfare, and are actively involved in municipal processes.

“there are like some groups at the municipality where they...discuss Roma questions. And in this group, they include Roma community, but for example, there's no Roma women in this... Roma population is not such a big issue in Maribor. There's still quite a lot of them, but you know, not that much. Their integration is very, very complex, but here in this region, for example, they have like normal housing. They get like social welfare. You don't see them begging on the streets. You don't see like them living in unbearable conditions. Cause in some other regions in Slovenia, you can't see like that. But here, I think it's pretty good taking care of them.”

However as the interviewee notes the community still faces a number of issues that increases their vulnerability to climate change – particularly a comparatively lower level of education/schooling, very little awareness of climate change, and patriarchal values within their communities that limit (economic) opportunities for women.

A number of interviewees were asked about their **experiences engaging the general public in participatory governance processes**. Here impressions were mixed. A number of interviewees told us that they had experience facilitating these processes and taking public views into account when designing public projects. One interviewee told us about successful use of participatory budgeting through an EU project:

“We have a lot of events at our association, not only related to climate change. Whenever we have events, we try to address always CCA. Also, sometimes we have events with the general public or we go to schools or universities. Yes, we mainly work

with municipalities, but we also wanted to reach the general public. E.g., we ask children how they experience climate change.

And what is really interesting: in LIFE4ADAPt, for the first time in Slovenia, we are using financial participatory approach, it is very nice where you engage local community. This is bottom up approach, you are providing funds to the local community, and based on their ideas, they propose measures, and then you reward them, then you co-fund the measures, we will continue this in the following next years.”

Another told us about their efforts to include a wide range of vulnerable stakeholders into a project on urban heating:

“... it was tough because we had to cooperate with all departments and especially also NGOs and also with people who are not employed by the municipality so we have tried to make a consensus with other associations, handicapped people, we have searched for example pensioners, elderly people who are living alone at home and also in kindergartens. Little children and schools and so it was a broader network where we discussed the measures. We invited a lot of also nursery homes, so a lot of people who are working with the vulnerable groups to prepare the measures and the measures are from raising awareness to investment projects, greening projects. So, everything that is included to cool the city when heatwaves are approaching”

Others mentioned **innovative approaches to public engagement**, including an app/platform used in the city of Maribor to identify to the municipal government potential issues and new projects. However the interviewee was concerned that there was a lack of capacity to follow through on this engagement and put ideas into practice:

“We have everywhere in Slovenia and also in Maribor sort of a platform... where the city collects people ideas. And there are many, many projects that actually put together citizens, different groups, and make them think, and so on. The problem is that you get ideas for innovation. You even get more developed potential products, let's say so, or services. But then it would need a support to develop to the level where it is actually manageable to start somewhere in the economy. And it doesn't work. It's on the paper, but it is not integrated in the system.”

One interviewee detailed an extensive citizen engagement process that was utilised in Maribor to help the city design urban greening, including adding green roofs to bus shelters in the city.

One interviewee noted incentives for participation were effective, but that they often faced **challenges in getting people to engage with participatory process**. When asked if they faced difficulty engaging the public, they told us:

“...if we offer like, some present or something, to be present in the workshop, to answer some questions, to share some ideas. People respond really quickly...I think also in the European project, they are doing this. That they dedicate some special budget for the general public to attend the final events of the projects.

[Interviewer] And what do you think are the barriers that people don't come if there is no benefit?

Lack of time, lack of interest, you know, everyone is living their life and doesn't want to be disturbed.”

However the value of getting public participation in CCA planning was recognised over relying on expert-led processes.

“I respect that this expert knows what they are talking about, what is possible, but that you also acknowledge the needs of the society, because, I mean, we just had now in Florence this conference about that. And there were some perfect green solutions in different cities across areas, but people didn't want to use them because nobody asked them. This is what they need in this green space. It's not like you will say: Okay, we will do green space here, yeah. You know, because we have problems with these, heat

islands in the cities and so on. But they really want this space used for something that they need, you know. So otherwise, it's a perfect solution, that nobody uses"

Multiple attendees attributed a public disinterest in participatory processes to the political history of Slovenia and the (comparatively) recent transition to democracy, meaning that there **was a low expectation amongst the general public to be consulted on planning and public policy questions**, and an expectation that the state/administration would solve problems for them.

"[The public are] used to waiting for others to sort out their problems. And that, I think, is Slovenia's big problem: when people wait for the state or for organisations or others. They aren't proactive themselves, do you see? And that's a way of thinking that, I think, stems from the socialist era. These people, who don't have much knowledge or anything, just wait for the local council, and that's a bit undemocratic, because the local council, I think, takes advantage of them. It's not that they're teaching them to fish, but, you know, they wait for everything. For generations now – not just one, but generations – and that's bad for the local council at that level."

Other interviewees pointed to a lack of experience and practice in facilitating public consultation amongst the administration:

"Cities, I think we need to be fair. Also, the people that are working in the local, municipalities. They don't usually possess the knowledge that you need in this participatory process, you know. Because, I mean, first half of year we had, like, 12 internal sessions by an expert partner who does that on the daily basis in Barcelona, you know, this participatory process, so our partners learn how to do that, you know? There is a methodology to do that, you just don't improvise because that causes confusion. So, once the plans were there, we took another half a year just to establish the dialogue, and then you go into the implementation. You just don't show up, and you say: We have a perfect solution for you, listen up, you know?"

Interviewees from smaller administrations also noted their opinion that formal processes of public consultation were unnecessary in small municipalities:

"[the difficulty] depends on the project, how much interest it gathers. But generally, in such smaller municipalities - ...we know each other - so you can imagine that in smaller municipalities, it doesn't have to be an official forum for people to express their mind and for the municipality to know what people want..."

And that this potential to directly engage members of the administration also meant there was little purpose to advocacy organisations or NGOs as a vehicle for making issues known to the administration:

"the general opinion of the population is that such non-government organizations are basically a waste of resources. "[in] these are smaller communities... you don't need an NGO organization to represent your voice. You can go directly and knock on the mayor's door and tell him, this is what I need. Or meet the mayor walking down the street and three people come up to him, look, we have this problem. And you don't need an NGO to represent it".

A frequent theme in the interviews was about the difficulties of getting **cooperation between small municipalities**, who sometimes have competing interests. For example:

"Since they are elected representatives of their municipalities, it actually makes sense that they take care of their municipality first..."

So except for some larger projects like fresh water supply, it's really difficult to convince them to work together. Because those are such projects then that are really big and single municipalities couldn't do it. So, for instance, there are 20 of them that are now involved in this project for fresh water supply.

But this is something that they understand. Because everybody knows that we have to collaborate if we want to have water. And with climate adaptation, they are not that far out. But at some point, it will be the same if we don't cooperate, then we will not be able to fight some problems that derive from climate change."

and:

[Our local municipality] weren't able to develop a strategy; instead, we basically took an ad hoc approach, getting involved in certain projects. And now, each municipality has commissioned its own project, however they see fit. We're not following any strategy, but just [national] guidelines.

The solution that interviewees mentioned in this case was for new legislation and incentives to enforce cooperation at a local level. The need for municipalities to have some coercive authority was also noted in a discussion about the risks of maladaptation that arise through a lack of ability to enforce adaptation planning through the legislature was also mentioned by one interviewee:

We also see that people, in their private lives, do certain things or build things, or the like, which make the situation worse. But you can't see that from the outset. You don't see it straight away. You can only really tell after the event that something might not have been right.

4.2.2 Distributive Justice

Interviewees also noted the challenge of knowing how to respond to "natural" variations in population hazard exposure – for instance the challenge of protect hazard exposed mountain communities:

"the biggest barrier is what we should actually be doing [as CCA planners]... I mean, the settlement is what it is. The mountains are what they are. We can't just relocate everyone now, or anything like that. We can't do that."

How administrations across scales are obligated to respond to "natural" variations in distributive outcomes is a open question and subject to high degrees of disagreement amongst theorists of justice. The EU concept of "[just resilience](#)" puts emphasis on this question in recognising that climate change does not impact all people equally, and that when developing adaptation responses to these impacts, individuals or social groups that are already vulnerable benefit fairly from these responses and are not disproportionately burdened ('leaving no one behind'). So while "just reliance" emphasizes the importance of targetting CCA measures to montane communities to ensure that they are not "disproportionately burdened", there is still substantial room for interpretation of when "just resilience" is met.

The **concept of a just transition** was brought up in one of the interviews. The interviewee pointed to the work of [EKO SKLAD](#) – the Slovenian Environmental Public Fund that offers financing in the form of grants for environmental projects, with finances raised through fees paid by end users of energy and funds from the climate change fund (revenues from CO2 allowances).

"I think maybe also what is important... if we are talking about climate change is also funds related to fair transition/just transition. This is a fund that is managed through EKO SKLAD in Slovenia eco fund and they are managing funds that are available to vulnerable people up to €18 000 for investments into the renovation of households."

The Slovenian statistical office estimates that approx 62,000 or 7% of households in Slovenia are in energy poverty (below the EU average). Podravja was slightly above average. The major cause of this was old and insufficient quality housing, followed by being unable to pay utility bills (water, electricity, heating, etc.), while being unable to keep home adequately warm (SURS, 2024). This was also identified by an interviewee from a rural municipality, who told us:

[some groups are especially vulnerable to climate change], partly because they also live in buildings that are less sturdy, that aren't actually built very well. You can see that too. But fortunately, nothing serious has happened here yet.

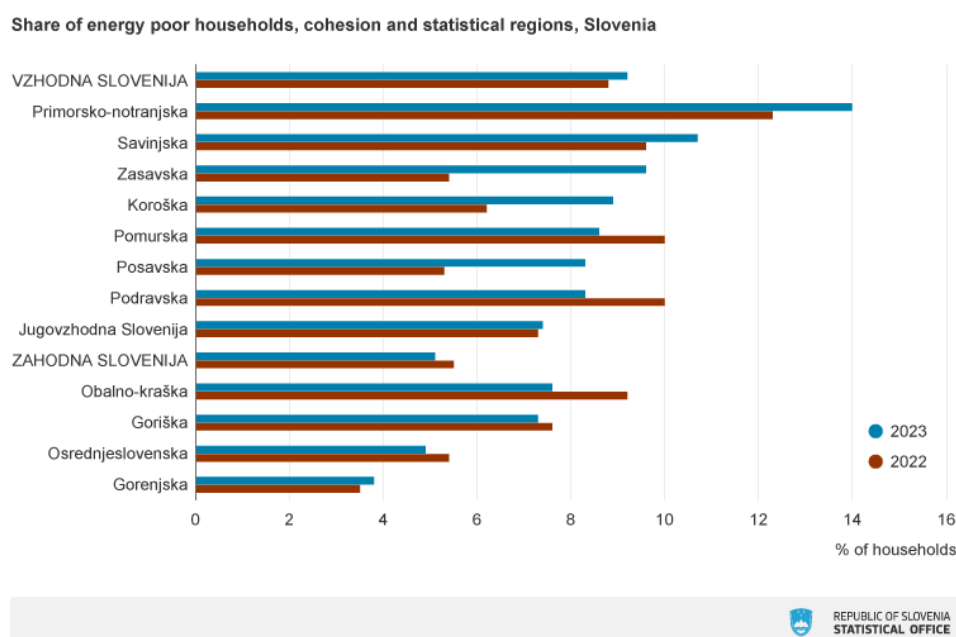


Figure 36: Share of “Energy Poor” Households by Slovenian Administrative Regions in %.
Source: Slovenian Statistical Office (SURS)

One interviewee from a rural municipality mentioned that they used **social vulnerability analysis** and **hazard mapping** as a means of targeting and prioritising interventions:

“[Our municipality] have done the risk and vulnerability study, so we have main risks and measures. Regarding the target group you know they are always like elderly and small as a by theory, but then - I look at every but this is only in my municipality because I professionally work on this - we have a very, very specific group. So I divided my municipality not only by elderly and small children, but also depending on the risk. For example they live in quite remote areas so they are as a group, they're a quite vulnerable group because in the case of road destruction or they have a bad internet connection, they don't have a telephone... So we found them as a really vulnerable group so we dedicate special measures how to overcome this.”

This integration of targeting public investment towards especially vulnerable groups identified through risk and vulnerability is well aligned with the expectations of the EU Just Resilience concept and with the expectations of theoretical accounts of just adaptation, such as that used in the evaluation of national plans above. However, the interviewee noted that this municipality was practicing this kind of analysis and prioritisation in part because of the role and knowledge the interviewee had gained outside of their role in the municipal administration. A priority may be then disseminating these best practice innovations out from isolated examples into the wider system of municipalities and ensuring there is adequate support and resourcing to permit this.

Some interviewees talked about how to **distribute the costs of adaptation**, between public funds and private investors. One interviewee noted that private investors were not being adequately incentivised to make investments into climate adaptation causes, but might if there was legislative reasons for them to do so.

“Here in Slovenia the legislation is actually the only push and if the legislation is not clear enough... Then the companies cannot decide, because they are not pushed, they don't decide for any investment that would improve their... ecological path”

Others expressed the difficulties of maintaining long term continuity and planning while being dependent on European funds for climate adaptation.

“[Climate and Nature funding] shouldn't come only from European projects. It should come from the government or some municipality funding.

[Interviewer:] And do you see a perspective there to also involve the private sector?

Yes. Maybe the companies should get some benefit”

and:

“The social dimension of adaptation is very crucial. The ministry should be more aware of how to divide the funds. 90 % is going to mitigation, only 10% to adaptation, it is very difficult to provide support to municipalities. Because we cannot guarantee that the ministry will provide certain funds, but that's why we focus on EU funds.”

We should note that while “how the costs of adaptation should be shared” is a question about justice these responses also focus on the practicality of acquiring funding to do adaptation activities. As one interviewee told us, the decision to focus on EU funding is a pragmatic choice and not strictly one of preference for funds being distributed on a super-national basis. They said:

“what can the city do? Perhaps finance something with its own money or something like that. But I don't think any city can finance very much on its own just like that; it has to be EU projects or something similar.”

Throughout the interviews the difficulties of acquiring funding for adaptation, from whatever source, was mentioned frequently.

One interviewee mentioned a particular distributive justice hazard/maladaptive risk of “green gentrification” – the potential for new investment in CCA measures in an area to contribute to gentrification and the displacement of current residents as the neighbourhood becomes more attractive to a more affluent group of residents.

“people are also afraid of that because some neighborhoods that become let's say greener, or known by the quality of life, that also changes this economic picture of this. You know, maybe some people that are not well economically situated can be dragged out of the neighborhood, because this neighborhood becomes, like, popular. That means that the prices are rising there, and so on. So, there's also negative connected with that, you know.”

In other cases the movement and migration of people caused other risks and challenges to municipalities. A key issue for rural municipalities was the challenges that they faced from rural-urban migrations as (younger) residents increasingly move to urban areas leaving rural municipalities with both a smaller resource base to draw income from, but also (typically) and older and more vulnerable population with lower adaptive capacity, and a greater need for support. Referring to the impact of an EU level policy, we were told that:

“This will cause, again, centralization in urban areas, depopulation in rural areas.

INTERVIEWER: Which means less finances?

Yeah, overgrowth of the territory, I mean, it will be devastating for [small municipalities], basically.”

While not explicitly states, the question of how/on what basis to prioritise public funds between administrative areas (according to population/according to some other principle) is a question over which account of distributive justice should be preferred. There are risks that if demographic shifts in rural areas leave vulnerable groups at greater risk and municipalities less able to secure people from climate change, that a CCA strategy will not align with the EU concept on Just Resilience.

5 Barriers and enabling conditions

5.1 Introduction

This chapter provides an overview on barriers and enabling conditions / triggers to behavioral change in the context of climate change adaptation in Podravje. A barrier represents a factor or process that makes adaptation planning and implementation more difficult. Barriers can be grouped in seven categories:

1. conflicts of interest
2. leadership
3. governance and institutional constraints
4. resources
5. science and data
6. awareness and communication
7. attitudes, values and motivations

The data was gathered through an online survey with 46 local stakeholders, including representatives of government agencies, civil society organizations, research institutes, and the private sector. The survey questions and methodology can be found in Appendix 8.7.27. In addition, the information gathered in the survey was supplemented in a targeted manner by semi-structured interviews with selected stakeholders.

Figure 37 shows how survey participants are distributed across different stakeholder groups. Out of 46 respondents, 32 are government actors, 4 are civil society actors, 4 are academic and 3 are economic actors. 3 participants defined themselves as “other”. Due to the low number of members of the non-governmental groups, the further analysis groups responses into state actors (including government actors) and non-state actors (including civil society, academic actors, economic actors and “other”). Hence, 32 participants are state actors and 14 are non-state actors.

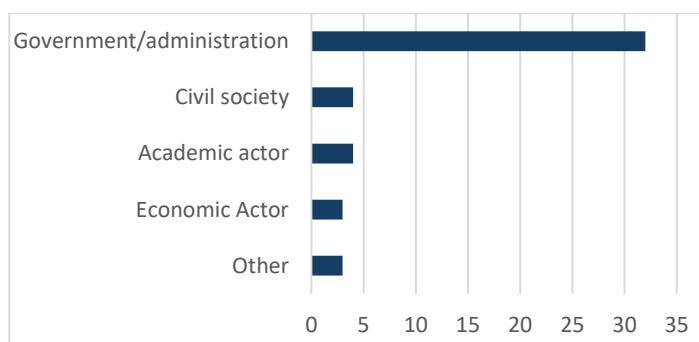


Figure 37: Distribution of stakeholder groups

Question: What stakeholder group do you attribute yourself to? n = 46

16 of 46 participants assessed the situation of barriers to climate change adaptation from the perspective of the Podravje region. 16 respondents took the perspective of Maribor city, which the capital of the Podravje region, and 14 respondents took the perspective of another municipality in the Podravje region.¹³

¹³ These included Središče ob Dravi, Hoče – Slivnica, Benedikt, Makole, Pesnica, Gorišnica, Cirkulkane, Šentilj, Sv. Jurij v Slov. Goricah, Majšperk, and Ormož. Some municipalities are represented twice. An explanation for the high number of respondents from Maribor city could be that the local project partner, who sent out the survey invitation, is itself also based in Maribor.

5.2 Barriers to Climate Change Adaptation

Overall results

The following barriers were the ten most relevant¹⁴ according to the survey participants (for a full overview of barriers, see Figure 46 or the questionnaire in Appendix 8.7.2):

1. Lack of municipal government staff time
2. Lack of municipal government finances
3. Lack of political will (e.g. due to short term political cycles)
4. Lack of funding from the national to the municipal level
5. Lack of funding from the national to the regional level
6. Lack of regional institutions' finances
7. General mistrust of national government among the public
8. Powerful interests hindering the planning and implementation of adaptation measures
9. Lack of collaboration and cooperation across different governance levels (municipality, region, national)
10. Lack of alignment between national climate policies and regional or municipal priorities

This implies that the identified barriers can be grouped into four main topics:

- 5 out of 10 of the most relevant barriers belong to the topic of **resources**: Lack of municipal government staff time and finances, lack of funding from the national to the municipal as well as the regional level, and lack of regional institutions' finances seem to be some of the most relevant barriers to CCA.
- Two barriers belong to the topic of **conflict of interest**: There appears to be a lack of political will as well as powerful interests hindering the planning and implementation of adaptation measures.
- Two barriers belong to the topic of **governance and institutional constraints**, particularly the lack of alignment between national climate policies and regional/municipal priorities, and the lack of collaboration and cooperation across different government levels (municipality, region, national level).
- In addition, there seems to be some **mistrust** of the national government among the public (this barrier is part of the topic "attitudes, values and motivations").

Results by category

Fehler! Verweisquelle konnte nicht gefunden werden.³⁸ provides an overview of the relevance of different categories of barriers across all 47 barriers. The overview shows clearly that the topic of "resources" seems to be the most prominent, followed by "conflict of interest" and "governance and institutional constraints". This result at the level of categories reflects a similar order of relevance as when looking at the relevance of the individual barriers.

¹⁴ The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant, moderate, minor, non-existent, or "don't know" (implies low relevance). n=46



Figure 38: Overview of relevance of barrier categories

n=46; Average relevance of categories of barriers. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or “don’t know” (implies low relevance and equals 0.5 points).

When only looking at responses of non-state actors, the level of agreement with the suggested barriers is generally higher, implying that **non-state actors perceive potential barriers to climate change adaptation as generally more relevant.**

Looking at the different categories of barriers and specific subgroups of respondents, the following observations seem noteworthy:

Barriers related to “**resources**” are considered most relevant overall. This result is dominated by the high significance that is given to barriers related to a lack of finance and staff time, specifically “lack of municipal government staff time”, “lack of municipal government finances”, “lack of funding from the national to the municipal level”, “lack of funding from the national to the regional level” and “lack of regional institutions’ finances”. In addition, the majority (71 %) of non-state actors also consider “lack of regional institutions’ staff time” as a moderate or significant barrier. A lack of knowledge of actors about the science of climate adaptation or the planning processes are considered moderate or significant barriers by a majority of participants, but still less relevant than barriers related to financial or staff resources. The barrier “lack of tools, technology, methods or similar” is considered least relevant, but still more than half of the participants considered it to be a moderate or significant barrier.

The barriers revolving around a lack of funding and staff time are most supported by actors from municipalities beyond Maribor. For example, 85 % of the respondents of this group consider the lack of municipal government finances to be moderate or significant.

Regarding the barrier related to the lack of financial and staff resources of non-state actors, a high share of “don’t know” responses from regional-level respondents is striking (31%). This suggests limited interaction with or visibility of non-state actors at this administrative level, making it difficult for these respondents to assess the barrier.

Insights from interviews:

Most interviewees confirm that there is a lack of resources at various levels and that this constitutes a relevant barrier. They noted that small municipalities, especially those with limited economic activity and investment, often lack funding even for detailed data such as erosion maps. They also argued that small municipalities often lack the capacity and knowledge to apply for (EU) funding. Larger municipalities are better placed to obtain funds because they have stronger networks and active local stakeholders.

However, some interviewees were more critical of the “lack of funds” argument. They argued that financial resources are not always the issue; rather, the problem can lie in how funds are prioritised. In their view, this is also linked to a lack of clear legal guidance leading to investment priorities that are not necessarily climate friendly (e.g. for buildings that are not resilient). Furthermore, with available funds tied to specific expenditures, there is little room for innovation.

Regarding the barrier on staff knowledge and time, several interviewees linked this to limited funding, arguing that small municipalities cannot offer attractive jobs to skilled people.

The lack of financial resources on the regional level was explained by one interviewee by a structural setting that limits the Podravje Regional Development Agency’s decision-making power and financial means, preventing it from taking a stronger role. Another interviewee stated that national funds are not equally distributed at the regional level, with Podravje receiving relatively fewer resources for regional development than other regions.

Finally, some non-state interviewees noted that limited resources also affect non-state actors, which often lack human resources or face a difficult funding landscape. One interviewee stated that their organisation is funded only by the EU, not by the Slovenian state. EU funding cycles are considered to be short and therefore limiting the ability to build long-term, stable programmes.

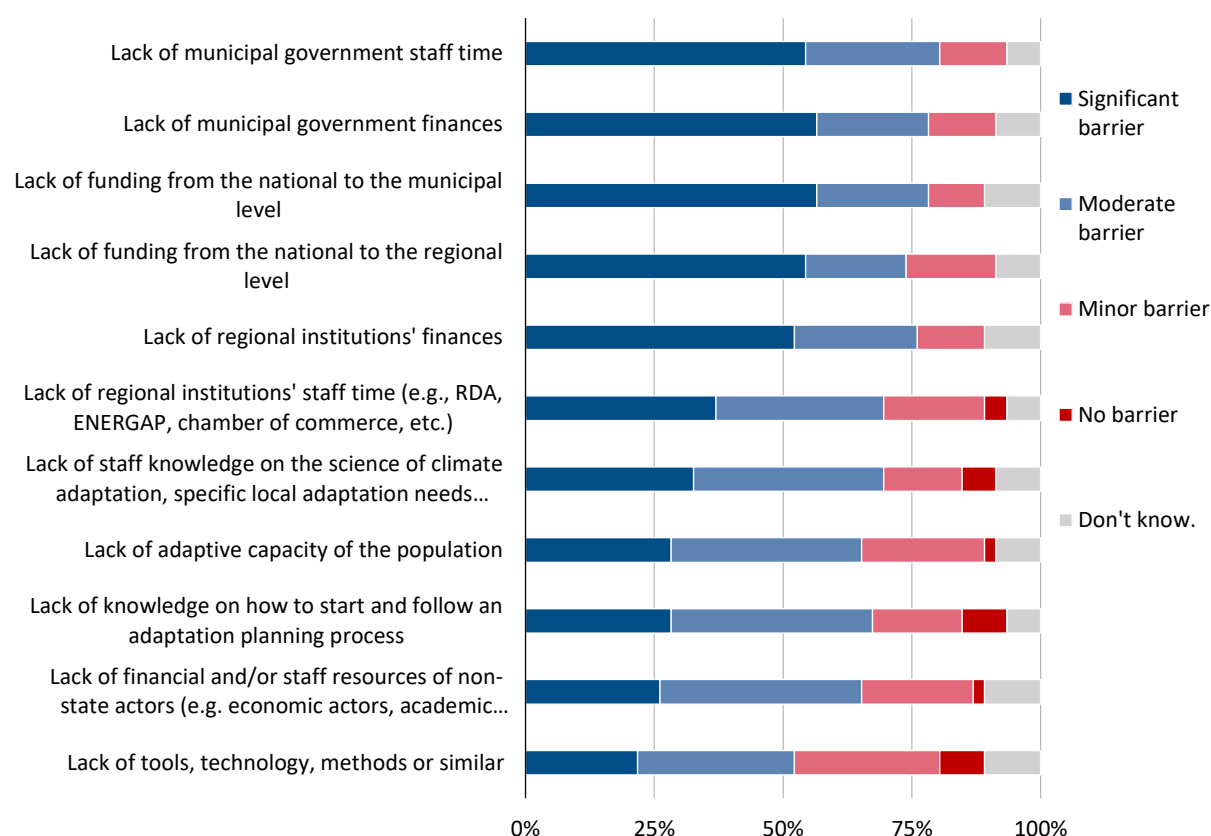


Figure 39: Overview barriers “resources”

n = 46. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or “don’t know” (implies low relevance and equals 0.5 points).

The second most relevant category of barriers is “**conflict of interest**”. Most of the barriers in this category are considered moderate or significant by a majority of the respondents. When

only looking at the responses of non-state actors, however, the topic is considered a bit less relevant compared to others.

Compared with the others in this category, the barrier “lack of interest from the population” falls short in terms of its relevance, only 50% consider the barrier to be moderate or significant. However, a substantial majority of respondents from municipalities beyond Maribor consider this barrier as moderate or significant (79%).

Insights from interviews:

With regard to the topic “conflict of interest”, interviewees argued that there is also a lack of interest of the municipalities, that different priorities compete sometimes (e.g. no adaptation measures can be implemented in protected Natura 2000 areas) and that the level of activity in CCA seems to depend on how strongly municipalities are confronted with climate change.

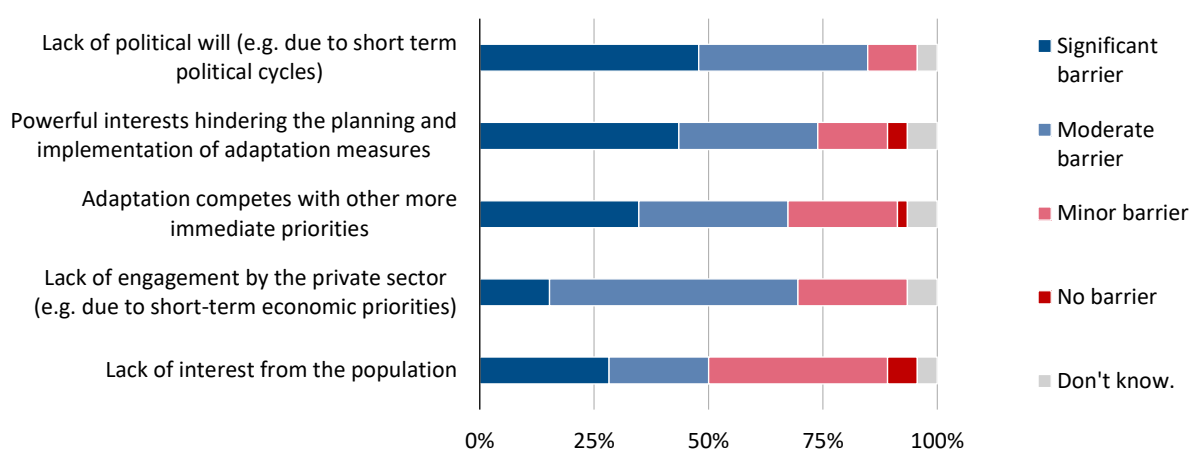


Figure 40: Overview barriers “conflict of interest”

n = 46. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or “don't know” (implies low relevance and equals 0.5 points).

All barriers related to “**governance and institutional constraints**” are considered moderate or significant by a majority of respondents, with the “lack of collaboration and cooperation across governance levels” emerging as the most prominent issue (80 % moderate or significant). Overall, barriers linked to cooperation and policy alignment are perceived to be more relevant than legal barriers and barriers related to the inclusion of non-state and vulnerable actors.

However, perceptions vary by governance level: respondents from the Podravje regional level and municipalities beyond Maribor rate the barrier “fragmentation or lack of legislation creating a mandate for action at the regional level” more often as moderate or significant than respondents from Maribor, while municipalities beyond Maribor also place greater emphasis on the lack of a municipal mandate for action (barrier “fragmentation or lack of legislation creating a mandate for action at the municipal level”, 86 % significant or moderate).

Insights from interviews:

Issues around governance and institutional constraints were discussed widely in many interviews. The high number of municipalities and the lack of a strong region acting as an intermediary between municipalities and the national level were mentioned as major barriers to effective CCA. The lack of collaboration and cooperation between different municipalities,

across different administrative levels but also among non-state actors are considered problematic. According to one interview, most municipalities act mainly on behalf of their own municipality rather than having the larger context in mind. Furthermore, it was mentioned that the regional development priorities often do not align with the municipalities' priorities and that the regional development agency is not collaborating with the national strategy planner.

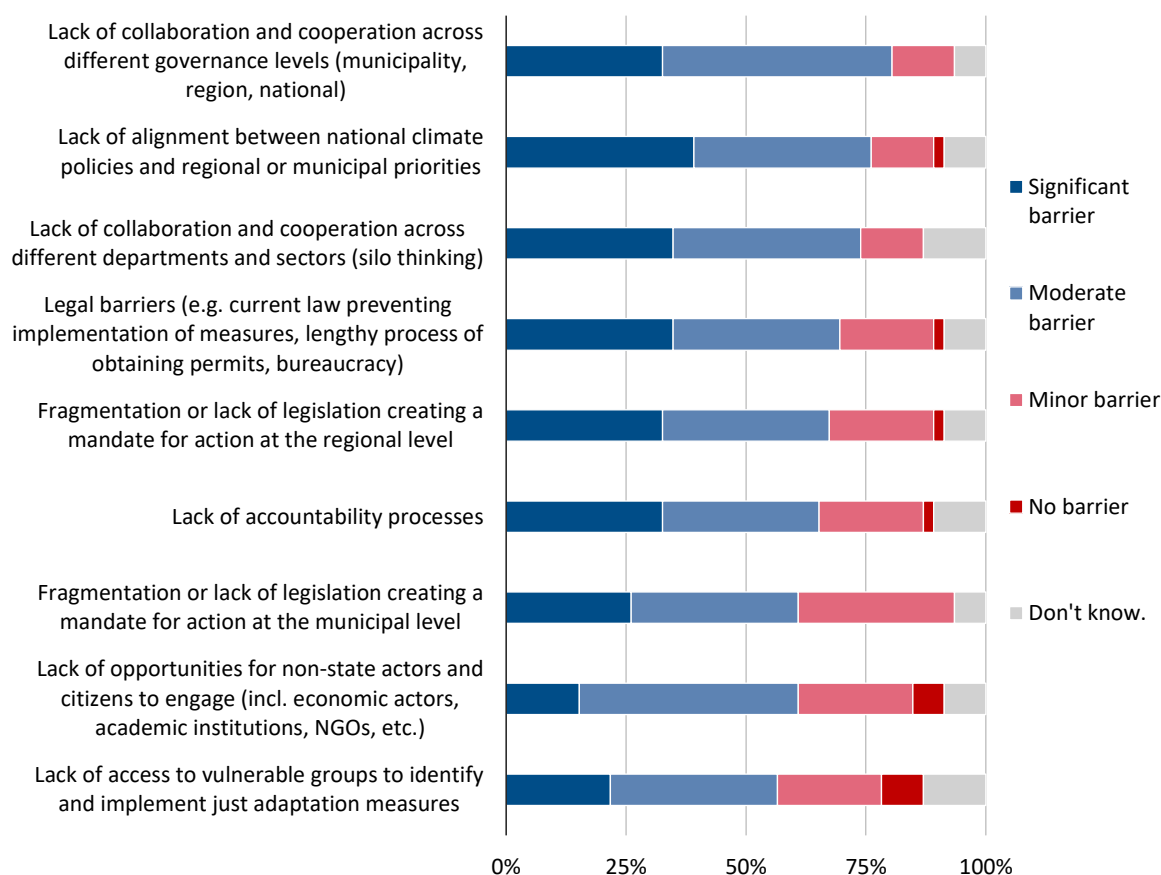


Figure 41: Overview barriers "governance and institutional constraints"
n = 46. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

Even though all barriers in the category **"awareness and communication"** are considered moderate or significant by more than half of the participants, this category is considered less relevant compared to other categories. When only looking at non-state actors' responses, however, it is the second most relevant category. Specifically, 79% of the participating non-state actors perceive the barrier "inability to effectively communicate the need for adaptation internally in municipal government" as moderate or significant. None of the four barriers was considered to not exist by any of the non-state respondents.

Differences also appear across governance levels. A majority from municipalities beyond Maribor consider the inability to communicate the need for adaptation externally, for example to economic actors or the broader public (86%), and internally within regional institutions (79%) as moderate or significant barriers. By contrast, they do not perceive internal communication within their own municipal governments as a relevant barrier (only 35% of the respondents consider this barrier moderate or significant)

Insights from interviews:

Against the overall lower significance of this category of barriers in the survey, interviewees did mention the lack of awareness as relevant barriers to CCA. This includes both a lack of awareness among the population, but also among leadership and municipality staff.

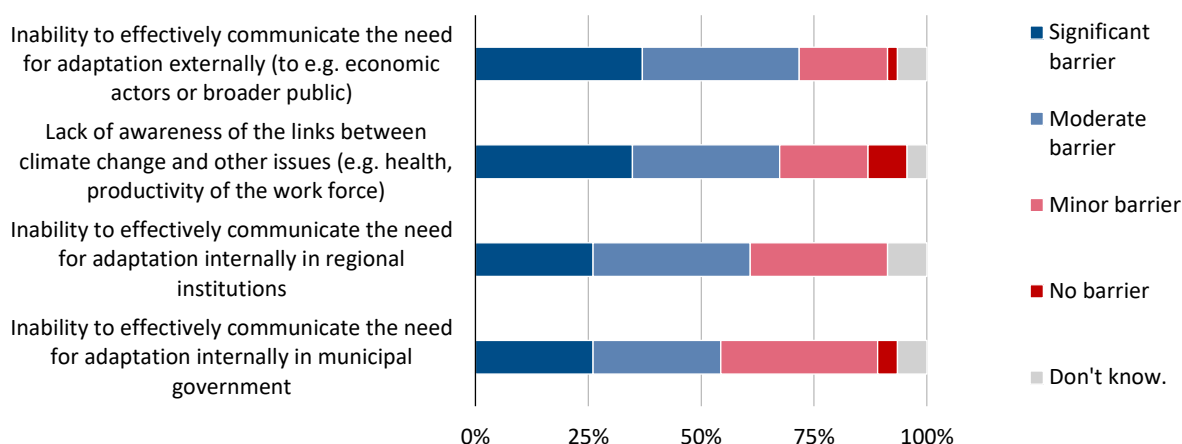


Figure 42: Overview barriers "awareness and communication"

n = 46. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

While the category of **"attitudes, values and motivation"** is overall less relevant than other categories, individual barriers still received relatively high levels of agreement in the survey. Except for the barrier "suppression of scientific knowledge and professional expertise", every barrier in this category was rated as significant or moderate by more than 50% of the respondents.

While the barrier "suppression of scientific knowledge and professional expertise" is considered least relevant in this category overall, when only looking at responses of non-state actors, 57% consider this a moderate or significant barrier. In contrast, non-state actors find the barrier "general mistrust of the regional institutions among the public" much less relevant than when looking at all actors' responses.

Looking at different governance levels, respondents focusing on the Podravje region find all barriers in this category less relevant than respondents from Maribor or individual municipalities. Particularly, the barriers around mistrust of municipal, regional, but also European institutions have low acceptance on the Podravje regional level, but higher acceptance on the other levels.

Insights from interviews:

That mistrust can indeed be a barrier is confirmed by one interviewee who argued that some municipalities have low trust in the mayor of Maribor because they feel left out from (CCA) measures.

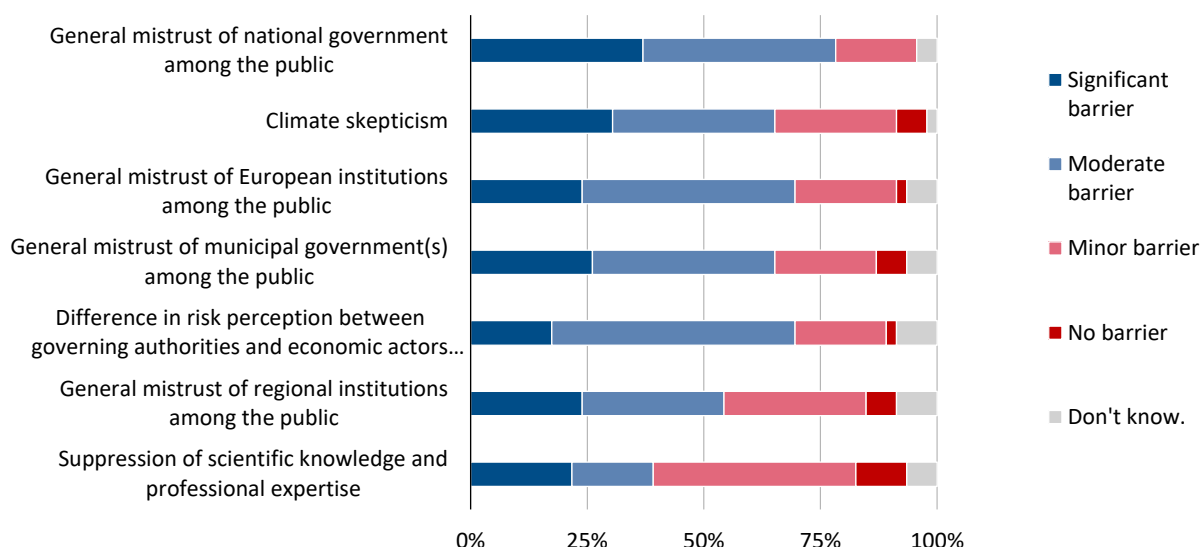


Figure 43: Overview barriers "attitudes, values and motivations"
n = 46. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

The category of **"science and data"** is overall less relevant than other categories. Still, individual barriers received relatively high levels of agreement in the survey. Every barrier in this category was rated as significant or moderate by more than 50% of the respondents. Non-state actors rated barriers in this category as more relevant than state actors.

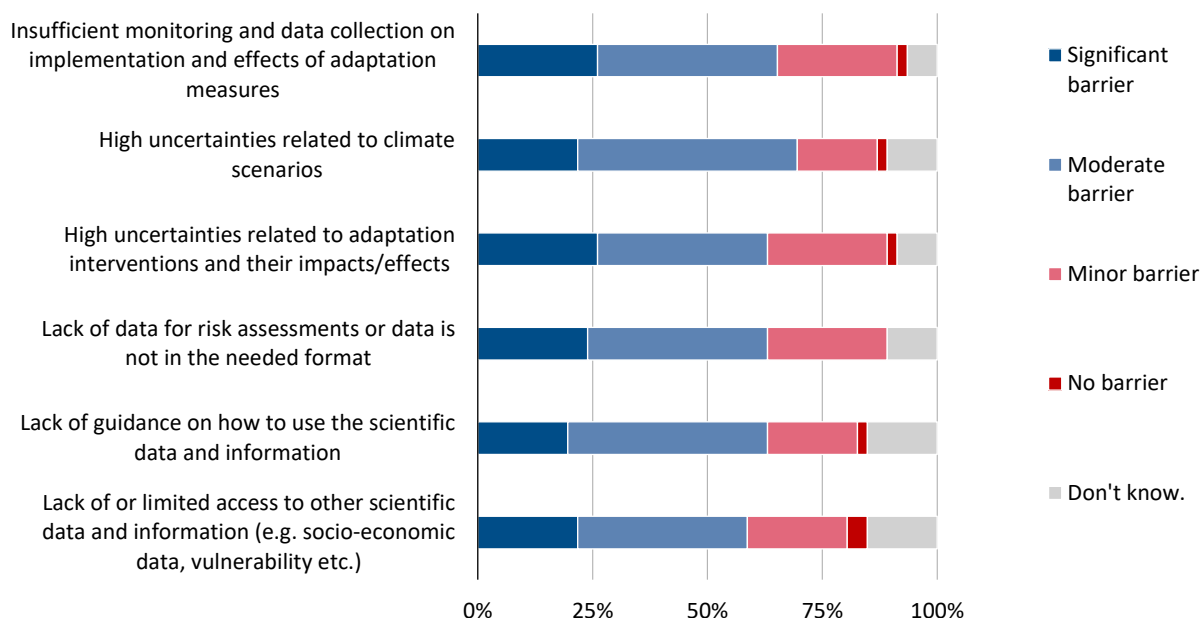


Figure 44: Overview barriers "science and data"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

"Leadership" is considered the least relevant issue with regard to barriers to CCA. Still, except for the barrier "lack of leadership on climate issues by non-state actors", all barriers are assessed as moderate or significant by more than 50% of the respondents. In addition,

responses vary according to actor type. While overall, the barrier “lack of leadership on climate issues by the national government” was considered most relevant, non-state actors assess the barrier “too many leaders on climate change without clarity on their roles” as most relevant. 79% of non-state respondents consider it to be moderate or significant.

At the municipal level beyond Maribor, the barrier on lack of leadership by non-state actors is considered much more relevant than by respondents of Maribor and the regional level. This seems to imply that the engagement of non-state actors at the local level beyond Maribor is low.

Insights from interviews:

One interviewee links the perceived lack of leadership by non-state actors in municipalities to the small size of many municipalities. In such contexts, distances are short, citizens have direct access to the mayor, and NGOs representing specific population groups are often not seen as necessary. One interviewee noted that, where no formal organisations exist, non-state engagement in small municipalities depends on motivated individuals. According to the same interviewee, NGOs may also be active in adaptation but label their activities differently because awareness of the topic remains limited.

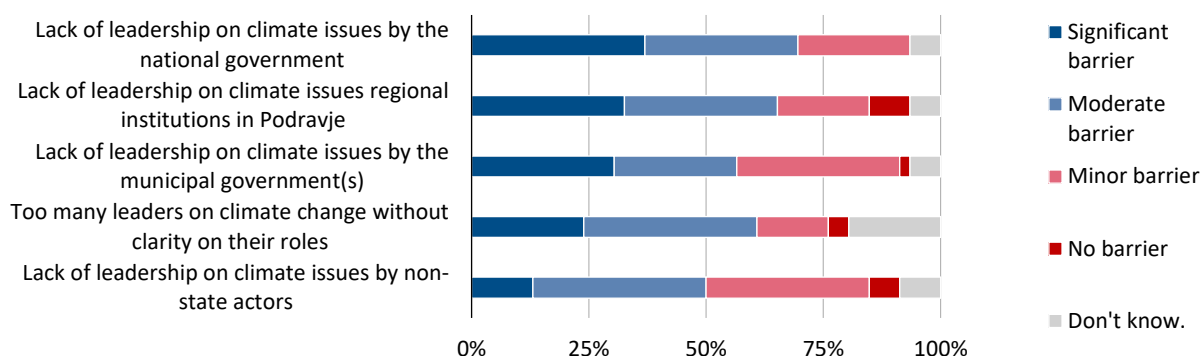


Figure 45: Overview barriers “leadership”

n = 46. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or “don't know” (implies low relevance and equals 0.5 points). Figure INFRAS.

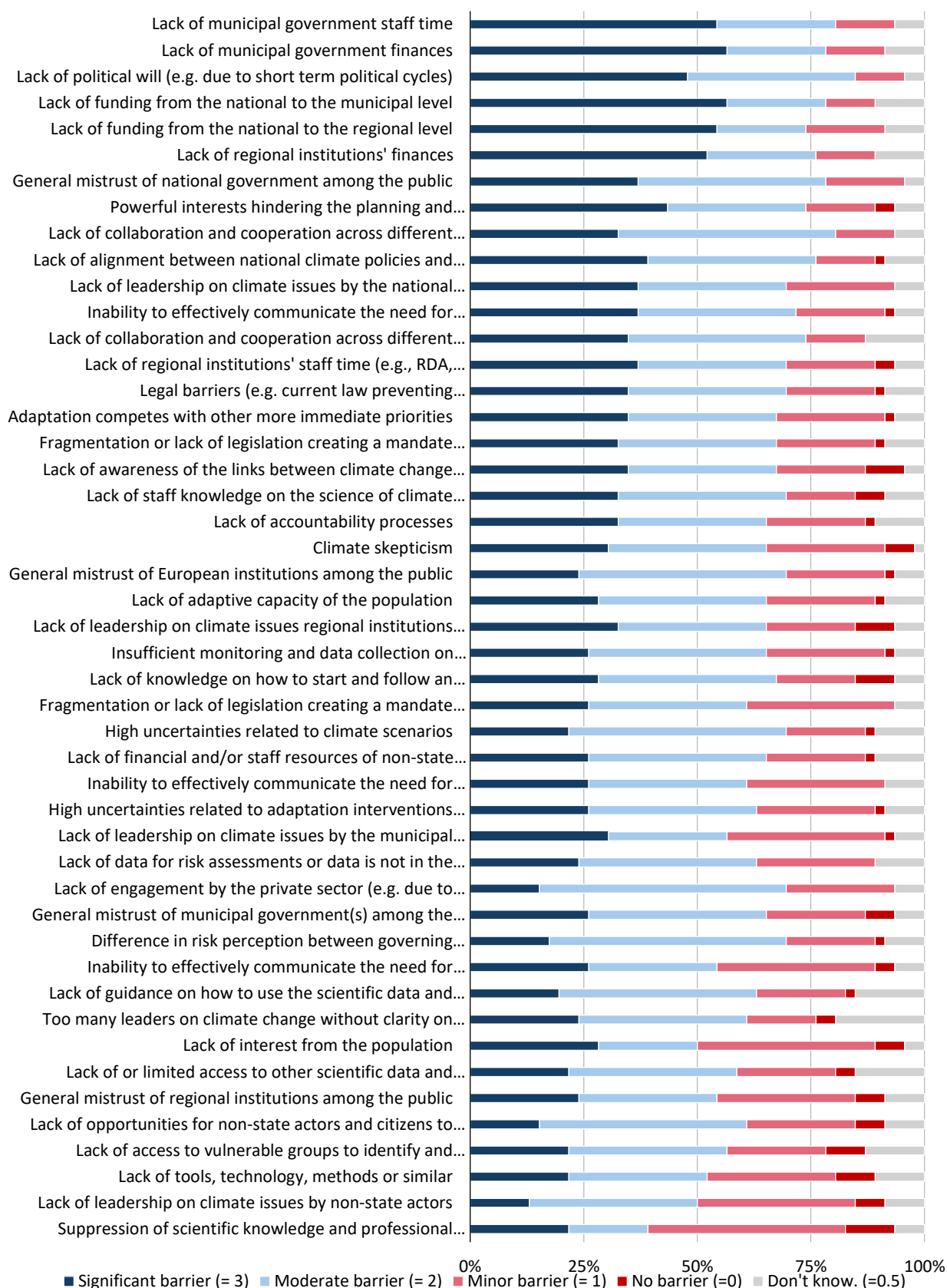


Figure 46: Overview of barriers sorted along significance

n = 46. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points).

5.3 Barriers along the CCA policy cycle

The survey participants were asked to identify the most relevant barriers from their perspective and allocate them to a specific phase of the policy cycle on climate change adaptation (see Fehler! Verweisquelle konnte nicht gefunden werden.).



Figure 47: Policy cycle of climate change adaptation
Ideal-type stages of the adaptation decision-making process; Source: ClimateADAPT 2025

Sorting the different phases according to how often they were mentioned by survey participants looks as follows:

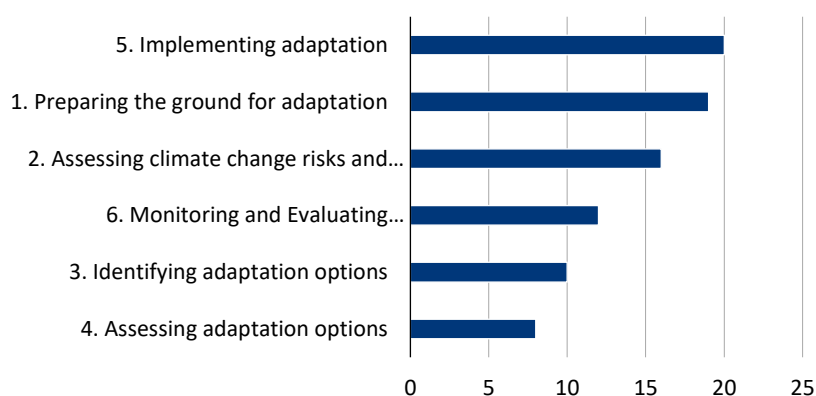


Figure 48: Barriers along the CCA policy cycle, sorted according to relevance
Question: In your own words, which are the most important barriers to climate change adaptation (max. 3), and in which stage of the process are they located? Select the respective stage(s) and note down the specific barrier(s). Figure INFRAS.

The following overview summarizes the barriers that respondents identified within specific stages of the adaptation decision-making process:

- Phase 1**, Preparing the ground for adaptation: Inaccessibility to and lack of (local) data on current situation and future developments, lack of risk and vulnerability assessments; insufficient communication with the population; lack of leadership; lack of coordination and exchange among different actors and the public

- **Phase 2**, Assessing climate change risks and vulnerabilities: lack of (access to) climate risk and vulnerability data at the local and regional level, lack of assessments on future trends
- **Phase 3**, Identifying adaptation options: lack of knowledge and expertise at national and regional levels.
- **Phase 4**, Assessing adaptation options: various responses, no clear pattern. Responses include the lack of data, expertise, tools, funding, and a national adaptation strategy.
- **Phase 5**, Implementing adaptation: The most prominent issue is considered the lack of appropriate funding for implementing adaptation options. Furthermore, a lack of expertise and personnel, administrative barriers hindering the implementation of adaptation measures and the lack of awareness on adaptation and its benefits among the population
- **Phase 6**, Monitoring and Evaluating adaptation: The main barriers mentioned in this phase of the adaptation cycle were a lack of an M&E system, insufficient data for monitoring and the lack of flexibility or openness to suggestions for change.

These responses partly correspond with the results presented in chapter 5.2, with a few differences: Respondents in this open question focused strongly on the lack of appropriate data, even though the barriers revolving around “science and data” in the previous section only received relatively low levels of agreement, compared to the other categories. The results also show that phase 5, the phase of implementing adaptation, seems to be the phase in which most barriers occur – respondents argue this is due to a lack of financial resources.

5.4 Sectors affected by barriers to Climate Change Adaptation

The sector most affected by barriers to CCA in Maribor, according to the full set of respondents, is the sector of agriculture, followed by land use planning / spatial planning and water management. The high relevance of the sector of agriculture was also confirmed in interviews. When only looking at the responses of non-state actors, the sector of land use / spatial planning receives by far the highest support, followed by energy and agriculture. State actors also consider biodiversity management to be a sector highly affected by barriers to CCA.

Differences also came up between different governance levels: While the sector of agriculture is considered as most affected by respondents at the regional level and the level of municipalities beyond Maribor, respondents from the city of Maribor consider land use / spatial planning as most relevant.

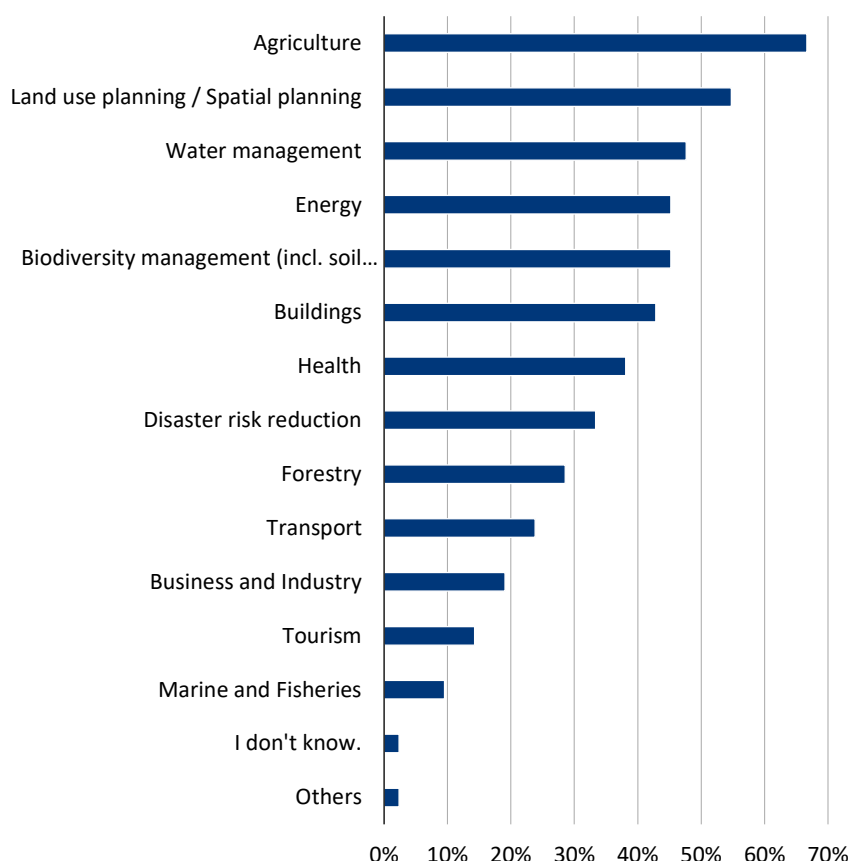


Figure 49: Sectors affected by barriers to CCA, according to relevance, overall
Question: Which sectors are particularly affected by barriers that hinder the planning and implementation of necessary measures for climate change adaptation? n = 42, multiple responses possible

5.5 Overcoming barriers to climate change

The survey participants were asked to elaborate on possible ways for overcoming the identified barriers to CCA. The answers to this open question can be clustered as follows:¹⁵

1. **Exchange and cooperation:** Strengthen transparent and inclusive exchange and cooperation between different stakeholders at administrative levels, between state and non-state actors, with the public and across sectors. Exchange best practices, coordinate activities.
2. **Awareness, knowledge generation & capacity building:** Strengthening awareness and knowledge of decision-makers but also the public.
3. **Legislative frameworks and bureaucracy:** Make sure there are clear and harmonized guidelines on implementing adaptation measures, based on a national framework, and remove bureaucratic barriers.
4. **Data and assessments:** Strengthening access to reliable data, scenarios, assessments of impacts of measures, monitoring of ecosystems.
5. **Acquiring financial resources:** Gathering information on available funding sources at different levels and improving access to funding from these different sources, provide financial incentives for CCA.

¹⁵ The order of the bullet points does not reflect a prioritisation.

6. **Implement a strategic, context-specific approach to CCA:** developing strategies to CCA based on general consensus, adapting practices to the specific context of implementation
7. **Sector-specific measures:** agriculture, infrastructure, energy, land use / spatial planning, water, tourism, nature-based solutions

Insights from interviews:

Interviewees confirm the statements on exchange and cooperation as well as awareness raising. On strengthening exchange and cooperation, an interviewee suggests stronger partnerships between municipalities, but also the involvement of local communities (e.g. inhabitants, citizen groups, elderly). Furthermore, interviewees suggest that awareness could be strengthened by not talking about CCA in theory but framing it along observable problems, such as forest fires, and discussions on how to address these problems. The suggestion to acquire more financial resources was specified by an interviewee in the sense that specific, project-based funds could be acquired. The discussion around strategic approaches to CCA was complemented with the suggestion of planning more long-term.

6 Conclusion & way forward: from risk to climate action

6.1 From climate risk to adaptation priorities

The preceding chapters demonstrate that climate adaptation in Podravje cannot be approached solely as a response to individual hazards. Flooding, extreme heat, drought and landslides affect different places, population groups, economic activities and infrastructure, while their impacts are mediated by underlying socio-economic conditions and institutional capacity. The risk assessment therefore provides a basis for identifying where adaptation may be most needed, but the governance, justice and barriers analyses show that translating this evidence into action also depends on coordination between actors, access to resources, institutional capacity and the inclusion of vulnerable groups in adaptation planning. The way forward should consequently combine targeted hazard-specific measures with cross-cutting actions that strengthen the region's overall capacity to anticipate, prepare for and respond to climate change.

Adaptation measures can take many forms, ranging from engineered interventions to changes in behaviour, governance and ecosystem management. These may include **structural measures**, such as flood protection infrastructure, drainage systems or the adaptation of critical infrastructure; **behavioural measures**, such as changes in water-use practices, heat-risk awareness or responses to early warning systems; **institutional measures**, including land-use planning, building codes and the integration of climate considerations into sectoral policies; and **nature-based measures**, such as wetland restoration, urban greening or other interventions that use ecosystems and natural processes to enhance resilience. These different forms of adaptation are not mutually exclusive and are often most effective when combined, illustrating that adaptation extends beyond physical infrastructure to include social, institutional and ecological responses. These measures can also be combined. For example, flood risk reduction may involve protective infrastructure, land-use regulations, wetland restoration and improved public preparedness. These different types of measures may be implemented individually or in combination, depending on the specific risk, context and adaptation objective. This highlights the broad range of ways in which adaptation can be pursued beyond physical infrastructure alone.

Moreover, adaptation can also create opportunities alongside reducing climate-related risks. Climate change adaptation aims not only to moderate harm and reduce vulnerability, but, where possible, to take advantage of potential beneficial opportunities (IPCC, 2022). Some adaptation measures may therefore generate wider social, economic or environmental co-benefits in addition to addressing climate risks. A recent example from Maribor is the greening of bus stops implemented through the MISSION CE CLIMATE project (Mestna občina Maribor, 2026). Green shelters, additional vegetation and the removal of sealed surfaces contribute to reducing heat stress and improving the local microclimate, while at the same time creating more comfortable and attractive public spaces for public-transport users.

6.2 Strategic directions for adaptation

The findings of this report point towards several strategic directions for strengthening climate adaptation in Podravje. These directions draw together evidence from the regional risk assessment, socio-economic profile, governance analysis, justice assessment, and the identified barriers and enabling conditions. Rather than prescribing a fixed set of measures, they identify areas in which adaptation efforts could be further developed and prioritised together with regional and local stakeholders. The following sections reflect on these strategic directions, which are closely interconnected and may reinforce one another in practice.

6.2.1 Target adaptation to differences in risk, vulnerability and capacity

The regional risk assessment shows that climate hazards, exposure and social vulnerability are unevenly distributed across Podravje (Chapter 2). The SoVI analysis further shows that the underlying drivers of social vulnerability differ between settlements, with factors such as age structure, education, unemployment and income contributing to varying degrees. Adaptation planning should therefore consider not only where hazards and exposed populations, land uses and infrastructure are concentrated, but also the characteristics of the populations affected. At the same time, the governance and barriers analyses show that also the institutional capacity to respond varies across the region (Chapters 3 and 5). This is particularly relevant for smaller municipalities, which often operate with limited staff, technical expertise and financial resources and may face greater difficulties in accessing external funding.

At the sectoral level, agriculture emerges as a particularly important area for adaptation. In the barriers assessment, respondents in Maribor identified agriculture as the sector most affected by constraints to climate change adaptation, followed by land-use/spatial planning and water management (Chapter 5), with the importance of agricultural barriers also reinforced in the interviews. This aligns with the drought assessment for Podravje, which shows that agricultural drought exposure varies substantially between municipalities and land-use classes (Chapter 2), suggesting that **agricultural adaptation should be tailored to local conditions and to the characteristics of individual agricultural classes, rather than applying uniform measures across the region**. The results can help identify municipalities and agricultural sectors where more detailed assessment of drought vulnerability, water availability, irrigation needs and crop-specific adaptation options may be particularly relevant. At the same time, because the analysis captures exposure to meteorological drought rather than agricultural losses or vulnerability directly, such follow-up assessments remain necessary before specific measures are prioritised.

6.2.2 Mainstream adaptation within municipal decision-making

Municipalities play a central role in implementing adaptation, but particularly in smaller administrations it may not be realistic to assign climate adaptation to a dedicated staff member or department (Chapter 3). Given the large proportion of small-scale municipalities in Podravje, a specific focus should be laid on understanding their needs, capacities and opportunities. The governance analysis points to several ideas: **adaptation-mainstreaming approach** rather than assigned to a dedicated climate officer or department. Especially for smaller municipalities, as one interviewee explained, *“it is an illusion to say that I will have one person to cover this [...] everyone working in the municipality should understand what it means and how they can contribute from their specific”* field [Interview with a small municipality]. In such an approach, climate resilience is integrated across municipal responsibilities and considered within spatial planning, infrastructure investment, public-space management and other routine decisions. Building internal knowledge through regular training for municipal employees must support this process, while designating a contact person for climate-related issues in each municipality could facilitate information exchange and provide a clear connection to external support structures without placing responsibility for adaptation on a single individual (Chapter 3).

Mainstreaming also requires adaptation to become part of how municipalities finance, maintain and communicate their activities. Interviewees stressed, for example, that nature-based solutions and green infrastructure require more durable national or municipal funding, as short-term European projects may enable implementation but do not always ensure maintenance once project funding ends, such as maintenance of green infrastructure (Chapter 3). At the same time, EU-funded projects were viewed as valuable opportunities to pilot new approaches,

engage stakeholders and build momentum for measures that may initially be difficult to implement. Public engagement can complement these institutional changes through continued awareness-raising and, where appropriate, by involving or incentivising residents in activities such as the maintenance of public green spaces. Interviewees also emphasised the importance of communicating adaptation in terms of tangible improvements to people's everyday lives, rather than presenting it solely as an environmental or climate objective (Chapter 3).

6.2.3 *Strengthen cooperation across municipalities and governance levels*

Many climate impacts and adaptation challenges extend beyond municipal administrative boundaries, making coordination between municipalities and across governance levels important for effective adaptation. The governance and barriers analyses identify limited collaboration and insufficient alignment between governance levels as important constraints to climate change adaptation (Chapters 3 and 5). These challenges are compounded by substantial differences in municipal capacity. Smaller municipalities, particularly those with limited economic activity and investment, may lack the financial and technical resources required even for detailed risk information, such as erosion maps, and may have less knowledge and capacity to apply for national or European funding. Larger municipalities, by contrast, were perceived as better positioned to access funding because of stronger networks and more active local stakeholder communities (Chapter 5).

Existing cross-municipal and regional structures could therefore play a stronger role in reducing these capacity gaps by facilitating knowledge exchange, training, shared expertise and access to funding opportunities. Although Podravje does not constitute an administrative region, several structures already support cooperation between municipalities. The SOS Climate Office, for example, provides guidance on climate adaptation and could help connect municipalities with relevant expertise, funding programmes and experiences from elsewhere (Chapter 3). Such cooperation could be particularly valuable for municipalities that lack the capacity to develop specialised expertise or prepare complex funding applications independently. It is also suggested to designate - not an expert - but a **contact person for climate-related issues** in each municipality to help coordinate information internally and strengthen communication with other municipalities and external support structures. **Existing cross-municipal structures can further support** this process by providing training, guidance and knowledge exchange. In particular, the SOS Climate Office was identified as an important source of support for municipalities on climate adaptation (Chapter 3). Together, these approaches could help strengthen adaptation capacity without requiring smaller municipalities to develop extensive new administrative structures.

6.2.4 *Build on the region's innovation, learning and engagement capacities*

The regional innovation system presents both constraints and opportunities for climate adaptation. The socio-economic analysis shows relatively low public-sector R&D expenditure, declining firm-level R&D and non-R&D innovation expenditure, and decreasing collaboration between innovative SMEs compared with 2018 (Chapter 1). These trends may constrain the development, testing and diffusion of new adaptation solutions, particularly where implementation depends on cooperation between firms, public authorities and other regional actors. At the same time, Podravje has capacities that could be mobilised more deliberately for adaptation. The presence of SMEs engaged in product and business innovation suggests firms' openness to invest in process improvements that could support the development and uptake of more climate-resilient production processes, a point also reflected in the interviews. In addition, the region scores relatively high in terms of participation in lifelong learning, offering opportunities for skills development and community-led adaptation initiatives.

Innovation in adaptation should, however, not be understood only in technological terms. The governance analysis (Chapter 3) highlights how interviewees understand innovation for climate adaptation. The main understanding relates to organizational and institutional change, particularly improved planning, cross-sectoral governance, and collaboration. The importance of European projects as valuable environments for piloting innovative approaches that may initially be difficult to implement, bringing relevant actors together and building momentum for wider change. Such projects can therefore support learning and experimentation, but their longer-term value depends on whether successful approaches can be embedded in municipal practice, maintained after project funding ends and, where appropriate, replicated elsewhere in the region (Chapter 3).

Nature-based solutions, such as greening public spaces, planting trees, and depaving, are also prominent, though sometimes adaptation is understood too narrowly as only green infrastructure. Social and behavioral innovation, including public engagement and linking adaptation to people's values and identities, is seen as important but lacks concrete examples. Technological and private-sector innovation, such as risk-monitoring tools, is considered helpful but remains secondary, sector-specific, and often narrowly associated with patents or technical products.

6.2.5 Create enabling and durable financing conditions for adaptation

A lack of resources was the most frequently identified category of barriers to climate change adaptation, with smaller municipalities particularly affected by limited financial, technical and administrative capacity (Chapter 5). However, the findings also suggest that the challenge is not solely the availability of funding. Interviewees highlighted how resources are prioritised, difficulties in accessing funding programmes, limited flexibility in how available funds can be used, and a lack of clear legal guidance for climate-resilient investment (Chapter 5). The socio-economic analysis also shows relatively low investment in environmental protection in Podravje: gross fixed capital formation for environmental protection represented approximately 0.2% of regional GDP in 2024, compared with around 0.5% nationally (Chapter 1; SiStat, n.d.). While this indicator does not specifically measure only adaptation expenditure, it provides broader context on environmental investment in the region and includes expenses such as protection of green spaces or wastewater management. Strengthening adaptation will therefore require attention not only to mobilising additional resources, but also to improving access to funding, supporting climate-resilient investment decisions and ensuring continuity beyond individual funding cycles.

Long-term financing is particularly important for measures that require continued management and maintenance. Interviewees noted, for example, that European projects can provide valuable opportunities to pilot nature-based solutions and green infrastructure, but that maintaining these interventions after project funding ends can be challenging (Chapter 3). Where such measures prove effective, more durable municipal, national or other financing arrangements may therefore be needed to support their continued operation and maintenance.

At the same time, the barriers analysis suggests that limited adaptation is not always simply a consequence of insufficient funding. Interviewees also pointed to the way available resources are prioritised, a lack of clear legal guidance for climate-resilient investment, and funding streams that are tied to narrowly defined expenditures and therefore leave limited room for innovation (Chapter 5). Strengthening cooperation should therefore involve not only improving access to financial resources, but also supporting municipalities in identifying appropriate investment priorities, interpreting policy and legal requirements, and sharing approaches that have worked elsewhere. Better alignment between local, regional and national actors could in

this way help create more consistent enabling conditions for adaptation across municipalities with very different levels of capacity.

6.2.6 Integrate adaptation, mitigation and regional development

Finally, adaptation in Podravje should not be treated as a stand-alone environmental agenda. The region faces climate risks alongside industrial decarbonisation pressures, socio-economic inequalities and broader regional-development challenges (Chapters 1 and 4). Adaptation decisions may interact with these processes, creating potential synergies as well as trade-offs. Integrating adaptation considerations with mitigation and regional-development objectives can help identify investments that contribute to multiple objectives, while attention to justice is needed to avoid disproportionately shifting the costs or burdens of adaptation towards groups or municipalities with fewer resources (Chapter 4). Together, these strategic directions provide a basis for identifying and further specifying concrete adaptation measures through the co-creation process described in Section 6.3.

6.3 Way forward: towards adaptive and coordinated action

The quantitative and qualitative evidence presented in this report should be viewed as a foundation for the next stage of adaptation planning rather than as a prescriptive adaptation plan. It identifies important spatial patterns of climate hazard, exposure and social vulnerability, while the governance, justice and barriers analyses highlight institutional conditions that may facilitate or constrain adaptation. A next step is to bring these different strands of evidence together with local knowledge, stakeholder priorities, and information on the feasibility, costs, benefits and potential trade-offs of adaptation measures. The upcoming workshop in October in Maribor will provide a platform to further prioritize key risks and identify adaptation strategies for further exploration. Additionally, financing options will be discussed.

At the same time, the report provides an evidence base for the future development of adaptation pathways for Podravje. Adaptation pathways explicitly recognize that climate risks and other relevant conditions evolve over time and therefore emphasize flexible and staged decision-making under uncertainty (Haasnoot et al., 2024). Rather than determining a single long-term adaptation strategy in advance, a pathways approach allows measures to be implemented progressively, with additional or alternative actions introduced when changing conditions indicate that existing measures are no longer sufficient or appropriate. Decisions can therefore be revisited as new climate information becomes available, adaptation measures are implemented, and regional priorities or other contextual conditions change. The co-creation process undertaken within TiCCA4Danu provides important building blocks for such an approach by bringing stakeholders together to collectively identify pressing risks, explore potential adaptation measures, consider implementation and funding options, and further specify promising strategies.

Moving from climate-risk assessment to effective adaptation will ultimately require linking scientific evidence with institutional responsibilities, local knowledge and the needs of affected communities. The findings of this report provide a starting point for this transition by identifying where climate pressures and social vulnerabilities intersect, while also highlighting the governance conditions, barriers and opportunities that shape the capacity to respond. The next challenge is therefore not only to identify suitable adaptation measures, but to establish a coordinated, inclusive and flexible process through which these measures can be prioritized, implemented and adjusted over time.

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8 Appendix

8.1 Supporting material for flood assessment

8.1.1 Hazard data

Open-access data are available for fluvial flooding through the Joint Research Centre (JRC) at the global scale (Dottori et al., 2016), and a recently updated dataset at the European scale (Baugh et al., 2026). The fluvial flood hazard maps for Europe and the Mediterranean Basin are provided as a gridded dataset representing river inundation for nine different flood return periods, ranging from 1-in-10-year to 1-in-500-year events. River flow inputs for these maps are generated using the open-source hydrological model LISFLOOD, while flood inundation is simulated with the hydrodynamic model LISFLOOD-FP. The dataset covers most of Europe, as well as river basins draining into the Mediterranean and Black Seas, including those in the Caucasus, the Middle East, and North Africa. We removed water bodies from the hazard maps using geospatial data on natural and human-made water bodies derived from OpenStreetMap.

8.1.2 Exposure data

See Section 8.2.

8.2 Supporting material for development of SoVI

8.2.1 Socio-economic indicators and rationale

The Social Vulnerability Index (SoVI) is used to characterize spatial differences in the susceptibility of populations to the adverse effects of natural hazards and climate change. Social vulnerability reflects the extent to which demographic and socioeconomic characteristics may influence people's ability to anticipate, cope with, respond to, and recover from hazardous events. The SoVI therefore complements the hazard and exposure analyses by identifying areas where exposed populations may face comparatively greater challenges in dealing with flood or extreme-heat impacts. It should not be interpreted as a measure of hazard probability or risk itself, but rather as an indicator of the underlying social conditions that can influence the severity of impacts.

Indicator selection for the Podravje SoVI was informed by established social vulnerability research, data availability, and further supported by qualitative findings from fifteen semi-structured stakeholder interviews, with officials and practitioners from municipalities, regional institutions, non-governmental organizations (NGOs), and emergency services, providing a locally grounded basis for the index. Interviews were coded using a deductive codebook structured around five thematic dimensions of social vulnerability: awareness and preparedness; community and behavior; economic capacity; institutional capacity and infrastructure; and governance. A total of 157 coded passages were identified across ten sub-codes. The most frequently coded dimensions were institutional capacity (INST_CAP: 62 coded passages across 12/15 interviews), governance and justice (GOV_JUST: 39 coded passages across 12/15 interviews), community behavior (COMM_BEH: 17 coded passages across 9/15 interviews), and climate awareness (AWAR_KNO: 14 coded passages across 10/15 interviews) reflecting the predominantly institutional profile of the interview sample.

Elderly residents emerged as the most consistently identified vulnerable group across the interviews, referenced across every thematic dimension: from limited access to digital early warning systems and absence of cooling infrastructure, to social isolation and reduced mobility during hazard events.

A second dimension that emerged recurrently across the interviews concerns awareness and knowledge gaps, particularly among lower-income and marginalized communities. Respondents described limited understanding not only of climate risks but of institutional entitlements and available services:

"They don't understand anything – not what the city, the local council, should be doing for them"

"There's zero awareness, I would say. They're exposed pretty much in the same amount as everyone else in the local environment. But no, the awareness, I think it's very, very low"

Economic conditions at the household level were rarely addressed directly by interviewees, consistent with the predominantly institutional profile of the sample. Nevertheless, economic constraints at the municipal scale were described as a significant structural barrier to adaptation, with smaller municipalities in particular reporting an inability to plan and invest beyond reactive emergency response:

"We're actually still at the stage where we're just reacting. It is very difficult to plan and carry out anything on a larger scale with the resources we have"

While this evidence operates at the institutional rather than household level, it is consistent with the broader picture of economic and financial vulnerability undermining adaptive capacity across the region.

These qualitative findings provided direct support for the selection of indicators to form the Podravje SoVI. The selected indicators capture key dimensions of demographic sensitivity, educational and informational capacity, and economic capacity, including the proportion of elderly people and children, low educational attainment, unemployment, and average monthly earnings (Table 10). Indicators were selected to represent distinct aspects of vulnerability while minimizing overlap between closely related variables, thereby maintaining a transparent and interpretable index.

Indicator	Rationale	Weight
Proportion of elderly population	Older residents were consistently identified in the stakeholder interviews as one of the groups most vulnerable to climate-related impacts, providing particularly strong local evidence for this indicator. Older people can be more physiologically sensitive to extreme heat and may also face greater health, mobility, evacuation, and recovery constraints during floods. Given the strength and consistency of this evidence across vulnerability dimensions, this indicator receives the highest weight.	30%
Proportion of children	Children may be physiologically sensitive to extreme heat and are generally dependent on caregivers during emergencies, increasing household-level assistance requirements during hazardous events. Although children represent an important dimension of demographic sensitivity, they were less prominently identified in the stakeholder interviews than elderly residents and therefore receive a lower weight.	15%
Proportion with low educational attainment	Educational attainment is used as a proxy for aspects of information access, risk awareness, and adaptive capacity. Lower educational attainment does not necessarily imply lower climate awareness, but it may be associated with greater barriers to accessing, interpreting, and acting upon risk information. This indicator therefore receives a moderate weight, reflecting its relevance to preparedness and adaptive capacity while acknowledging its indirect relationship with vulnerability. Low educational attainment is defined in accordance with Eurostat as having completed at most lower secondary education (ISCED levels 0–2; Eurostat, 2025).	20%
Unemployment rate	Unemployment can indicate reduced economic resources and financial security, potentially limiting the ability to invest in preparedness measures, respond to emergencies, temporarily relocate, or recover from losses. It represents one component of economic vulnerability and is weighted equally with the income indicator to avoid overemphasizing closely related socioeconomic conditions.	17.5%
Average monthly earnings	Higher earnings can increase the ability to invest in measures such as cooling, property-level flood protection, insurance, transport, repairs, or temporary accommodation. The indicator is therefore inverted so that lower earnings correspond to higher vulnerability. It receives the same weight as unemployment because the two indicators capture complementary aspects of economic capacity: earnings reflect the level of financial resources among	17.5%

	those in employment, while unemployment reflects reduced access to employment and associated financial security.	
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Table 10: Indicators included in the Social Vulnerability Index (SoVI) for Podravje, including their rationale and assigned weights.

Indicator selection and weighting were informed by social vulnerability literature, data availability, and stakeholder interview findings, with greater weight assigned to factors that showed stronger and more consistent local evidence of vulnerability.

The weighting scheme was informed by the relative importance of vulnerability factors identified in the stakeholder interviews, while maintaining a balanced representation of demographic, educational, and economic dimensions. A higher weight was assigned to the proportion of elderly residents because older people were consistently identified across the interviews as one of the groups most vulnerable to climate-related impacts, whereas children received a lower weight within the demographic dimension. Low educational attainment was given a moderate weight because it may reflect barriers to accessing, interpreting, and acting upon risk information, while unemployment and average monthly earnings were weighted equally as complementary indicators of economic capacity. All indicators are transformed to a common scale and oriented so that higher values correspond to greater social vulnerability; average monthly earnings are therefore inverted, while the remaining indicators already have a positive relationship with vulnerability. The interviews also highlighted other potentially important vulnerability dimensions, including the situation of Roma communities and inequalities in access to services and decision-making. However, these factors were not included in the quantitative SoVI where sufficiently reliable and spatially detailed data were unavailable, and are instead retained as qualitative considerations. Because the assignment of weights inevitably involves a degree of judgement, an equal-weighted version of the SoVI is also considered as a sensitivity test to assess the robustness of the resulting spatial patterns.

8.2.2 Data processing

The population and socioeconomic data used for the Social Vulnerability Index were obtained from SURS (2026a,b,c,d), using 2025 as the reference year and the settlement as the main spatial unit. While the SURS data provide recent and spatially consistent population totals for all settlements, they do not contain information on the intra-settlement distribution of the population. This is particularly relevant for larger settlements, such as Maribor (40.99 km²), where assigning the total population uniformly to the entire settlement would mask substantial spatial variation. To introduce additional spatial detail, the SURS data were therefore combined with the Eurostat (2026a) census population grid. The Eurostat population grid provides harmonized census-based population data for 2021 on an approximately 1 km² grid, enabling a more detailed representation of population distribution within larger settlements. Combining both datasets allows the more recent SURS settlement totals to be retained while making use of the finer spatial distribution represented by the Eurostat grid.

$$T_{rescaled,i} = T_{adjusted,i} \times \frac{P_{SURS,s}}{\sum_{j \in s} T_{adjusted,j}} \quad (1)$$

Where $T_{(adjusted,i)}$ is the area-adjusted Eurostat population of polygon i . $P_{(SURS,s)}$ is the 2025 SURS population total for settlement s and $\sum_{j \in s} T_{(adjusted,j)}$ is the total area-adjusted Eurostat population across all polygons within that settlement. This procedure preserves the relative within-settlement population pattern provided by Eurostat while constraining the total population to the more recent SURS statistics. The approach therefore provides additional spatial detail for larger settlements without replacing the more recent administrative population totals. Importantly, the rescaling assumes that (1) the relative spatial distribution of population within each settlement remained broadly unchanged between 2021 and 2025; (2) population

change within a settlement occurred proportionally across the areas represented by the Eurostat grid; and (3) locations with zero population in the Eurostat grid remain unpopulated after rescaling.

Percentage elderly, percentage children, and low educational attainment were available at the settlement level from SURS. Low educational attainment was calculated as the share of the population aged 15 years or older with basic education or less. Where settlement-level values for any of these three indicators were unavailable, the corresponding official municipality-level SURS value was used as a fallback. This assumes that the municipality-level value provides a reasonable approximation of conditions in settlements for which no settlement-specific estimate is available. The unemployment rate and median monthly net earnings were only available at the municipality level. These values were therefore assigned to all settlements within the corresponding municipality. This assumes that socioeconomic conditions represented by these indicators are spatially uniform within each municipality, meaning that intra-municipal differences in unemployment and earnings are not captured. For earnings, the municipality-of-residence dataset was used so that the indicator better reflects the economic conditions of residents rather than workplaces located in the municipality. Figure 50 shows the spatial distribution of the population and the individual indicators used to construct the SoVI.

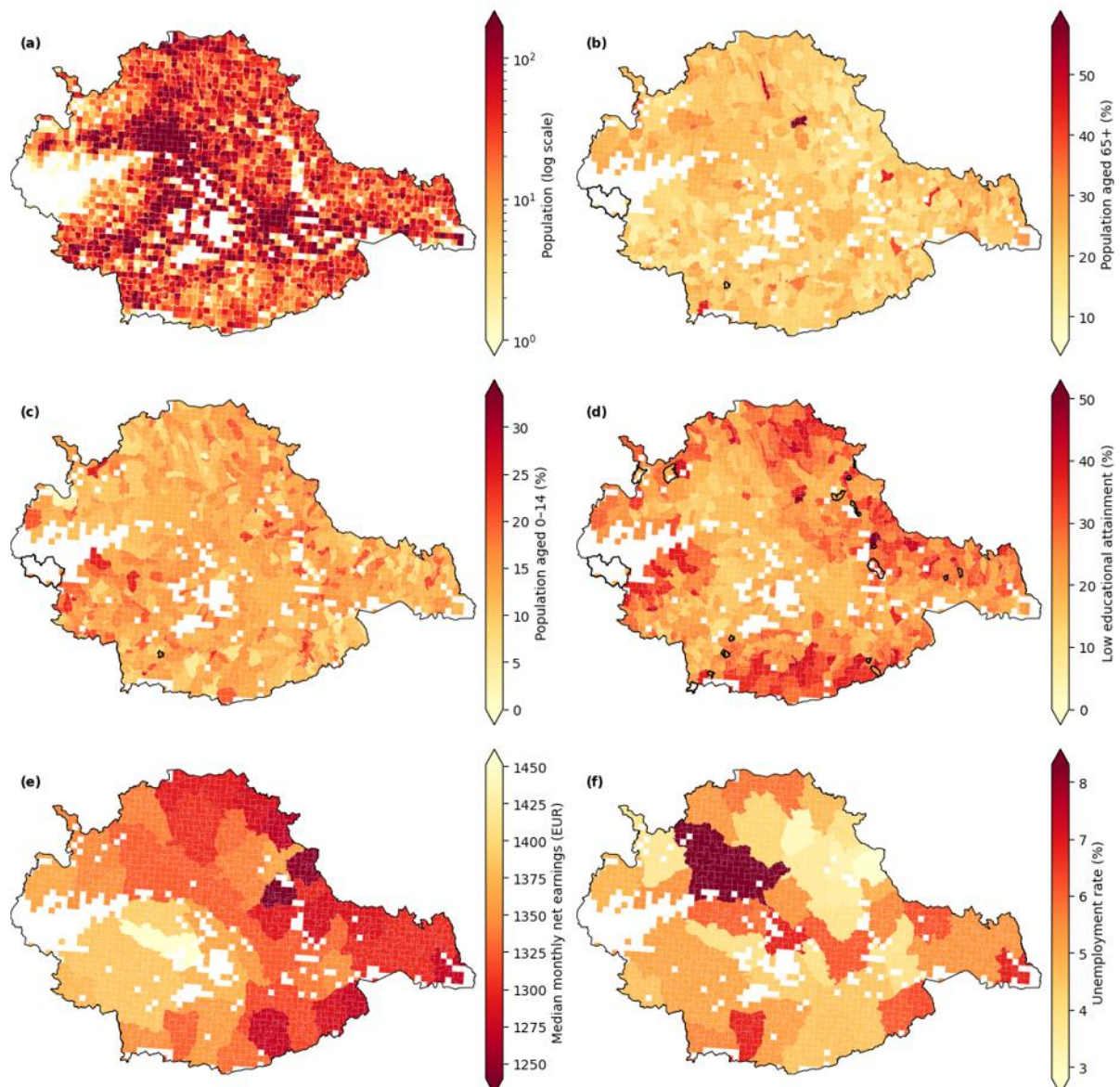


Figure 50: Spatial distribution of population and indicators used in the Social Vulnerability Index (SoVI) across Podravje.

Panel (a) shows the rescaled population distribution based on the 2021 Eurostat population data to match SURS settlement totals. Panels (b)–(f) show the proportion of elderly residents, proportion of children, low educational attainment, median monthly net earnings, and unemployment rate, respectively. Black outlines in panels (b)–(d) indicate settlements for which municipality-level SURS values were used to replace missing settlement-level data. Population in panel (a) is shown on a logarithmic scale, while the remaining indicators use continuous linear scales. Median monthly net earnings are displayed with a reversed colour scale so that lower earnings correspond visually to higher social vulnerability.

8.3 Supporting material for extreme heat assessment

8.3.1 Hazard data

The EMO-1 dataset was used to characterize climate extremes across the Podravje region at a spatial resolution of approximately 1.8 km for the period 1990-2025. The dataset provides gridded climate indicators derived from daily meteorological variables and allows both temporal changes and spatial variability in extreme conditions to be assessed. For the heat analysis, three complementary indicators were used. TX95p_days represents the annual number of days on which daily maximum temperature exceeds the 95th-percentile threshold, calculated relative to the 1991-2020 baseline period, and therefore captures the frequency of unusually hot days. TXx represents the annual maximum of daily maximum temperature and is used as an indicator of heat intensity. TR represents the annual number of tropical nights, defined as nights during which minimum temperature exceeds 20°C, and provides an indication of persistent nighttime heat. Together, these indicators capture different dimensions of extreme heat across Podravje, including frequency, intensity, and nighttime persistence. The analysis combines the spatial patterns of heat hazard with the Social Vulnerability Index (SoVI) to assess how heat exposure varies across socially vulnerable populations.

8.3.2 Exposure data

See Section 8.2.

8.4 Supporting material for drought assessment

8.4.1 Hazard data

Drought conditions were assessed using two indicators derived from the EMO-1 climate dataset for the Podravje region: the 3-month Standardized Precipitation Index (SPI-3) and the 3-month Standardized Precipitation Evapotranspiration Index (SPEI-3). SPI-3 characterizes short- to medium-term precipitation deficits over a three-month accumulation period, while SPEI-3 additionally accounts for the influence of atmospheric evaporative demand and therefore reflects the combined effect of precipitation deficits and temperature-related drying conditions. For both indices, drought conditions were identified where the index fell below -1 , corresponding to at least moderately dry conditions. The drought variables used in this assessment represent the annual sum of the absolute index values for periods when SPI-3 or SPEI-3 were below -1 . Consequently, larger annual values indicate a greater accumulated drought signal, reflecting either more severe drought conditions, a greater number of drought-affected months, or a combination of both.

8.4.2 Exposure data

Agricultural exposure to drought was assessed using the Slovenian RABA dataset (Ministrstvo za kmetijstvo, gozdarstvo in prehrano, 2026), the national register of the actual use of agricultural and forest land maintained by the Ministry of Agriculture. The dataset represents land use as polygons, with each polygon corresponding to a spatially continuous area characterized by the same actual land-use type. For each polygon, the database records the land-use class, area and spatial location, with classes defined according to the official interpretation key.

The relatively detailed RABA classification makes it possible to distinguish different types of agricultural land, including arable land, vineyards, orchards and other permanent or grassland uses, rather than treating all agricultural areas as a single exposure category. The RABA polygons were therefore used as the spatial exposure layer and intersected with the SPI-3 and SPEI-3 drought indicators to identify agricultural areas experiencing drought conditions.

Table 11 summarizes the treatment of the individual land-use classes and the rationale for their inclusion, grouping or exclusion. The classification was intended to focus the analysis on land uses for which drought-related water deficits may directly affect agricultural production or vegetation condition, while avoiding the inclusion of land-cover types that do not represent relevant agricultural exposure. The table therefore provides the methodological link between the detailed RABA classification and the broader exposure categories used in the drought analysis.

RABA_ID	Land-use class	Include?	Rationale
1100	Arable land	Yes	Directly relevant. Crop production is sensitive to precipitation deficits, soil-moisture limitations, and increased evaporative demand.
1160	Hop field	Yes	Highly relevant agricultural crop; drought can directly affect growth and yield and may increase irrigation requirements.
1180	Permanent crops on arable land	Yes	Represents active agricultural production and is therefore directly exposed to drought-related water stress.
1190	Greenhouse	Yes, with caution	Agricultural production is relevant, but exposure to meteorological drought may be moderated by controlled growing conditions and irrigation.
1211	Vineyard	Yes	Vineyards are directly affected by water stress, with potential impacts on grape yield and quality.
1212	Nursery	Yes	Plants grown in nurseries can be sensitive to water shortages.
1221	Intensive orchard	Yes	Fruit production can be strongly affected by drought and heat-related water stress, particularly during sensitive growth stages.
1222	Extensive orchard	Yes	Relevant for the same reason as intensive orchards, although management and irrigation may differ.
1230	Olive grove	Yes	Olive trees are relatively drought tolerant, but prolonged or severe water deficits can still reduce fruit development, yield, and oil production, making olive groves relevant for agricultural drought exposure.
1240	Other permanent crop	Yes	Represents productive perennial agriculture that can be affected by persistent moisture deficits.
1300	Permanent grassland	Yes	Drought can reduce biomass production and therefore affect fodder availability and livestock systems.
1321	Swampy meadow	No	Wet-grassland class that does not necessarily represent active agricultural production and is therefore excluded from the core agricultural exposure analysis.
1410	Overgrown agricultural area	No	Former or marginal agricultural land that is no longer under active cultivation and therefore does not directly represent current agricultural production exposed to drought.
1420	Forest plantation	No	Relevant to drought, but better treated within a separate forestry exposure analysis.
1500	Trees and shrubs	No	Vegetation may be drought-sensitive, but this class does not clearly represent an agricultural production sector.
1600	Uncultivated agricultural land	No	It is classified as agricultural land but currently lacks active production, so drought exposure does not directly translate into agricultural production impacts.
1800	Forest trees on agricultural land	No	More closely related to tree/forest systems than active agricultural production; better considered separately if analysing forestry or agroforestry.
2000	Forest	No	Highly drought-relevant, but should be analysed separately as a forestry sector.
3000	Built-up area and related surface	No	Not an agricultural land use and has no direct agricultural production exposure to meteorological drought.
4100	Swamp	No	Ecologically drought-sensitive but represents wetland ecosystems rather than agriculture.

4210	Reed	No	Primarily wetland vegetation; not part of agricultural production exposure.
4220	Other marshy area	No	Relevant for ecological/hydrological drought, but not for the agricultural exposure analysis.
5000	Dried open area with special vegetation	No	Not an agricultural production class and difficult to interpret in terms of sectoral drought exposure.
6000	Open area with little or no vegetation	No	No meaningful productive agricultural exposure.
7000	Water	No	Not agricultural land; drought impacts on surface water would require a hydrological drought analysis rather than this land-exposure analysis.

Table 11: RABA land-use classes considered for the meteorological drought exposure analysis in Podravje, including the rationale for their inclusion or exclusion from the agricultural sector assessment.

Irrigation and other water-management practices may reduce the direct relationship between meteorological drought and agricultural impacts across all included agricultural land-use classes.

Figure 51 shows the spatial distribution and extent of the agricultural land-use classes considered in the drought assessment. The RABA dataset represents observed land use at the time of mapping; however, the presence of a mapped agricultural land-use class does not necessarily imply that every parcel is actively cultivated or managed during the assessment period.

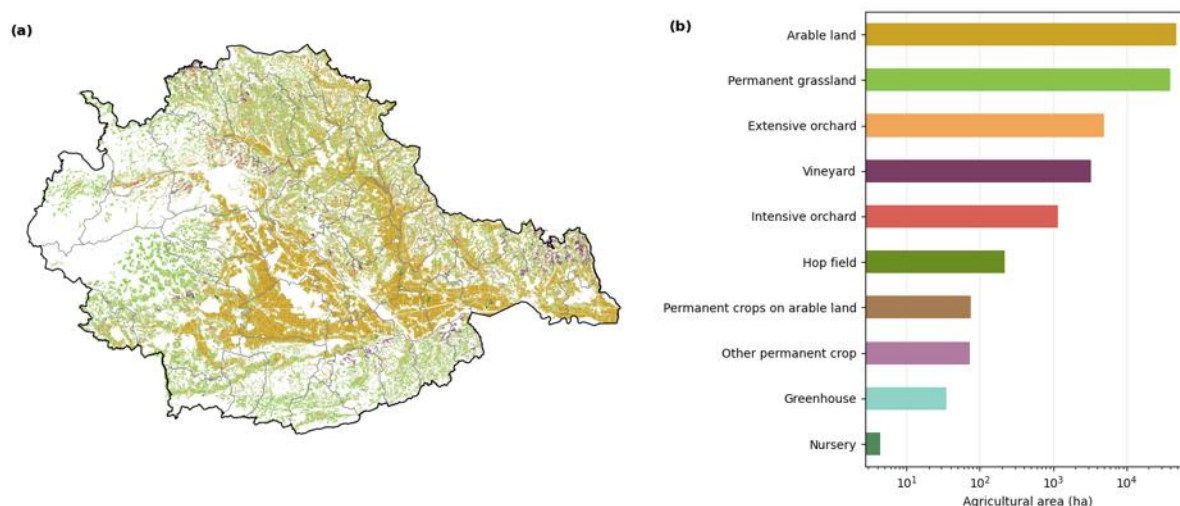


Figure 51: Spatial distribution and extent of agricultural land-use classes considered in the meteorological drought exposure analysis for Podravje.

Panel (a) shows the spatial distribution of the selected RABA agricultural land-use classes, with municipality boundaries shown for reference. Panel (b) shows the total area of each agricultural land-use class in hectares; the x-axis is displayed on a logarithmic scale to improve comparison between classes with substantially different spatial extents.

8.4.3 Agricultural drought severity exposure

Figure 52 summarizes the spatial distribution of agricultural drought exposure across Podravje by municipality and land-use class for the period 1990-2025. The figure shows how the share of each agricultural land-use class is distributed across three cumulative SPEI-3 drought-severity categories, allowing differences in exposure between agricultural sectors and municipalities to be compared. Panels (a)–(c) represent increasing drought severity, from 90–<104 to 104–<118 and ≥ 118 , respectively. Together, the panels highlight where particular agricultural land uses are more strongly concentrated within the higher drought-severity classes.

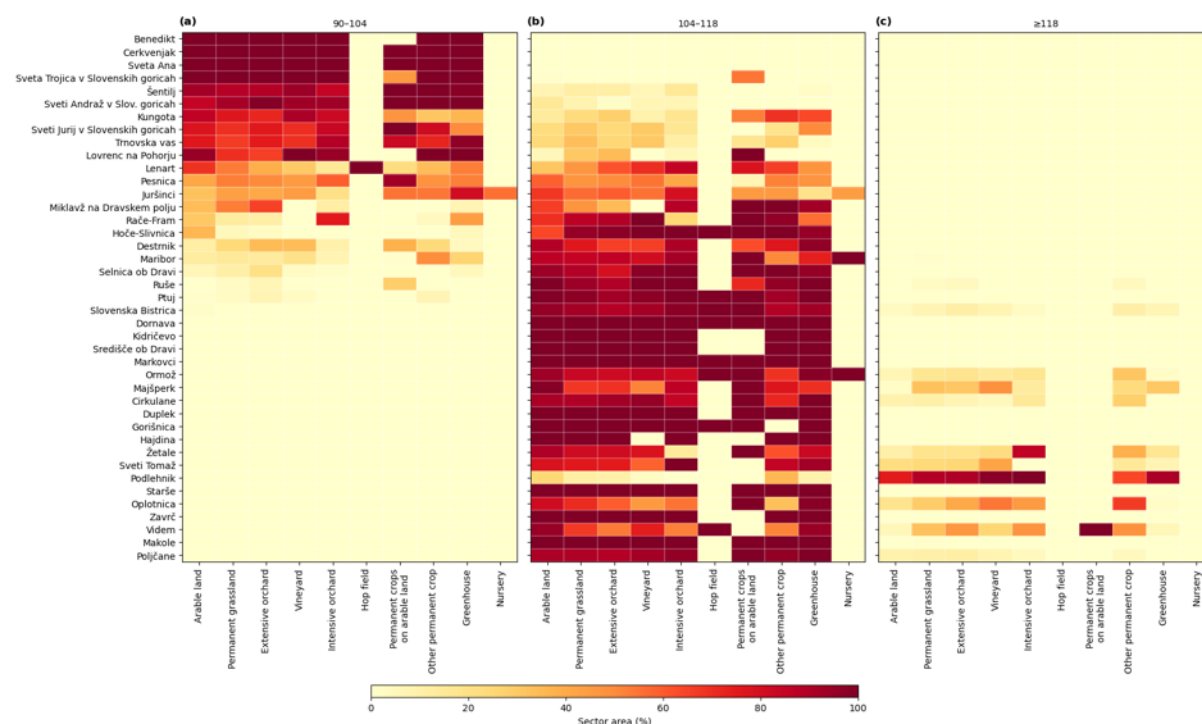


Figure 52: Distribution of agricultural drought exposure by sector and municipality in Podravje for 1990–2025. The three panels show the percentage of each agricultural land-use class falling within cumulative SPEI3 drought-severity classes of (a) 90–<104, (b) 104–<118, and (c) ≥118. Municipalities are shown along the y-axis and agricultural land-use classes along the x-axis. Color intensity indicates the percentage of the respective sector area within each drought-severity class.

8.5 Supporting material for landslide assessment

8.5.1 Hazard data

The assessment of slope mass-movement susceptibility is based on the GeoZS warning maps for landslides, rockfalls, and debris flows, produced at a scale of 1:25,000 and published by the Slovenian Water Agency (DRSV, 2026a-c). The maps classify terrain into six classes ranging from negligible (0) to very high (5) probability of initiation and were initially published for 85 municipalities in Slovenia, with the dataset subsequently being progressively expanded and updated. Although the official datasets refer to probability of occurrence, the classes are interpreted in this study as relative susceptibility, as they describe the favourability of conditioning factors for slope-failure initiation rather than a temporally defined probability or return period.

Landslide susceptibility is derived from lithology (weight 0.40), slope (0.25), land use (0.15), slope curvature (0.10), distance to structural elements and fault zones (0.05), and slope orientation (0.05). Rockfall susceptibility is based primarily on lithology and fault zones (0.50), slope inclination (0.35), and the relationship between geological-layer dip and slope orientation (0.15). The debris-flow model additionally incorporates triggering-related climatic information, combining lithology, structural elements and fault zones (0.19), slope inclination (0.15), altitude (0.05), 48-hour extreme precipitation (0.20), proximity to torrential terrain morphology (0.17), distance to surface watercourses (0.12), and slope curvature (0.12). Importantly, the warning maps represent source or initiation areas only and do not delineate subsequent transport or deposition zones; consequently, a mass movement initiated outside the mapped road intersection could still affect infrastructure downslope. The landslide warning map is also primarily intended to represent shallow landsliding and may not adequately capture deep-seated structural landslides governed by site-specific geological conditions. The datasets are therefore best suited for screening and identifying locations where more detailed hazard assessment may be warranted, rather than for estimating annual probabilities of failure.

8.5.2 Exposure data

OpenStreetMap (OSM) provides freely and openly accessible geospatial data on a wide range of features worldwide through a Volunteered Geographic Information (VGI) approach. For this study, OSM data were used to represent the road network in Podravje. The .osm.pbf file was downloaded on 27 August 2026. Road features were extracted based on their OSM 'highway' classification and subsequently harmonized into a reduced set of road categories. Link roads were merged with their corresponding parent classes, with 'motorway_link', 'trunk_link', 'primary_link', 'secondary_link', and 'tertiary_link' reclassified as 'motorway', 'trunk', 'primary', 'secondary', and 'tertiary' roads, respectively. Residential roads and roads classified as 'road' were retained as separate categories, while 'unclassified' roads were grouped together with 'track' features under the 'track' category.

8.6 Methodology of Adaptation Justice Index review.

This section details the indicators used when assessing the climate adaptation strategies and plans at the national and municipal level in Section 4.1.

The tool used to assess the plans was the [Adaptation Justice Index](#), developed by Juhola et al (2022). The Adaptation Justice Index synthesises prominent themes/topics of discussion from the adaptation justice literature into a set of “indicators” for four different “forms” of justice “distributive”, “procedural”, “recognition”, and “corrective/restorative”. For each of these indicators, four ordinal levels of achievement are defined enabling a climate adaptation plan to be given a score between 0 and 3 for each indicator. The highest total score is 48.

Relevant adaptation plans were identified by representatives of Maribor/Podravje at an early stage of the TiCCA4Danu project. The AJI is intended for use with comprehensive singular adaptation plans, however at the national level Slovenia’s climate adaptation plan is in the process of being superseded, and Maribor/Podravje’s adaptation strategies are not confined to a singular document but are dispersed over a number of relevant strategies and plans dealing with climate and environmental issues broadly, as well as specific climate risks. Therefore it was decided to in the case of the national context to give a *provisional score* with the intention to assess a draft version of the latests CCA plan once published and include the result in a later deliverable of the TiCCA4Danu project (D4.4). For the Maribor strategies, the method employed was to closely read three of the most relevant documents for evidence of the indicators being met, and select the highest score achieved across them for each indicator (unless there was compelling evidence as to why this was an outlier).

The documents selected for analysis are noted below. Translations of these documents into english was achieved through DeepL machine translation.

Table 12: Analyzed plans at the national and city level

National	Maribor
The Slovenian Strategic Framework for Climate Change Adaptation (SSF-CCA)	- Municipal Environment Protection Program (MEPP) - The Heat Action Plan (HAP), - Climate Change Vulnerability Assessment (CCVA)

Using the indicators from the AJI a close reading of each document was performed with a research coding relevant sections where achievement of each of the ordinal points of each indicator was achieved. Evidence for the score given at each point was noted in the tables below for transparency.

Table 13: Adaptation Justice Assessment of SSF-CCA

#	Indicator	Scale	Value	Source
D1	A risk mapping/assessment has been conducted.	No assessment has been conducted.	0	Conducted in the “basis for preparing an assessment”
		Risk assessment is mentioned but not used.	1	
		Risk assessment is conducted, and measures have been identified for some risks.	2	

		Risk assessment is conducted, and measures are identified for all risks.	3	
D2	There is a process for identifying vulnerable groups.	No process.	0	Conducted in the “basis for preparing and assessment” “It is vital that we continuously improve our knowledge and acquire new information, considering the changing vulnerability parameters (social and economic parameters, such as the challenges of population ageing and refugee crises, on the one hand and the physical exposure to new risks of natural and other disasters on the other).” (p6) Clear evidence of how the vulnerability assessment was linked to planning and monitoring choices was needed for a higher score.
		Vulnerable groups are identified.	1	
		There is a vulnerability assessment that will be updated.	2	
		Vulnerability assessment is connected to adaptation planning and monitoring.	3	
D3	There is a process that assesses the distribution of benefits.	No process.	0	There is discussion of “opportunities” of adaptation, including cost saving to Slovenia and its public finances by investing in adaptation early, but this is not a serious assessment of how these benefits will be shared within society
		The strategy identifies the distribution of benefits of adaptation in general.	1	
		Distribution of benefits is assessed as part of the strategy process.	2	
		Distribution of benefits is monitored continuously.	3	
D4	There is a process that assesses the distribution of costs.	No process.	0	Page 3 notes the potential recovered costs of investing early in adaptation Page 14 on Funding identifies potential funding sources for adaptation. Regretably this is too high level to count as an assessment
		The strategy identifies the distribution of cost of adaptation in general.	1	
		Distribution of costs is assessed as part of the strategy process.	2	
		Distribution of costs is monitored continuously.	3	

				of who will bear the costs of adaptation in a systematic way. They do note that there are high requirements of
D5	The strategy identifies the possibility of a distribution of negative impacts (e.g., maladaptation)	No identification	0	No clear discussion of potential negative impacts of adaptation measures
		The strategy (at least implicitly) identifies the possibility of the negative impacts of adaptation measures in general.	1	
		Distribution of negative impacts of some adaptation measures are identified.	2	
		Distribution of negative impacts of all adaptation measures are identified.	3	
#	Indicator	Scale	Value	Source
P1	Adaptation strategy details who participates in the strategy process	No participation outside of public sector.	0	Page 8-10 on broader cooperation states that “the inclusion of stakeholders and the participation of the wider interested expert public in the development of policies and the planning and implementation of measures are guaranteed;” However in the steps contributing to the implementation of the guidelines there is no step requiring public engagement. The focus is primarily on interministerial cooperation.,
		Participation through invitation of experts, private sector	1	
		Participation of experts and citizens through open invitation	2	
		Participation and measures to enable participation of vulnerable groups	3	
P2	The adaptation strategy has involved participation during different phases of the process	No participation	0	No evidence of public participation in the development of the strategy (possibly it is in the basis document)
		The strategy process has involved information provision about adaptation (at least once during the process before the final output publication)	1	
		The strategy process has involved consultation	2	

		The participation in the strategy process has been collaborative and continuous	3	
P3	The strategy allocates responsibility to adaptation	No allocation	0	The strategy is more of a high level framework for guiding how measures are identified in sectoral plans, and as such there is no direct allocation of responsibilities for specific measures
		Responsibilities are mentioned	1	
		Responsibilities for some adaptation measures are allocated	2	
		Responsibilities for all adaptation measures are allocated	3	
P4	The adaptation strategy has a structured plan for implementation	No participation in adaptation plan	0	P12 makes awareness raising on CCA in general an objective of the strategy “We will plan and conduct communication campaigns and closely cooperate with the media to support objectives and measures in the field of adaptation to climate change and, more broadly, to achieve the purpose of informing the target audience of climate change impacts. The campaigns will be tailored to the target audience and will contribute to the goal of increasing awareness among the wider public.”
		The implementation plan involves informing different stakeholders	1	
		The implementation plan involves stakeholder consultation	2	
		The implementation plan involves stakeholder participation in a collaborative and continuous manner	3	
P5	The adaptation strategy has a plan for updating and evaluating the strategy	No plan	0	There are indicators developed for the measures in the strategy, and discussion of the need to continually update advice included in sectoral adaptation plans as new information on climate change impacts and
		The strategy involves a plan for updating, but evaluation is not described	1	
		The strategy involves a plan for updating and describes how progress will be evaluated	2	
		The strategy involves an update and evaluation plan that includes stakeholder participation.	3	
#	Indicator	Scale	Value	Source

R1	The strategy acknowledges that adaptation needs are different across groups in society	No acknowledgement	0	Page 7 almost repudiates this point – stating emphatically that climate change affects all sectors and is hard to break down by individual sectors of social activity. However sectoral measures are identified later on, as is notes on the varying vulnerability to impacts. Differentiation of needs appears to have been determined by the expert review of the “basis” document but requires further evaluation
		The strategy states that adaptation needs are different	1	
		The strategy takes into account different adaptation needs based on expert review	2	
		The strategy is built on different groups identifying their adaptation needs	3	
R2	The strategy acknowledges the impact of existing societal structures on vulnerable groups in adapting to the impacts of climate change	No acknowledgement	0	No acknowledgement
		The existence of structures is mentioned in a general manner	1	
		There are measures to decrease the impact of structures	2	
		There is a structured plan to assess the impact of societal structures on vulnerability	3	
R3	The strategy acknowledges adaptation as a way to secure basic human rights	No acknowledgement	0	No acknowledgement
		Adaptation as a way to secure basic rights is mentioned	1	
		The strategy describes how adaptation can secure basic rights in general	2	
		The strategy has measures to secure basic rights.	3	
#	Indicator	Scale	Value	
C1	The strategy acknowledges the need to compensate for the diverging impacts of climate change	No acknowledgement	0	No evidenced acknowledgement
		The strategy acknowledges the need to compensate	1	
		The strategy has compensation measures	2	

		for some impacts of climate change		
		The strategy has compensation measures for all relevant impacts of climate change	3	
C2	The strategy has compensation measures to deal with maladaptation	No mention of the need to compensate	0	No mention of compensation measures could be identified
		The need to compensate is mentioned	1	
		There are compensation measures for some maladaptation	2	
		There are measures to compensate for all groups	3	
C3	The unequal distribution of resources for adaptation is compensated for by redistribution	No mention of unequal distribution.	0	Implied in the discussion on resourcing in the discussions of the unsuitability of relying on private financing
		The need for reallocation of resources for adaptation is acknowledged (at least partially).	1	
		There are measures for application of adaptation resources.	2	
		There are measures for reallocation of adaptation resources to develop adaptive capacity.	3	

Adaptation Justice Assessment of Maribor level strategies

#	Indicator	Scale	Value	Source
D1	A risk mapping/assessment has been conducted.	No assessment has been conducted.	0	a risk assessment was conducted as part of MISSION CE CLIMATE, and was disaggregated by geographical region (lowland and highland), climate scenario (RCP4.5 & 8.5), and then by sector. Key risks are identified but these are not yet clearly linked to specific actions
		Risk assessment is mentioned but not used.	1	
		Risk assessment is conducted, and measures have been identified for some risks.	2	
		Risk assessment is conducted, and measures are identified for all risks.	3	
D2	There is a process for identifying vulnerable groups.	No process.	0	A vulnerability assessment was conducted as part of the
		Vulnerable groups are identified.	1	

		There is a vulnerability assessment that will be updated.	2	MISSION CE CLIMATE project. This analysis assessed at a municipal scale sectoral vulnerabilities and included some social vulnerabilities, but does not single out particular vulnerabilities beyond commonplace markers of increased vulnerability (e.g. age and employment status). A very detailed vulnerability assessment exists for the health sector but is not expanded generally. Vulnerability analysis in Heat action plan looking at both biological factors and socio economic factors, with targeted measures
		Vulnerability assessment is connected to adaptation planning and monitoring.	3	
D3	There is a process that assesses the distribution of benefits.	No process.	0	P.48 notes that adaptation is likely to bring a variety of benefits, but does not try to quantify these or assess how they are shared within social groups. “Implementing adaptation activities and measures undoubtedly yields savings, reduces damage during disasters, protects public health, and enhances residents’ safety, as well as creating new jobs, new business opportunities, and greater investment security while fully capitalizing on certain opportunities, particularly in the tourism, agriculture, and construction sectors”
		The strategy identifies the distribution of benefits of adaptation in general.	1	
		Distribution of benefits is assessed as part of the strategy process.	2	
		Distribution of benefits is monitored continuously.	3	
D4		No process.	0	

	There is a process that assesses the distribution of costs.	The strategy identifies the distribution of cost of adaptation in general.	1	Implicit discussion of how costs of climate change are shared amongst society present in some sections of the MEPP
		Distribution of costs is assessed as part of the strategy process.	2	
		Distribution of costs is monitored continuously.	3	
D5	The strategy identifies the possibility of a distribution of negative impacts (e.g., maladaptation)	No identification	0	Maladaptation is mentioned in RVA implicitly as something that can happen with adaptation, but as the aim of the report is not to identify measures there is no specific discussion of possible impacts,
		The strategy (at least implicitly) identifies the possibility of the negative impacts of adaptation measures in general.	1	
		Distribution of negative impacts of some adaptation measures are identified.	2	
		Distribution of negative impacts of all adaptation measures are identified.	3	
#	Indicator	Scale	Value	Source
P1	Adaptation strategy details who participates in the strategy process	No participation outside of public sector.	0	While preliminary p51 sets the progress monitoring objectives and these note an ambition to include both citizen engagement in the strategy and ngo engagement in the strategy as success metrics. However it does not make clear what kind of engagement this will be. Quality of engagement – i.e. meaningful engagement. This appears also on p.19 in the objective to utilise participatory planning for spatial interventions “Participatory planning of spatial interventions to ensure a higher quality of life while respecting sustainable development, the principles of the circular
		Participation through invitation of experts, private sector	1	
		Participation of experts and citizens through open invitation	2	
		Participation and measures to enable participation of vulnerable groups	3	

			economy, climate change mitigation, etc. (involving all stakeholders).” Which hints to a utilisation of all affected principle – but is not adequately linked to climate adaptation specifically. Heat action plan made specific efforts to target vulnerable groups “As part of the project Ready4Heat, a comprehensive approach has been developed for interaction with stakeholders and vulnerable groups, which has been crucial for shaping an effective plan to mitigate the negative consequences of heat waves in the Municipality of Maribor. The key vulnerable groups include the elderly, people with chronic illnesses, individuals with disabilities, children, infants, pregnant women, and outdoor workers. Tailored preventive measures are particularly important for these groups. The project included workshops for individual vulnerable groups, which took place in February and March 2024. At the workshops and meetings, participants, including representatives of the city administration, healthcare workers, and educational institutions, discussed local needs and vulnerabilities related to heat waves. 14 This enabled the development of targeted measures tailored to
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				specific groups. Workshops also contributed to establishing communication paths and action processes that are essential for quick responses during heat events. In addition to the workshops, questionnaires were prepared and sent to employees in kindergartens, primary schools, pensioners' associations, the disabled, and companies. The questionnaires facilitated the collection of specific information. about how different groups experience heat waves, what their concerns are regarding heat, and what preventive measures they perceive as the most effective”
P2	The adaptation strategy has involved participation during different phases of the process	No participation	0	Strong evidence of stakeholder and vulnerable group participation in drafting of heat action plan, including in identifying relevant measures linked to identified concerns of vulnerable groups and an ambition to include these stakeholders in a review and evaluation of the plan. However as elsewhere the heat action plan diverges from the approach taken elsewhere
		The strategy process has involved information provision about adaptation (at least once during the process before the final output publication)	1	
		The strategy process has involved consultation	2	
		The participation in the strategy process has been collaborative and continuous	3	
P3	The strategy allocates responsibility to adaptation	No allocation	0	A number of different agencies have responsibilities for parts of the adaptation strategy on a sectoral basis, but the report does not contain a clear
		Responsibilities are mentioned	1	
		Responsibilities for some adaptation measures are allocated	2	

		Responsibilities for all adaptation measures are allocated	3	tracking of objectives to responsible agencies owing to the preliminary status of the document. Likewise there is a combination/running together of adaptation and mitigation actions. Heat action plan clearly notes expertise of different groups for implementing the action plan and marks these out for inclusion in the working group
P4	The adaptation strategy has a structured plan for implementation	No participation in adaptation plan	0	In heat action plan vulnerable groups and other stakeholders are involved in the implementation plan in a working group tasked with implementing the agreed measures.
		The implementation plan involves informing different stakeholders	1	
		The implementation plan involves stakeholder consultation	2	
		The implementation plan involves stakeholder participation in a collaborative and continuous manner	3	
P5	The adaptation strategy has a plan for updating and evaluating the strategy	No plan	0	Heat action plan includes an action plan that will involve stakeholder participation „The coordination of the implementation and evaluation of the effects of the measures, as well as monitoring the plan, will be carried out by a working group that will actively collaborate with all stakeholders who have already participated in the preparation of the action plan. Regular reports on the implementation of the measures will be provided to the Municipal Administration and Municipal Council of
		The strategy involves a plan for updating, but evaluation is not described	1	
		The strategy involves a plan for updating and describes how progress will be evaluated	2	
		The strategy involves an update and evaluation plan that includes stakeholder participation.	3	

				MOM, enabling budget planning for the financial resources necessary for the implementation of the planned measures.” Though note that the description of this plan is cursory and the process is not detailed. So an intermediate score is given.
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8.7 Methodology and questionnaire for the survey on barriers to CCA

8.7.1 Methodology

Research design

The context-specific information on barriers and enabling conditions to climate change adaptation was gathered through an **online survey** with a wide range of local stakeholders in Podravje. The stakeholders included representatives of government agencies, civil society organizations, research institutes and the private sector. While some respondents took on the city-level perspective, others had the perspective of the region or other municipalities within the region. The online survey was considered the best option to gather this information because it allowed the research team to gather a wide range of different perspectives. The survey responses were analysed descriptively.

In a second step, the information gathered in the survey was selectively complemented through **semi-structured interviews** with selected stakeholders.

Questionnaire development

The questionnaire is structured into several thematic areas, which are listed and elaborated on below. The complete questionnaire can be found in the next chapter. The survey was set up in English and Slovenian.

0) Introductory questions

As introductory questions, the survey includes a question on the actor type of the respondent (government/administration, economic actor, academic actor, civil society actor, other). Optionally, respondents can name the specific institutions they represent. In addition, respondents are asked to name the geographic level they are referring to when answering the survey: the regional level, the region's capital level or the level of another municipality within the region.

1) Specific barriers to climate change adaptation

The main part of the questionnaire revolves around the identification of relevant barriers to climate change adaptation. This part is based on existing literature on barriers to climate change adaptation. The main input on which the questionnaire is based is the [CASCADE](#) project's list of barriers. CASCADE was a project funded by the EU (DG ECHO) and implemented between 2019-2021. It aimed to improve the capacity to understand, assess, and treat current and future climate change related risks on the local level, focusing in particular on the Baltic Sea Region (BSR) conditions.¹⁶ CASCADE identified a list of barriers to climate

¹⁶ [CASCADE project](#)

change adaptation based on the above mentioned paper by Weyrich (2016).¹⁷ Weyrich defines nine main categories of barriers: 1) Conflicting timescales and conflicts of interest, 2) Leadership, 3) Resources, 4) Science, 5) Governance and institutional constraints, 6) Lack of communication and awareness, 7) Attitudes, values and motivations, 8) Politics, and 9) Adaptation process. Weyrich (2016) is itself mainly referring to Ekstrom & Moser (2014)¹⁸, who organise barriers to adaptation along the adaptation cycle (or generally, the policy cycle).

Apart from consulting existing literature, the project team also engaged with the Thematic Working Group on Transformational Adaptation (TWG TA) of the EU Mission on Adaptation to Climate Change's Implementation Platform (MIP4Adapt). The [TANALOA](#) Water Project, which is part of the TWG TA, had developed an extensive list of barriers and opportunities to transformational adaptation, based on data collected within the project region. The TiCCA4DANU project team assessed the TANALOA list of barriers and concluded that while most of the thematic areas in which barriers are categorised overlap with those of CASCADE, the TANALOA list is too extensive for an accessible survey and the barriers are partly sector specific, which does not comply with the general view that TiCCA4DANU would like to generate. The literature-based barriers identified by CASCADE were therefore considered still more useful than the TANALOA list.

To **define the list of barriers** used in the questionnaire, the list of barriers identified by the CASCADE project was taken as a basis and partly adjusted to match the wording used for specific terms in the Podravje region. In addition, the research team added examples to barriers that appeared very theoretical, it deleted and combined some barriers that were very similar, and it added some barriers and reference to private actors, because these had not been integrated into the CASCADE barriers. The questionnaire finally includes a list of 47 barriers, clustered into 7 topics (see Table 14). Respondents are asked to assess the significance of each of these barriers using a 4-point scale (significant barrier, moderate barrier, minor barrier, no barrier) and a “don’t know” option.

Table 14: List of barriers to CCA used in survey

1. Conflict of interest

Powerful interests hindering the planning and implementation of adaptation measures (from various actors, including political/governmental, economic and/or civil society actors)

Lack of political will (e.g. due to short term political cycles)

Lack of engagement by the private sector (e.g. due to short-term economic priorities)

Lack of interest from the population

Adaptation competes with other more immediate priorities

2. Leadership

Lack of leadership on climate issues by the regional institutions in Podravje

Lack of leadership on climate issues by the municipal government(s)

Lack of leadership on climate issues by the national government

Lack of leadership on climate issues by non-state actors (e.g. economic actors, academic institutions, NGOs, other civil society actors)

Too many leaders on climate change without clarity on their roles (leaders in different departments; leaders on multiple levels, public and private sector leaders, etc.)

3. Governance and institutional constraints

¹⁷ Weyrich, P. (2016): Barriers to Climate Change Adaptation in Urban Areas in Germany. Report 26. Climate Service Center Germany, Hamburg.

¹⁸ Ekstrom, J.a. & Moser, S.C. (2014): Identifying and overcoming barriers in urban climate adaptation: Case study findings from the San Francisco Bay Area, California, USA. Urban Climate 9 (2014): 54-74.

Lack of alignment between national climate policies and regional or municipal priorities

Fragmentation or lack of legislation creating a mandate for action at the regional level (e.g. lack of regional policy or guidance, resistance to regional approach)

Fragmentation or lack of legislation creating a mandate for action at the municipal level (e.g. lack of municipal policy or guidance, resistance to local approach)

Legal barriers (e.g. current law preventing implementation of measures, lengthy process of obtaining permits, bureaucracy)

Lack of collaboration and cooperation across different departments and sectors ("silo thinking")

Lack of collaboration and cooperation across different governance levels (municipality, region, national)

Lack of opportunities for non-state actors and citizens to engage (including economic actors, academic institutions, NGOs, other civil society actors)

Lack of access to vulnerable groups to identify and implement just adaptation measures

Lack of accountability processes (e.g. inadequate systems in place for the public to challenge and require correction of mismanagement or lack of action)

4. Resources

Lack of regional institutions' finances

Lack of municipal government finances

Lack of regional institutions' staff time

Lack of municipal government staff time

Lack of funding from the national to the regional level

Lack of funding from the national to the municipal level

Lack of staff knowledge on the science of climate adaptation, specific local adaptation needs and/or existing adaptation options

Lack of knowledge on how to start and follow an adaptation planning process

Lack of tools, technology, methods or similar

Lack of financial and/or staff resources of non-state actors (e.g. economic actors, academic institutions, NGOs, other civil society actors)

Lack of adaptive capacity of the population

5. Science and data

Lack of data for risk assessments (e.g. no data, low resolution) or data is not in the needed format

Lack of or limited access to other scientific data and information (e.g. socio-economic data, vulnerability etc.)

Lack of guidance on how to use the scientific data and information (e.g. overload of information, how to deal with contradicting information, etc.)

High uncertainties related to climate scenarios

High uncertainties related to adaptation interventions and their impacts/effects

Insufficient monitoring and data collection on implementation and effects of adaptation measures (e.g. because people do not want to know about failures, need to show reasonable return on investment)

6. Awareness and communication

Lack of awareness of the links between climate change and other issues (e.g. health, productivity of the work force, weather extremes damaging production sites, effects on vulnerable groups)

Inability to effectively communicate the need for adaptation internally in regional institutions

Inability to effectively communicate the need for adaptation internally in municipal government

Inability to effectively communicate the need for adaptation externally (to e.g. economic actors or broader public)

7. Attitudes, values and motivations

Climate scepticism

Suppression of scientific knowledge and professional expertise

General mistrust of European institutions among the public

General mistrust of national government among the public

General mistrust of regional institutions among the public

General mistrust of municipal government(s) among the public

Difference in risk perception between governing authorities and economic actors or broader public

2) Barriers along the adaptation implementation cycle

Apart from the specific barriers, the questionnaire also includes a question on where the barriers appear along the adaptation implementation cycle, using the following stages of the process, based on ClimateADAPT (2025). In order to take measures to overcome barriers, it is important to know in which stage of the policy cycle they are located. This is particularly the case for barriers that might appear throughout every stage of the cycle (Weyrich 2016).

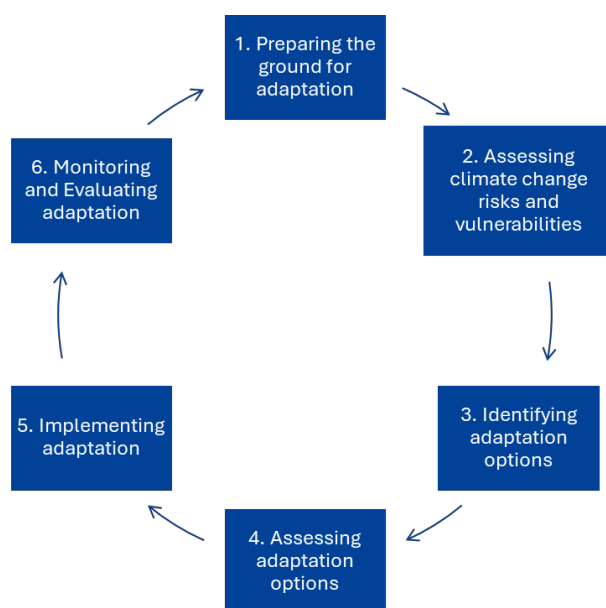


Figure 53: Adaptation cycle

Ideal-type stages of the adaptation decision-making process; Source: ClimateADAPT 2025

3) Barriers in different sectors

In a further part of the questionnaire, participants are asked to which sectors are particularly affected by barriers that hinder the planning and implementation of necessary measures for climate change adaptation. This question provides valuable insights on the most problematic areas in terms of climate change adaptation from the participant's view. It guides the coming steps of the project, including the selection of priority thematic areas and adaptation measures to be implemented.

4) Factors to overcome barriers to CCA

In a next section of the questionnaire, participants are asked to elaborate on how the identified barriers could be best overcome. This question is set up as an open question with no predefined answer categories, so participants could share their thoughts freely. The intention of this section is to gather insights and ideas from various perspectives, which could then feed into the coming parts of the project, when concrete adaptation measures are identified.

5) Collaboration and influence on Climate Change Adaptation

The last section of the questionnaire includes several questions on the level of interaction and the influence of different actors on issues related to climate change adaptation. This section is included in the survey on barriers and enabling conditions but provides insights for task 2.1, the socio-economic analysis and stakeholder mapping.

Sampling and Response Rate

The sampling of relevant stakeholders for the questionnaire in each of the regions was conducted as part of the stakeholder analysis (WP2, task 2.1). A list of relevant stakeholders on climate change adaptation was developed by UNIVIE in consultation with the respective project partner in each of the four regions. The list of stakeholders aimed at being diverse in terms of geographic focus (city, municipalities, region) and type (government, civil society, academia, private sector). Moreover, stakeholders included in the list needed to have some connection to the topic of climate change adaptation.

The sample size in Maribor/Podravje was 167. 46 actors responded to the survey, resulting in a response rate of 28%.

Data collection

The questionnaires were developed and distributed using the software Survalyzer. Participants were contacted by the local project partners, making use of often already established contacts. Furthermore, the local project partners sent reminders by e-mail and called some of the stakeholders to increase the response rate.

Data was collected between 10.03.2026 and 20.04.2026.

Data processing and analysis

To conduct the analysis, we included responses from survey participants that at least finalised the first part of the survey on specific barriers to climate change adaptation (up to question 10). Data entries of respondents that replied to less than the first block of questions were deleted.

The survey data was analysed descriptively. R and Excel were used for descriptive statistics of closed questions. Open-ended questions were categorised and analysed thematically. Furthermore, comparisons were done between the responses of different actor groups and different geographic foci. Given that the sizes of sub-groups are often small, group-specific results need to be analysed with caution. For Maribor/Podravje, a workaround was introduced: Respondents describing themselves as academic, economic, or civil society actors were grouped into one sub-group “non-state” actors, to increase the group size.

Ethical Considerations

The survey data is treated confidentially, analysed anonymised and only used for research and project purposes. It can only be accessed by INFRAS and the University of Vienna.

- Informed consent

- Anonymity and data protection (e.g., GDPR compliance)
- Voluntary participation
- Approval by an ethics committee, if applicable

8.7.2 Questionnaire

Table 15: Questionnaire on barriers to climate adaptation in Podravje

Question	Response categories	Comments
Introduction		
Q1 What stakeholder group do you attribute yourself to? Please note that the information on specific institutions will not be shared with anyone outside the research team of INFRAS and University of Vienna. The analysis of the survey will be carried out using anonymised data.	▪ Government/administration (add name of governmental/administrative entity): ▪ Economic actor (add name of company or organisation): ▪ Academic actor (add name of institution/organisation): ▪ Civil society (add name of organisation): ▪ Other (please specify):	Multiple choice with optional possibility to add names
Q2 For which situation will you assess the barriers? I will express my opinion on the situation:	▪ In the city of Maribor ▪ In another municipality of the Podravje region (please specify): ▪ On the regional level of Podravje	Single choice
Q3	Would you like to comment on this question?	Open question
Barriers to Climate Change Adaptation		
We would like to know about existing barriers to climate change adaptation in the Podravje region and its municipalities. A barrier represents a factor or process that makes adaptation planning and implementation more difficult. We want to gather perspectives from a variety of institutions, sectors, and professional backgrounds. Barriers can be grouped in seven categories: 1) conflicts of interest 2) leadership 3) governance and institutional constraints 4) resources 5) science and data 6) awareness and communication 7) attitudes, values and motivations		



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Q4	Please rate the following barriers around the topic of “ conflicts of interest ” according to their significance in your municipality or the Podravje region.	▪ Powerful interests hindering the planning and implementation of adaptation measures (from various actors, including political/governmental, economic and/or civil society actors) ▪ Lack of political will (e.g. due to short term political cycles) ▪ Lack of engagement by the private sector (e.g. due to short-term economic priorities) ▪ Lack of interest from the population ▪ Adaptation competes with other more immediate priorities	Matrix question: Response options: ▪ Significant barrier ▪ Moderate barrier ▪ Minor barrier ▪ No barrier ▪ Don't know.
Q20	Are there any other barriers around the topic of “conflict of interest” that you find significant?		Open question
Q5	Please rate the following barriers around the topic of “ leadership ” according to their significance in your municipality or the Podravje region.	▪ Lack of leadership on climate issues by the regional institutions in Podravje ▪ Lack of leadership on climate issues by the municipal government(s) ▪ Lack of leadership on climate issues by the national government ▪ Lack of leadership on climate issues by non-state actors (e.g. economic actors, academic institutions, NGOs, other civil society actors) ▪ Too many leaders on climate change without clarity on their roles (leaders in different departments; leaders on multiple levels, public and private sector leaders, etc.)	Matrix question: Response options: ▪ Significant barrier ▪ Moderate barrier ▪ Minor barrier ▪ No barrier ▪ Don't know.
Q21	Are there any other barriers around the topic of “leadership” that you find significant?		Open question

Q6	Please rate the following barriers around the topic of “governance and institutional constraints” according to their significance in your municipality or the Podravje region.	▪ Lack of alignment between national climate policies and regional or municipal priorities ▪ Fragmentation or lack of legislation creating a mandate for action at the regional level (e.g. lack of regional policy or guidance, resistance to regional approach) ▪ Fragmentation or lack of legislation creating a mandate for action at the municipal level (e.g. lack of municipal policy or guidance, resistance to local approach) ▪ Legal barriers (e.g. current law preventing implementation of measures, lengthy process of obtaining permits, bureaucracy) ▪ Lack of collaboration and cooperation across different departments and sectors (“silo thinking”) ▪ Lack of collaboration and cooperation across different governance levels (municipality, region, national) ▪ Lack of opportunities for non-state actors and citizens to engage (including economic actors, academic institutions, NGOs, other civil society actors) ▪ Lack of access to vulnerable groups to identify and implement just adaptation measures ▪ Lack of accountability processes (e.g. inadequate systems in place for the public to challenge and require correction of mismanagement or lack of action)	Matrix question: Response options: ▪ Significant barrier ▪ Moderate barrier ▪ Minor barrier ▪ No barrier ▪ Don’t know.
Q22	Are there any other barriers around the topic of “governance and institutional constraints” that you find significant?		Open question
Q7	Please rate the following barriers around the topic of “resources” according to their significance in your municipality or the Podravje region.	▪ Lack of regional institutions’ finances ▪ Lack of municipal government finances ▪ Lack of regional institutions’ staff time ▪ Lack of municipal government staff time ▪ Lack of funding from the national to the regional level ▪ Lack of funding from the national to the municipal level ▪ Lack of staff knowledge on the science of climate adaptation, specific local adaptation needs and/or existing adaptation options ▪ Lack of knowledge on how to start and follow an adaptation planning process ▪ Lack of tools, technology, methods or similar ▪ Lack of financial and/or staff resources of non-state actors (e.g. economic actors, academic institutions, NGOs, other civil society actors) ▪ Lack of adaptive capacity of the population	Matrix question: Response options: ▪ Significant barrier ▪ Moderate barrier ▪ Minor barrier ▪ No barrier ▪ Don’t know.
Q23	Are there any other barriers around the topic of “resources” that you find significant?		Open question

Q8	Please rate the following barriers around the topic of “science and data” according to their significance in your municipality or the Podravje region.	▪ Lack of data for risk assessments (e.g. no data, low resolution) or data is not in the needed format ▪ Lack of or limited access to other scientific data and information (e.g. socio-economic data, vulnerability etc.) ▪ Lack of guidance on how to use the scientific data and information (e.g. overload of information, how to deal with contradicting information, etc.) ▪ High uncertainties related to climate scenarios ▪ High uncertainties related to adaptation interventions and their impacts/effects ▪ Insufficient monitoring and data collection on implementation and effects of adaptation measures (e.g. because people do not want to know about failures, need to show reasonable return on investment)	Matrix question: Response options: ▪ Significant barrier ▪ Moderate barrier ▪ Minor barrier ▪ No barrier ▪ Don't know.
Q24	Are there any other barriers around the topic of “science and data” that you find significant?		Open question
Q9	Please rate the following barriers around the topic of “awareness and communication” according to their significance in your municipality or the Podravje region.	▪ Lack of awareness of the links between climate change and other issues (e.g. health, productivity of the work force, weather extremes damaging production sites, effects on vulnerable groups) ▪ Inability to effectively communicate the need for adaptation internally in regional institutions ▪ Inability to effectively communicate the need for adaptation internally in municipal government ▪ Inability to effectively communicate the need for adaptation externally (to e.g. economic actors or broader public)	Matrix question: Response options: ▪ Significant barrier ▪ Moderate barrier ▪ Minor barrier ▪ No barrier ▪ Don't know.
Q25	Are there any other barriers around the topic of “awareness and communication” that you find significant?		Open question
Q10	Please rate the following barriers around the topic of “attitudes, values and motivations” according to their significance in your municipality or the Podravje region.	▪ Climate skepticism ▪ Suppression of scientific knowledge and professional expertise ▪ General mistrust of European institutions among the public ▪ General mistrust of national government among the public ▪ General mistrust of regional institutions among the public ▪ General mistrust of municipal government(s) among the public ▪ Difference in risk perception between governing authorities and economic actors or broader public	Matrix question: Response options: ▪ Significant barrier ▪ Moderate barrier ▪ Minor barrier ▪ No barrier ▪ Don't know.
Q26	Are there any other barriers around the topic of “attitudes, values and motivations” that you find significant?		Open question

Q11	The ideal typical process of planning and implementing climate change adaptation consists of the following steps: 1. Preparing the ground (political support, structures and mechanisms, relevant data, awareness) for adaptation 2. Assessing climate change risks and vulnerabilities 3. Identifying adaptation options 4. Assessing adaptation options 5. Implementing adaptation 6. Monitoring and Evaluating adaptation In your own words, which are the most important barriers to climate change adaptation (max. 3), and in which stage of the process are they located? Select the respective stage(s) and note down the specific barrier(s). Multiple responses are possible (max. 3).	1. Preparing the ground for adaptation, namely: 2. Assessing climate change risks and vulnerabilities, namely: 3. Identifying adaptation options, namely: 4. Assessing adaptation options, namely: 5. Implementing adaptation, namely: 6. Monitoring and Evaluating adaptation, namely: Other (please specify):	Multiple Choice with text boxes per answer category.
Affected sectors and overcoming barriers			
Now we would like to know which sectors are particularly affected by the barriers identified above, and how these barriers could be overcome.			
Q12	Which sectors are particularly affected by barriers that hinder the planning and implementation of necessary measures for climate change adaptation? Multiple responses are possible.	▪ Agriculture ▪ Biodiversity management (incl. soil quality) ▪ Business and Industry ▪ Buildings ▪ Disaster risk reduction ▪ Energy ▪ Forestry ▪ Health ▪ Land use planning / Spatial planning ▪ Marine and Fisheries ▪ Tourism ▪ Transport ▪ Water management ▪ Others (please specify): ▪ I don't know.	Multiple choice question
Q13	What are possible ways for overcoming barriers in the sectors identified above?	Open question.	
Collaboration on climate change adaptation			
Now we would like to know about different actors and their influence with regard to climate change adaptation.			

Q14 Please indicate whether you have had any interaction or cooperation with the following groups of actors on issues related to climate change adaptation in the past five years - and if so, how frequent it was.	▪ City / municipal government ▪ Emergency services / disaster risk management authorities ▪ Podravje regional institutions ▪ Slovenian national ministries or agencies ▪ European Union or other international organisation ▪ Private sector companies / industries ▪ Utility companies (e.g., water, energy, waste) ▪ Workers' unions ▪ Civil society organisations / NGOs / Local community groups / citizen initiatives ▪ Academic / research institutions / universities ▪ Other (please specify)	Matrix question: response options: ▪ Never ▪ Sometimes ▪ Often ▪ Very often ▪ Don't know.
Q27 Have you had any interaction or cooperation with other actors on issues related to climate change?		Open question
Q15 For each actor listed below, please indicate how much influence you think they currently have over climate change adaptation planning and implementation in the Podravje region or its municipalities.	▪ City / municipal government ▪ Emergency services / disaster risk management authorities ▪ Podravje regional institutions ▪ Slovenian national ministries or agencies ▪ European Union or other international organisation ▪ Private sector companies / industries ▪ Utility companies (e.g., water, energy, waste) ▪ Workers' unions ▪ Civil society organisations / NGOs / Local community groups / citizen initiatives ▪ Academic / research institutions / universities ▪ Other (please specify)	Matrix question: response options: ▪ No influence ▪ Some influence ▪ High influence ▪ Very high influence ▪ Don't know.
Q28 Are there any other actors that, from your perspective, have some, high or very high influence over climate adaptation planning and implementation in the Podravje region or its municipalities?		Open question
Q16 Which actor(s) do you think should have more influence (or a stronger role) in climate adaptation the Podravje region or its municipalities?		Open question

Q17 Lastly, we want to hear about your vision for climate change adaptation in your region. Please indicate how much you agree with the following statements. Climate change adaptation in my region...	▪ ... should be business-led, attracting private-sector investment to drive innovation and economic growth. ▪ ... requires quick solutions, even if they delay or conflict with longer-term structural reforms. ▪ ... should go hand in hand with efforts to reduce greenhouse gas emissions, even if it means fewer adaptation options in the short term. ▪ ... should be community-led, empowering affected and vulnerable populations to take an active role in adaptation planning and decision-making. ▪ ... should focus on technological and market-based solutions to strengthen the resilience of key economic sectors. ▪ ... should focus on supporting the people most affected by climate change and on reducing inequalities that make them particularly vulnerable. ▪ ... should prioritize infrastructural and regulatory solutions to increase societal stability and resilience. ▪ ... should aim for economic opportunities, even if they damage the environment. ▪ ... should include all affected stakeholders in adaptation efforts, even when their priorities conflict and complicate the process. ▪ ... should be led by strong public institutions that can provide direction, plan, and implement adaptation efforts.	Matrix question: A scale ranging from 'least like how I think' to 'most like how I think'. ▪ strongly agree ▪ agree ▪ disagree ▪ strongly disagree ▪ Don't know.
Further comments		
Q18 Please add any further comments on the barriers, stakeholders, this survey or on the TiCCA4Danu project.		Open question.
Information about the interviewee		
Q19 Please share your contact information with us and let us know, whether you agree to being contacted for a follow-up interview. Note that this information will only be used for the purpose of this research project and will not be shared with anyone outside of the research team of INFRAS and University of Vienna. Furthermore, the analysis of the survey will be carried out using anonymised data.	▪ Name: ▪ E-Mail: ▪ Phone number: ▪ I do not want to provide this information. ▪ I am open to being contacted for a follow-up interview	Multiple choice with open text fields.