TICCA4DANU

TRANSFORMATIVE INNOVATION FOR CLIMATE CHANGE ADAPTATION IN THE DANUBE REGION

Climate Change Risks and Adaptation in Burgas District

Preliminary Results

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Table of Content

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Figures

Tables

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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, transformative change in 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 Burgas District and is organized as follows.

The first two chapters take a quantitative approach to describe the Burgas district'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 analyzes climate risks by identifying current and projected hazards – floods, wildfires, and extreme heat – and assessing the exposure of infrastructure, the population, and economic sectors.

To address existing climate risks, Burgas District has already initiated several adaptation measures. Chapters 3, 4 and 5 adopt a qualitative approach to deepen understanding of the current CCA landscape. Chapter 3 maps the institutional and governance settings in which climate adaptation currently occurs. It identifies the most relevant stakeholders, such as local and regional authorities, NGOs, and research institutions, to clarify their mandates, resources, and coordination mechanisms. Chapter 4 analyzes existing CCA documents (the National Strategy on CCA and Burgas Municipality) for their inclusion of justice considerations and establishes an understanding of how justice and fairness are perceived in Burgas District. Chapter 5 diagnoses existing barriers to ongoing climate change adaptation, including policy, financial, technical, social, and governance obstacles.

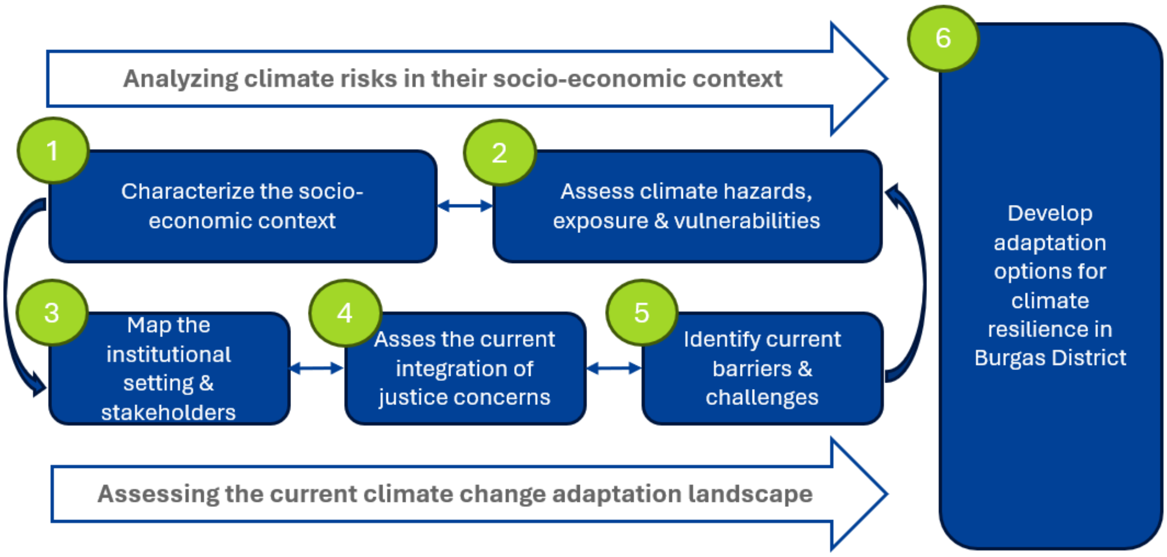

Figure 1: TiCCA4Danu Research Framework (WP2) and Report Structure

The two tracks converge in Chapter 6, where findings are synthesized to design transformative adaptation measures and policies for Burgas District. 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

Oblast Burgas (NUTS 3) is Bulgaria's fourth-largest province with a population of 384,446 people, situated in the larger Yugoiztochen (Southeast) planning region (NUTS 2). From 2014 to 2024, Burgas' population has been shrinking and aging: children under 5 fell 21% (2014-2024), working-age population declined 11%, and those 65+ rose to 22.5% of the population – a population group notably vulnerable to climate change. Since 2020, population loss has slowed as net migration turned positive, helped by the recovery of the tourism industry and inflows of migrants. The economy is recovering after a steep COVID-era dip, ranking 8th in GDP per capita in 2023 with relatively low unemployment levels (4.4% in 2024). Burgas specializes in trade, transport, accommodation, real estate, and construction, underpinned by its Black Sea port and a rapidly expanded capacity for tourist accommodations. Manufacturing is another strong economic sector (capital-intensive, with outsized volatility linked to the Lukoil refinery), while agriculture, forestry, and fishing also remain to be important employers.

Yet, the region's economic strengths (see Figure 2) are also pressure points when it comes to climate change. In Yugoiztochen, per-capita emissions are more than double Bulgaria's average, largely driven by energy production. A significant share of these emissions originates from the oil refinery located in Burgas District. In addition, the historically grown economic weight of the tourism and real estate sectors has incentivized dense coastal development, thereby increasing exposure and vulnerability to climate change impacts; an issue that was discussed publicly following the devastating floods of autumn 2025. Structural challenges - including health-system capacity gaps, an aging population, economic inequalities and uneven municipal resources to deal with climatic changes - heighten vulnerability to climate change, particularly outside Burgas City. At the same time, several positive trends create opportunities for climate adaptation and mitigation. Improvements in digital infrastructure, positive migration patterns that help slow population decline, strong absorption of EU funds, and a recovering economy all support the development of innovative solutions to address climate adaptation. Furthermore, the Southeastern development region (NUT 2) possesses significant untapped renewable energy potential (solar, wind, and hydro), which could play a key role in addressing decarbonization pressures and offering new business opportunities.

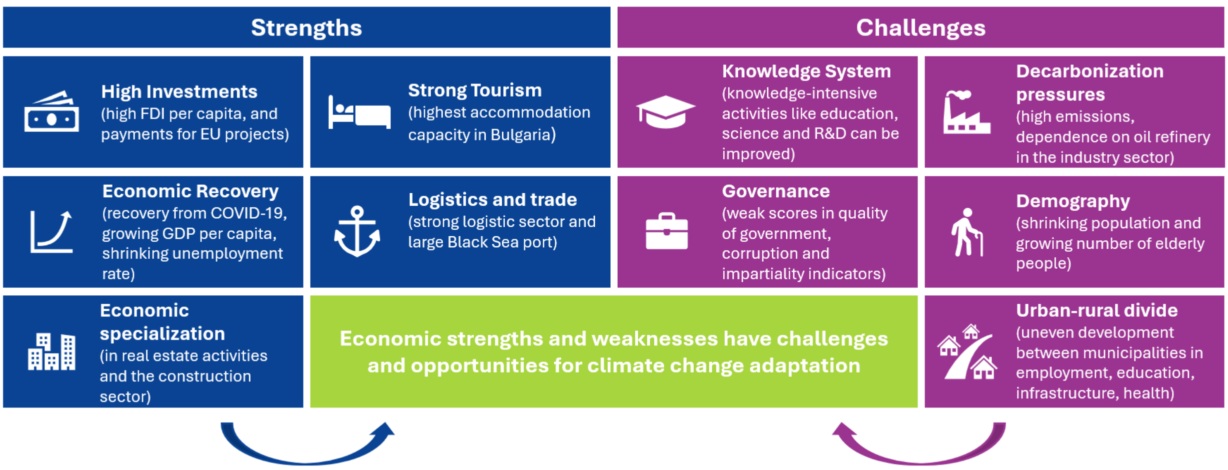

Figure 2: Socio-economic context of Burgas District

Climate risks

The report assesses three different types of climate risks.

Fluvial Flooding: Flood risk in Burgas is largely governed by rainfall-related processes, while also reflecting the influence of multiple interacting drivers, particularly for riverine flooding. Based on historical evidence, both coastal and pluvial flooding should be considered alongside river flooding in water risk management and adaptation planning. The present analysis focuses on fluvial flooding due to data availability. The population exposure for fluvial flooding rises with event magnitude: ~2,990 people for a 1-in-10-year flood to ~4,285 for a 1-in-500-year event (in Burgas province). Burgas municipality has the highest municipal exposure: ~950 (1-in-10-year) to ~1,440 (1-in-500-year) with hotspots around Meden Rudnik and the adjacent industrial area to the northeast; there are additional clusters within Burgas city and southwest of Dimchevo. The risk, expressed as expected annual damage (EAD), for Burgas Province is estimated at €3.9 million (interquartile range: €2.7–5.4 million). Our results show the highest EAD in the water supply network, followed by the power and rail networks, and the road network.

Wildfire: The last decades have shown a modest but increasing trend in conditions associated with higher potential wildfire danger, and this is expected to further increase under higher emission scenarios. Both current and future wildfire potential are the highest in the central parts of Burgas Province. Under historical conditions, the vast majority of the population in Burgas Province is exposed to >90 days per year of moderate fire danger on average. Future scenarios indicate a systematic shift toward higher exposure frequencies across all fire danger levels, resulting in more prolonged periods of wildfire-prone conditions. Spatial hotspots (notably Kameno and Aitos) persist and intensify; while Sredets emerges as a hotspot for very high danger. Historical wildfire activity is highly concentrated in a few extreme years, driving disproportionate impacts. Economic impacts are significant and sector-specific, with small firms most affected; estimated losses of €25-€42 million district-wide under conservative assumptions.

Extreme Heat: Extreme heat in Oblast Burgas has increased significantly and persistently since 1950, with the strongest intensification since the early 2000s. Tropical nights were rare before the 1980s and are now frequent, indicating a structural climate shift. Annual counts of very hot days have risen markedly; extremely rare events have also increased, though more moderately. Heatwave duration does not show a statistically significant trend, suggesting change is driven more by frequency than duration of heat events. Under current conditions, the majority of the population in Burgas Province is exposed to more than 30 tropical nights per year on average, with the highest levels of exposure occurring in coastal municipalities such as Burgas Municipality. In terms of affected economic sectors, the most consistent and policy-relevant finding concerns the construction sector, where extreme heat is associated with a statistically significant decline in firm activity.

Climate Adaptation Governance Structures

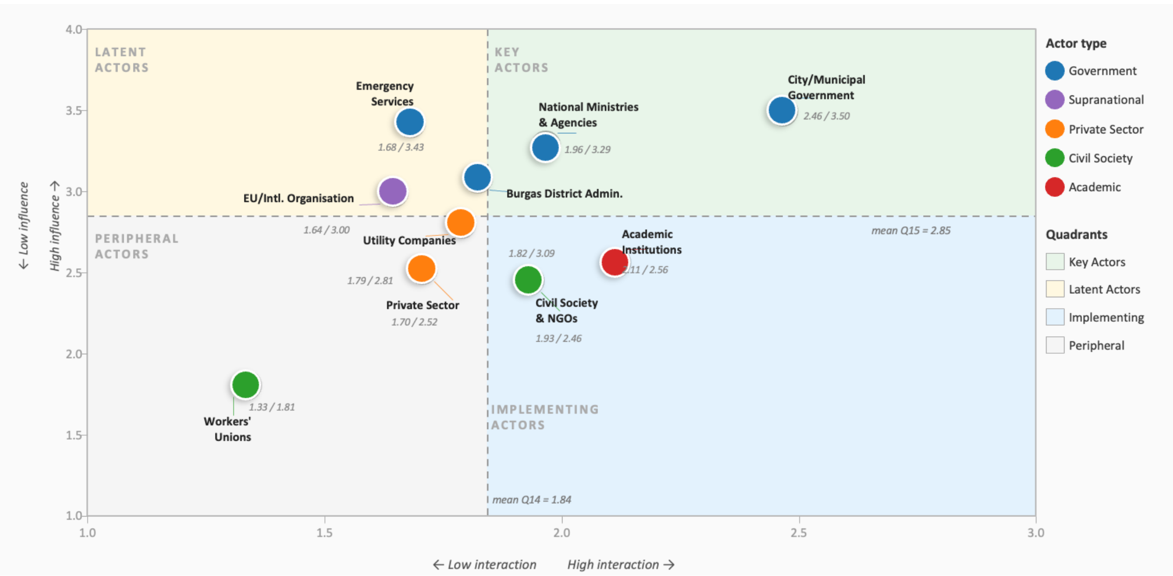

Figure 3: Stakeholder Groups Influence-Interaction Matrix, Burgas District
Note: The graph was developed based on the responses to questions Q14 and Q15 in the survey on barriers to CCA, n=30 (see Chapter 5 or Annex 8.4 for more information).

To understand the institutional setting, interviews with key stakeholders were conducted in Burgas District. They highlight the complex dynamics of climate adaptation efforts, emphasizing the central role of Burgas Municipality as a leader in climate adaptation efforts. The study reveals that while municipalities are primary drivers of climate adaptation initiatives (supported by the influence-interaction matrix, Figure 3), they face significant challenges due to limited resources, fragmented responsibilities across different sectors, and reliance on national-level approval or funding for projects. Despite active collaboration in regional committees and informal networks, bureaucratic constraints sometimes hinder effective cooperation between different governance levels. National institutions are perceived as similarly influential despite interacting less with local groups; their role is primarily in strategic alignment and funding. The district administration and regional branches of national institutions, both representatives of the national government, support local initiatives mainly with sectoral expertise and data. Civil society organizations, NGOs, and academic institutions are well embedded in local networks - evidenced by frequent interactions - yet their perceived influence is relatively limited. Private sector actors, utility companies, and workers' unions are seen as having low influence and are engaged relatively infrequently. Despite limited direct contact with the EU, it is perceived as having high influence on CCA actions, mostly through its funding decisions, which are particularly important for NGOs.

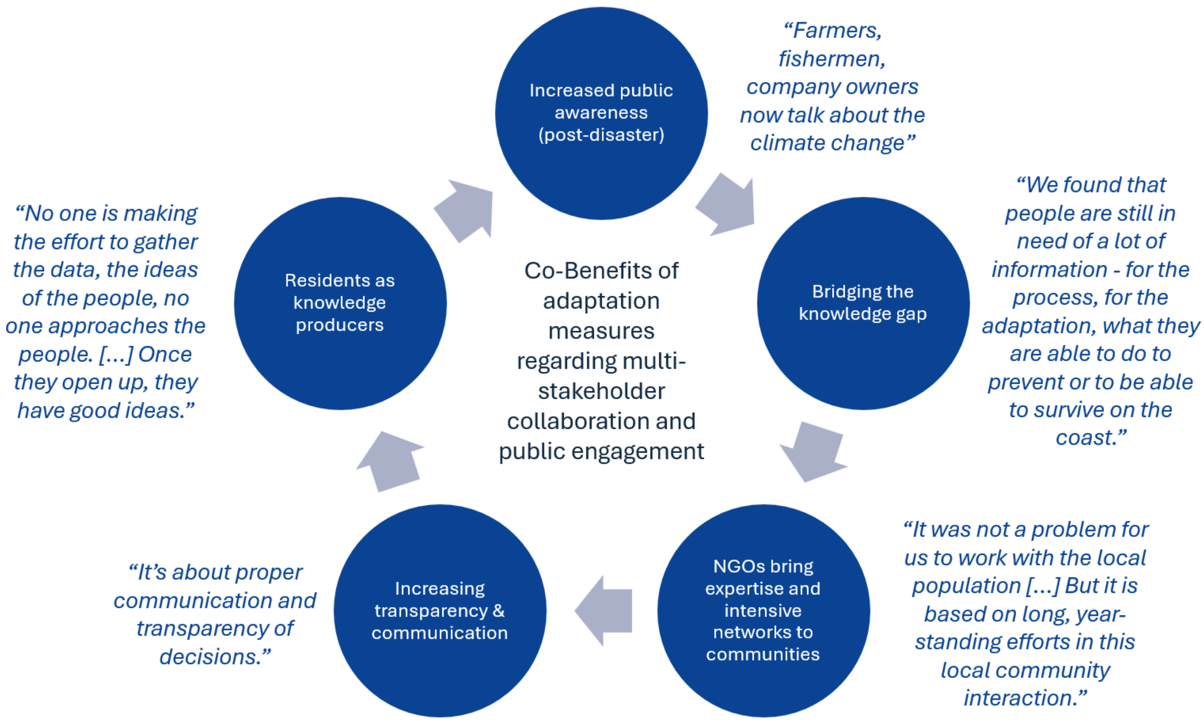

Figure 4: Recommendations with regards to multi-stakeholder collaboration and public engagement for adaptation measures

Over the past years, NGOs take on a larger role in engaging in climate change action. They are a valuable bridge to communities – often through work on the ground – also in some more rural communities. This can be leveraged by municipalities by engaging them in CCA actions. Recommendations synthesized from the interviews emphasize the importance of using public awareness post-disaster, bridging knowledge gaps on climate change adaptation, and creating structured platforms for collaboration among stakeholders to improve climate adaptation efforts in Burgas District (see Figure 4 for illustration and quotes).

Justice Integration into Adaptation Planning

The Adaptation Justice Index assessment shows that Burgas Municipality's Sustainable Energy and Climate Action Plan (SECAP) scores below Bulgaria's National CCA Strategy across all four justice dimensions – recognitional, distributive, procedural, restorative (Table 1). The national plan achieves only about half of the available points - indicating substantial room for improvement at both, municipality and national levels. Both plans include risk and vulnerability assessments and identify measures, yet both plans fall short on specifying who benefits and how costs and risks (including maladaptation) are distributed and tracked over time. Further information on vulnerability and hazard mappings are included in this report. In terms of procedural justice, the national plan engages sectoral experts and clarifies responsibilities more than SECAP, but both largely emphasize informing over co-implementing with stakeholders and lack clear methodologies for participatory monitoring and iterative updating. Recognitional justice is acknowledged through expert-led identification of differential needs but lacks structured processes for communities to define their own priorities; links to broader social objectives remain limited. Restorative justice commitments are minimal in both plans.

Table 1: Forms of justice in climate adaptation

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/Transitional Justice	justice in the way in which existing or previous injustices are accounted for and rectified.

Moreover, some interviewees expressed challenges they perceived in implementing participatory governance (procedural and recognitional justice): low public trust, weak community institutions, perceived lack of transparency and rule enforcement, and limited engagement capacity. Distributive concerns center on rural-urban disparities in capacity, service access, and financing, alongside general resource constraints in local administrations. Additionally, stakeholders emphasized the importance of targeting investments to vulnerable groups and areas.

Barriers and enabling conditions

The survey on barriers to climate change adaptation shows that identified barriers are very diverse in terms of thematic areas, led by barriers from the category "attitudes, values, and motivations". Priority barriers include public mistrust of national and European institutions, climate skepticism, low risk perception, siloed collaboration across sectors and governance levels, gaps in awareness of climate–society linkages, and limited staff knowledge on adaptation and planning. Figure 5 shows a list of the ten most relevant barriers - as listed by survey respondents.

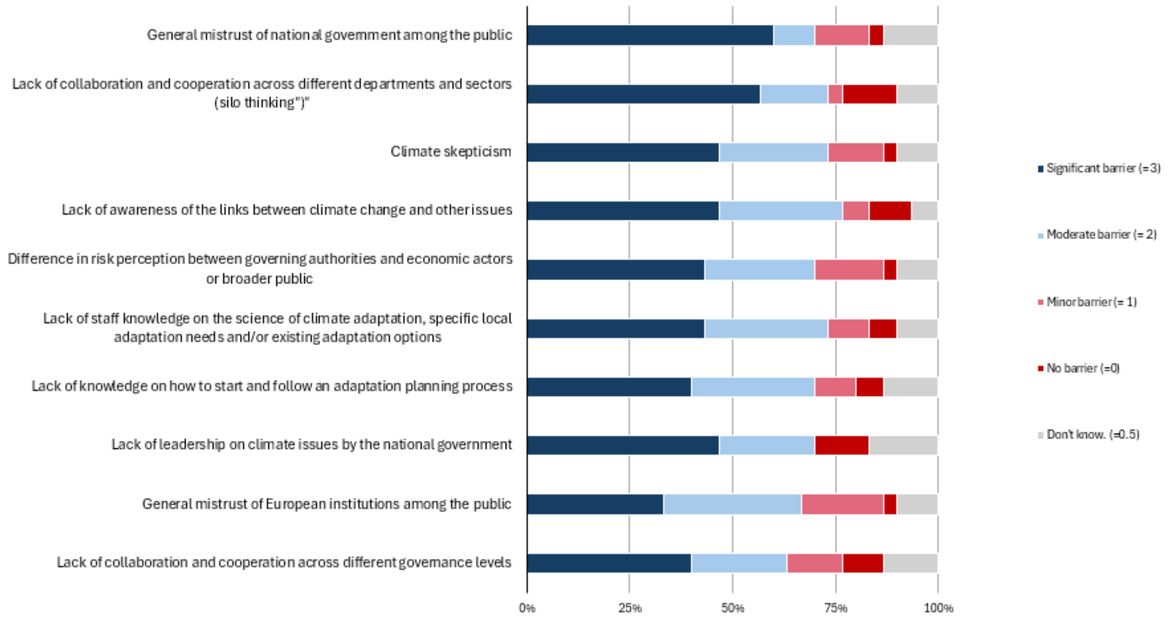

Figure 5: Top 10 barriers to climate change adaptation
The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant, moderate, minor, non-existent, or "don't know" (implies low relevance). n=30

Most barriers as per survey respondents appear in the early stages of the adaptation policy cycle, when preparing the ground for adaptation, assessing risks vulnerabilities to climate change and identifying feasible measures to address them. Respondents identified various ways of overcoming these barriers: Through awareness raising and education of both the public and government actors, strengthening governance and coordination, ensuring sustainable funding instruments, building knowledge and data infrastructures, and improving administrative capacity and efficiency.

Adaptation Options

This section translates Burgas's risk profile - floods, wildfires, and extreme heat with different interrelated socio-economic impacts - into a preliminary portfolio of measures including structural, behavioral, institutional, and nature-based approaches. It emphasizes municipal leadership supported by regional data and coordination, stronger inter-municipal collaboration, and active engagement with NGOs, academia, and volunteers to overcome barriers such as low awareness, data gaps, and a lack of cross-sectoral cooperation. For climate change adaptation to be sustainable in the region beyond this project, it makes sense to include cross-cutting measures that reduce these barriers and create the conditions necessary for successful adaptation, such as improving data infrastructure, institutionalizing collaboration processes or improving climate education and communication. Alongside these cross-sectoral governance measures, adaptation options like urban greening, floodplain restoration or heat-health plans are suggested. The proposed options will be refined and prioritized in workshop sessions with local stakeholders based on indicators such as scope, feasibility, effectiveness, co-benefits, costs, timelines, justice considerations, and risks of maladaptation.

1 Socio-economic profile

1.1 Demography[1]

As of 2024, the Burgas region (NUTS 3) has a population of 384,446 inhabitants and is the fourth-largest NUTS 3 region in Bulgaria after Sofia-City Province, Plovdiv and Varna. Burgas City contains almost half of the population of the wider region (189,014 inhabitants[2]). Both, the population of the Burgas region and that of Burgas city are shrinking, driven by a **natural population decline** and, until 2020, a net migration decline.

For the region, a clear shift in population growth is noticeable between 2019 and 2020, after which the population declines at a much slower rate. This can be explained by an **increase in net migration**, positive between 2020 and 2023, explained by returning jobs through the **normalization of the tourism sector** after the COVID-19 pandemic (Slavova, Nikolov & Nedev, 2024) and by **refugees from Ukraine**. In 2024, there were 80,000 people from Ukraine in Bulgaria and 30,000 in the Burgas region (BNR news, 2024). Nevertheless, a **demographic change**, reflected in shifts in population groups, can be observed. The Burgas region (NUTS 3) has seen a sharp decline in the number of children under 5 years old (-21%, 2014-2024) and a slight decrease in the working-age population (-11%, 2014-2024), while the elderly population (people over 65 years old) is growing (by 22% from 2014 to 2024).

1.2 Economy

1.2.1 General economic performance[3]

Following a 17% decline in GDP per capita in 2019–2020, the steepest among Bulgaria's 28 regions during the COVID-19 crisis, the Burgas region is now recovering economically. **Strong investments** are driving recovery (Foundation Institute for market economics, 2023), with Burgas ranking 8th in GDP per capita among Bulgaria's 28 provinces in 2023 - at 22,169 BGN (11,359 € per person). **Unemployment remains low** at 4.4% in 2024, lower than the national average (5.5%) and the EU average (5.9%). The unemployment rate has been steadily decreasing since 2013, apart from a one-year spike in 2020, likely due to the tourism decline during the COVID-19 pandemic. Looking at investments and business activities, the Burgas region (NUTS 3) exceeds the national average with **higher accumulated foreign direct investments** (FDI) per capita than the Bulgarian average with steady increases since 2015. The region also scores high in **payments made to beneficiaries of EU projects,** mostly aimed at developing water and sewerage infrastructure (Foundation Institute for market economics, 2024).

However, compared to the economic recovery and growth after the pandemic, investment still lags, likely still to be a consequence of retained investment in the hotel and restaurant sector during the COVID-19 pandemic and related increased investors' insecurities (Foundation Institute for market economics; 2024, May 10). Similarly, other indicators show that Burgas still faces economic challenges. **Annual wages of employees** under labor and civil service contracts in Burgas are still significantly lower (18,805 BGN or 9,591€ in 2023) than the national average (24,485 BGN in 2023), potentially due to many jobs in the service sector that are often lower-paid. Both values increased significantly over the past few years, but the national average rose more, causing the gap between them to widen. Moreover, Burgas region also has a **high percentage of people living below the national poverty line**, which is currently at 390,63€ (BNR news, 2025). In 2024, 23% of the population in the Burgas region (NUTS3) lived under the national poverty line, slightly more than the national average. The

[1] If not stated differently, the data in this subsection originates from EUROSTAT.

[2] EUROSTAT and National Statistical Institute Bulgaria.

[3] If not stated differently, the data in this subsection originates from https://www.regionalprofiles.bg

number for the region is up from 2019 (20%) but below its peak from 2020 (26,5%) during the COVID-19 pandemic. The region is also affected by a consistently high Gini coefficient (31.7 in 2024), whereas the European average Gini coefficient is sinking, indicating **high income inequalities**.

To better identify Burgas's economic strengths and weaknesses, as well as the sectors most vulnerable to climate change, the following chapter provides a more in-depth analysis of the region's economic specialization.

1.2.2 Economic Specialization[4]

Table 2: Gross Value Added per sector as a percentage of all sectors, 2023

Sector		Burgas	Bulgaria	EU	Specialization factor based on location quotient (Burgas / Bulgarian average)
Agriculture, forestry and fishing	**GVA**	2,80%	2,88%	1,81%	**0,97**
	Employment	4,75%	3,78%	1,67%	**1,26**
Industry (except construction)	**GVA**	17,80%	21,47%	20,19%	**0,83**
	Employment	19,32%	23,68%	17,19%	**0,82**
Manufacturing (included in industry)	**GVA**	17,65%	15,34%	16,46%	**1,15**
	Employment	15,34%	20,26%	15,42%	**0,76**
Construction	**GVA**	5,46%	4,43%	5,53%	**1,23**
	Employment	6,05%	5,84%	9,32%	**1,59**
Wholesale and retail trade, transport, accommodation and food service activities	**GVA**	30,67%	23,18%	18,79%	**1,32**
	Employment	38,04%	25,52%	24,11%	**1,49**
Real estate activities	**GVA**	13,75%	8,66%	10,73%	**1,59**
	Employment	1,52%	0,88%	0,98%	**1,72**
Professional, scientific and technical activities; administrative and support service activities	**GVA**	4,08%	7,05%	11,76%	**0,58**
	Employment	5,99%	8,33%	12,08%	**0,72**
Public administration, defense, education, human health and social work activities	**GVA**	20,39%	16,16%	18,25%	**1,26**
	Employment	15,36%	21,75%	26,57%	**0,71**

Table 2 shows the share of the gross value added for the different sectors in Burgas District as a percentage of all sectors and compares them to Bulgaria and the EU. Therefore, we can infer Burgas' economic specialization.

Burgas' economy specializes **in trade- and tourism-related services**, **real estate and construction**. The sectors of "wholesale/retail, transport, accommodation and food services" dominate both output and jobs, reflecting the central role of its Black Sea Port and pointing to a strong tourist economy. Real estate and construction are two other standout sectors that are probably also influenced by price increases before and after joining the Eurozone in 2026 (Bogdanova, 2026; Novinite, 2025). The combination points to a **growth model based on tourism, logistics, and property development** - also visible in the expansion of accommodation capacity from 2012 (284 beds in accommodation establishments per 1,000 population) to 2024 (368 beds in accommodation establishments per 1,000 population). Also compared to all other districts in Burgas, this is exceptionally high (see Figure 6).

[4] If not stated differently, the data in this subsection originates from EUROSTAT

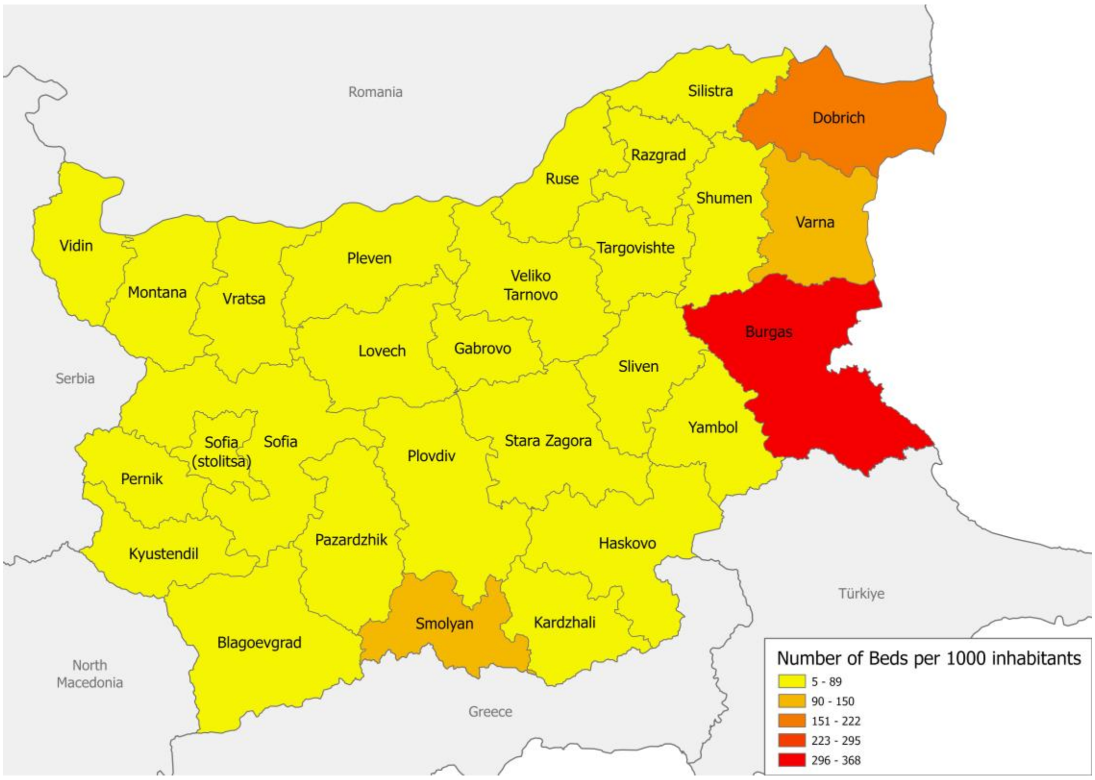

Figure 6: Number of Beds in accommodation establishments per 1,000 inhabitants, 2024.
Data source: Regional Economic Profiles. Own illustration.

Manufacturing is the main driver of the **industrial** performance, the share of regional GVA exceeds both the average of Bulgaria and the EU, signaling a strong manufacturing base. However, employment in this sector is below national expectations, suggesting that manufacturing firms are relatively capital-intensive or that their output is driven by high-value activities rather than headcount. The manufacturing share inside industry rose from 70.91% (2013) to 97.43% (2024), with a sharp, likely one-off dip in 2014 (40.9%) and a subsequent surge (99.14% in 2023). The Lukoil oil refinery's strong weight in Burgas' economy potentially explains such strong volatility.

Agriculture, forestry, and fishing are significant sectors. Value added is close to the national average, but employment is markedly higher. This is consistent with land-use patterns in Yugoiztochen, where the two largest industries are agriculture (43.6% of the total area) and forestry (39.6%) and fishing and aquaculture are also above EU and national averages. These sectors carry importance for the livelihood of farmers and other workers who are employed in these sectors and are particularly vulnerable to climate change.

Where Burgas underperforms is in knowledge-intensive activities. **For professional, scientific and technical services**, both GVA and employment shares are significantly lower than the national and EU averages. This impression fits with other numbers as well: R&D efforts remain low and shows a flat development curve: in 2023, gross domestic expenditures on R&D as a share of GDP (GERD) was just 0.18% of GDP (Bulgaria 0.79%, EU 2.26%), with only a modest uptake over the last decade.[5] In the field of education, the Burgas region lags behind the Bulgarian average in the number of active students at colleges and universities and in the percentage of inhabitants with higher education. In 2024, the number of students in colleges or universities were only half the national average (16.4 per 1,000 inhabitants in Burgas compared to 31.6 per 1,000 inhabitants on average in Bulgaria). Both the national

[5] The data was obtained from https://www.regionalprofiles.bg

average and regional shares of students have been shrinking over the last ten years.[6] On the other hand, the share of the population in higher education is growing in both Bulgaria and the Burgas region, but with **regional differences within the area**. Smaller municipalities tend to have more residents with only basic or lower education, such as Ruen (63%) and Sungurlare (56%). While Burgas and Nesebar have illiteracy rates below 1%, other municipalities in the Burgas region experience rates of around 5% (Foundation Institute for Market Economics, 2023, 2024).

Public services (**Public Administration / Defense / Education / Health / Social Work**) equally show a telling mismatch: output is above the national average, but workforce participation is below both national and EU levels, potentially signaling a mismatch between public-sector demand for services and the supply of qualified staff. Compared to the national level, Burgas District has fewer capacities regarding available hospital beds and general practitioners (per population), and one of the lowest health insurance coverages nationwide (90% vs. 95% nationally in 2024).[7]

The following chapter concludes specific vulnerabilities related to climate change adaptation that follow from the regional economic profile.

1.3 Socio-economic risk profile to climate change

1.3.1 Sectoral Dimensions

Under the JRC PESTA scenarios (2°C warming, no additional adaptation) by 2050, an estimated 20.74% of Burgas's population will face harmful climate exposure, slightly above the EU average (19.61%) but below Bulgarian average (24.67%). However, the **projected economic impacts of climate change are larger in Burgas**: about 1.12% of regional GDP, versus 0.96% for Bulgaria and 0.75% for the EU (European Commission, 2024).

The Burgas region's economic strengths - tourism, real estate, trade - are also its Achilles' heel in the face of climate change. The **strong tourism & real estate sector** presents a **powerful sector with vested interests**, that increases vulnerability to climate change due to overdevelopment in climate sensitive coastal areas. Interviews with policymakers and NGO representatives in Burgas District[8] highlight growing public concern over unchecked development, especially after the 2025 floods in Burgas that damaged a resort in Elenite. Environmental groups see this as an opportunity to also push for sustainable tourism that benefits both the economy and climate resilience. The higher cost burden could additionally incentivize **stronger private-sector climate adaptation**, reducing the region's vulnerability. Moreover, also the tourism industry should have an interest in climate-resilient infrastructure due to its own vulnerability to climate change.

Decarbonization pressures due to high emissions in the energy sector: While both Bulgaria and the EU have managed to reduce their per capita greenhouse emissions since 2013, Yugoiztochen has followed the opposite trend.[9] Over the same period, emissions in the region have increased considerably, widening the gap compared to the national and European average levels. The main driver behind these high emissions is energy production, which accounts for roughly two-thirds of all greenhouse gas emissions in Yugoiztochen. This share is far higher than the Bulgarian average and nearly three times the EU average, highlighting the region's strong dependence on emission-intensive energy generation.[10] On the positive

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[6] The data was obtained from https://www.regionalprofiles.bg

[7] The data was obtained from EUROSTAT and https://www.regionalprofiles.bg

[8] For more information on the interviews, see Appendix.

[9] The data was obtained from EUROSTAT

[10] In 2022, Lukoil emitted 1,992,353 tCO2e, which accounts for more than half of the emissions in the energy sector in "Yugoiztochen" that same year (3,814,445 tCO2e) (*EUETS.INFO*, n.d.).

side, the region has a high potential for renewables since there is a high untapped potential for solar, wind and hydropower (4546,57 MWh/km²/year), more than twice as high as the EU average (2233,22 MWh/km²/year) (European Commission, 2024).

Health care system pressures: Climate change is expected to intensify existing health risks, i.e., related to increased heat stress. The current health care system poses a serious risk for the population; especially for the large share of vulnerable groups: those without health insurances or the large share of older people over 65 years (22.53% in 2024), who are more likely to suffer from stronger heatwaves and have mobility issues that makes them harder to evacuate in case of emergencies. The authorities already react to some of these challenges (e.g., municipalities give the emergency services a list of vulnerable groups with mobility issues to reach them quicker in case of emergencies).[11] Enlarging such capacities, strengthening the overall healthcare sector in underserved rural areas, and raising public awareness about heat-stress prevention are crucial for climate adaptation in the region.

1.3.2 Governance and innovation capacity dimensions:

Climate adaptation requires a strong enabling environment in which innovations can be conceived, financed, and implemented. In the Yugoiztochen region (NUTS 2), this environment is undermined by several governance-and-innovation capacity risks that directly threaten innovative solutions for climate resilience.

First, as shown above, the economic innovation system shows an underperformance in research and development, connected to **low spending and lack of qualified staff.** Second, the aging of the population increases challenges with regard to public participation and institutional capacities. Third, **corruption emerges as a major impediment**. In Yugoiztochen (NUTS 2), more than half of firms (54.4%) said that corruption was a major constraint for them between 2018 and 2021, compared with only 22.4% at the national average (European Commission, 2024). Fourth, governance quality further compounds these challenges. The Quality of Government Index places Yugoiztochen below the EU average by –1.33 points, with particularly weak scores in the *Quality sub-pillar* (–1.71), *Corruption* (–1.15) and *Impartiality* (–0.95). Although these figures are better than Bulgaria’s national averages, they remain well short of European benchmarks (Charron et al., 2024). Poor governance hampers the design and enforcement of adaptation regulations, delays decision-making, and weakens accountability mechanisms. Fifth, Yugoiztochen lags behind both the average of Bulgaria and the EU across many of the 25 R&I indicators of the Regional Innovation Scoreboard. Declines between 2023 and 2025 are concentrated in new-innovation metrics: sales of new-to-market innovations, SMEs adopting innovations and business-process improvements all see the steepest drops (European Commission, 2025). These trends suggest that without targeted support, the regional innovation gap will widen further.

Despite these obstacles, **certain strengths can be leveraged for adaptation.** The region performs relatively well in trademark applications, non-R&D related expenditures and design submissions, indicating a creative capacity. Moreover, improvements in broadband penetration and growth in employed ICT specialists between 2023 and 2025 suggest emerging digital infrastructure that can support data-driven adaptation strategies (European Commission, 2025). Also, the study *The geography of EU discontent and the regional development trap* shows that both Bulgaria as a whole and the Burgas region are less EU sceptic than other EU countries, where an average of 28,51% of votes went to soft- or hard Eurosceptic parties between 2019 and 2023. In Burgas (NUTS3), the share is 15.51% of the votes, still above Bulgaria's average - 14.56% of votes (Rodríguez-Pose, Dijkstra & Poelman, 2024).

[11] Information from the interviews.

1.3.3 Social Vulnerability Dimensions

A high share of the population in Burgas District is particularly vulnerable to climate change. In the interviews, people with reduced mobility or special needs were mentioned to be easily trapped or isolated by heavy snowfalls or windstorms. Emergency services request lists from municipalities before every winter season to be able to react accordingly when climate disasters hit the specific areas. These are often elderly people, and we know from the data that the population aged 65 and over increased by 22% from 2014 to 2024 and currently accounts for 22.53% of the population (2024). Moreover, disadvantaged socio-economic groups were mentioned, more specifically poor population, migrants (notable from Ukraine and Russia), as well as the Sinti and Roma community.[12] This is especially relevant because the percentage of people living below the national poverty line (which is currently at 390,63€) is still high with 23%.

Uneven development and fragmented municipal capacities: Burgas City contains almost half of the population of the wider NUTS3 region (189,014 inhabitants), with a big hinterland that is more scarcely populated.[13] Spatial inequality arises from insufficient resources and capacities in smaller municipalities. As written above, smaller municipalities experience **higher unemployment**, lower education levels, and **limited health infrastructure**: These disparities can hinder coordinated regional adaptation efforts. Interviewees report of floods with insufficient post-flood repairs and recurrent infrastructure failures (to bridges or the drainage system) in such regions. They also tend to lack advanced monitoring systems for climate-related disasters compared to Burgas Municipality.

Herein lies the opportunity to strengthen inter-municipal cooperation through a Burgas District Climate Adaptation Authority, standardizing climate risk assessments across all localities (discussion tbc in the workshop).

1.4 Further indicators and data

The exact figures for all years, along with additional demographic, social, economic and environmental indicators, are available at the following link: https://ucloud.univie.ac.at/index.php/s/QAGAw2DJotsn7Ap

[12] In 2024, there were 80,000 people from Ukraine in Bulgaria and 30,000 in the Burgas region.

[13] EUROSTAT and National Statistical Institute Bulgaria

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 impacts of natural hazards and climate change in Burgas municipality using spatial analysis. Such an analysis requires geospatial data about the extent and severity of natural hazards. This may include historical hazard data or hazard information expressed in terms of return periods, which signify the statistical likelihood of an event occurring. The latter type of data is used to assess risk in a probabilistic manner and is commonly applied to hazards such as flooding. The spatial extent of the hazard is overlaid with data on population distribution, assets, or infrastructure to determine exposure to an event. When this exposure is combined with information on the vulnerability, the direct damage, expressed in terms of Expected Annual Damage (EAD), can be calculated. For further information on the methodology, please see Annex (9.1).

2.1 Flooding

2.1.1 Flood hazard context and historical flood dynamics

Flooding can occur through several mechanisms, including pluvial (surface), fluvial (river), and coastal flooding. This study examines fluvial flooding, which arises when rivers exceed their capacity and overflow. Due to limited data availability, particularly the absence of open-access pluvial data and incomplete coastal coverage for the Black Sea region, the analysis is based on open-access fluvial flood hazard maps provided by the Joint Research Centre (JRC). These maps offer a consistent representation of river inundation across multiple return periods, ranging from 1-in-10-year to 1-in-500-year events (see Section 8.1.1 for further methodological details).

While this study focuses on fluvial flooding due to data availability constraints, a broader perspective is needed to contextualize historical flood dynamics in Burgas Province. Therefore, historical flood events were examined using the HANZE dataset, which captures multiple flood types, including fluvial, pluvial, and coastal events (Paprotny, 2025). Figure 7 presents flood events recorded between 1870 and March 2025, covering the different flood types and their underlying causes. The distribution of events shows a clear dominance of rainfall-driven flooding. Flash floods are primarily associated with extreme rainfall, highlighting the importance of short-duration, high-intensity precipitation as a key driver of localized flooding. River floods, in contrast, are linked to a broader range of causes, including sustained heavy rainfall and snowmelt, indicating the role of both prolonged precipitation and seasonal processes. Coastal flooding appears to be relatively limited in the dataset, with only a single recorded event associated with storm surge.

Overall, these findings suggest that flood risk in Burgas is largely governed by rainfall-related processes, while also reflecting the influence of multiple interacting drivers, particularly for riverine flooding. This highlights that flood risk in the region is not limited to fluvial processes alone. Based on historical evidence, both coastal and pluvial flooding should be considered alongside river flooding in water risk management and adaptation planning. While the present analysis focuses on fluvial flooding due to data availability, a comprehensive assessment should account for the combined influence of multiple flood drivers to better reflect observed conditions.

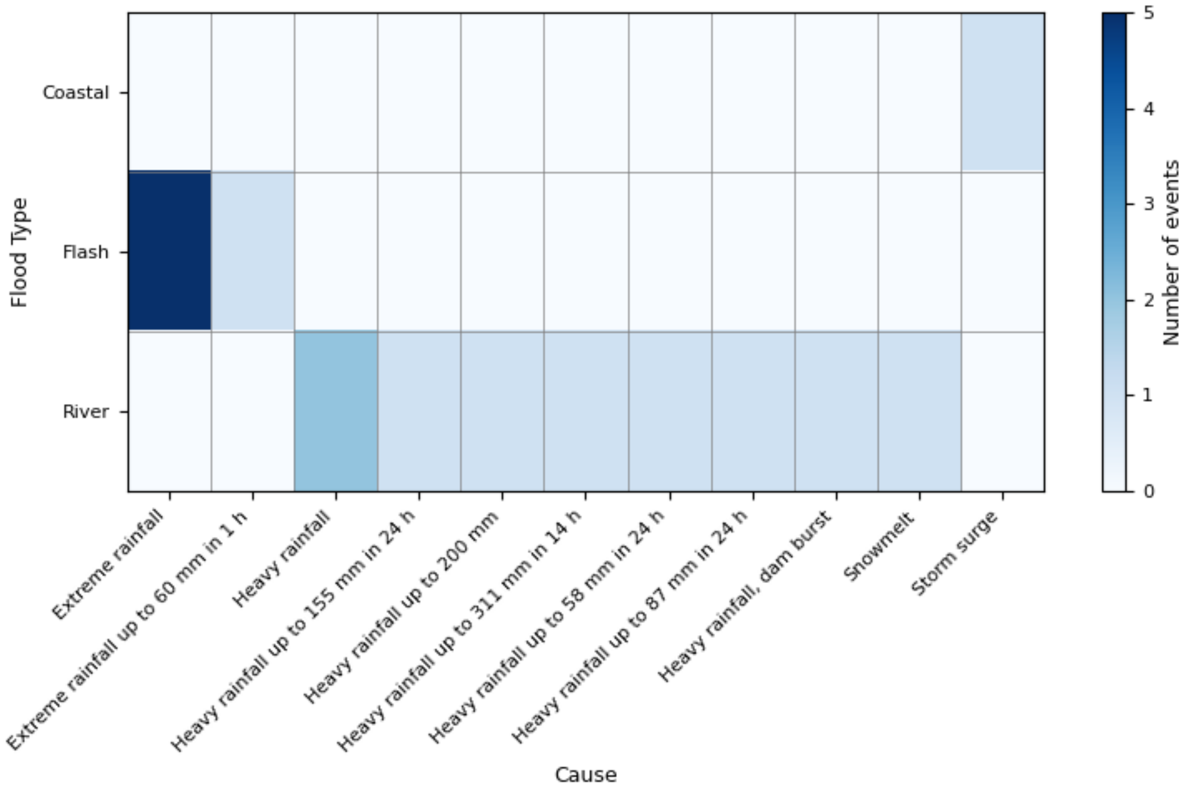


Figure 7: Historical flood events in Burgas Province categorized by type and cause, derived from the HANZE dataset (1870–2025). The distribution of events demonstrates how different flood types are associated with specific drivers, such as intense rainfall, storm surges, or combined processes, emphasizing the importance of considering multiple flood mechanisms in risk assessments.

2.1.2 Exposed population

Population data from the National Statistical Institute (NSI) were combined with the hazard maps for fluvial flooding to assess the flood exposure of the population in Burgas Province across multiple return periods. Figure 8a captures the relationship between event magnitude and the number of people affected and shows that population exposure increases with flood magnitude, rising from approximately 2,990 people for a 1-in-10-year flood event to 4,285 people for a 1-in-500-year flood event in Burgas Province.

At the municipal level, exposure patterns vary considerably. Burgas municipality exhibits the highest population exposure, with approximately 950 people affected during a high-frequency 1-in-10-year flood event, increasing to around 1,440 people for a low-frequency 1-in-500-year event (Figure 8a).The spatial distribution of exposed population for the 1-in-500-year event (Figure 8b) shows that exposure is primarily concentrated around Meden Rudnik and the industrial area to its northeast. Additional clusters of exposed population are observed within the city of Burgas and southwest of Dimchevo.

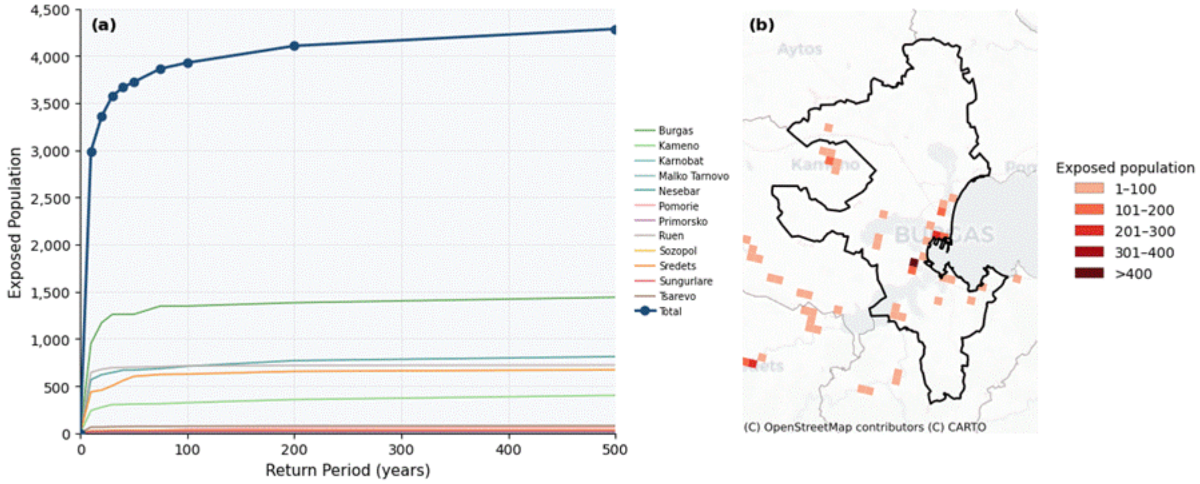


Figure 8: Population exposure to flooding in the Burgas region. Panel (a) shows the population exposure as a function of return period at the municipal-level and for Burgas Province. Panel (b) shows the spatial distribution of exposed population for a 500-year return period.

However, these results should be interpreted with consideration of local characteristics. For instance, the mapped flood extent around Meden Rudnik appears to be largely confined to a green buffer zone separating the settlement from the adjacent water body, which may reduce actual flood exposure. In contrast, industrial areas northeast of Meden Rudnik lie within the inundation extent and are therefore more likely to be directly affected in the absence of adaptation measures. It is also important to acknowledge limitations related to data resolution and temporal dynamics. The population data used in this analysis has a spatial resolution of 1 km², which may obscure finer-scale variations in exposure. Higher-resolution population datasets would improve the accuracy of the estimates. Furthermore, population exposure is inherently time-dependent, as the number of people present in a given location can vary throughout the day.

2.1.3 Critical infrastructure exposure and risk

Fluvial flood exposure of critical infrastructure

Infrastructure data from OpenStreetMap (OSM) were combined with the hazard maps for fluvial flooding to assess both exposure and risk (see Appendix 8). Exposure to fluvial flooding in Burgas Province varies considerably across infrastructure types and return periods, as illustrated in Figure 9. The transport network accounts for the largest share of exposure, with track roads being particularly affected, reaching up to 165 km under a 1-in-500-year flood event. This is followed by, although at substantially lower levels, tertiary roads (23 km) and residential roads (15 km). In addition to transport infrastructure, energy sector are also notably exposed. Power transmission and distribution lines intersect flood-prone areas, with approximately 60 km of transmission lines and 31 km of distribution lines exposed. Moreover, several energy assets are located within flood zones, including one power plant, 13 substations, 120 power towers, and 396 power poles under a 1-in-500-year event. Water-related infrastructure also shows significant vulnerability, with ten water treatment plants exposed from as early as the 1-in-20-year flood event, and one wastewater treatment plant already affected under a 1-in-10-year event.

At the municipal level, exposure patterns reveal clear spatial differences across Burgas Province. For the transport sector, Tsarevo exhibits the highest exposure of track roads, with approximately 28 km affected under a 1-in-500-year flood event, followed closely by Ruen (27 km) and Nesebar (23 km). Focusing on Burgas municipality, the analysis shows that it ranks highest in terms of motorway and trunk road exposure, with around 0.4 km and 7 km affected, respectively. It ranks third for several other road types, including primary roads (0.8 km), tertiary roads (2.7 km), and residential roads (0.1 km), indicating a moderate but consistent level of exposure across the road network.

For energy infrastructure, the highest exposure of transmission lines is observed in Burgas (17 km), followed by Karnobat (11 km) and Sredets (8 km). The only exposed power plant is located in Sredets, east of the village of Debelt. Substation exposure is particularly concentrated in Nesebar, which accounts for nine of the exposed substations, while two are located in Sredets and one each in Karnobat and Burgas. In addition, Burgas municipality records the highest number of exposed power towers (45), highlighting its significance as a potential hotspot for energy-related flood impacts.

Exposure of water and waste infrastructure is more spatially concentrated. The wastewater treatment plant exposed to flooding is located in Burgas municipality, while all ten exposed water treatment plants are situated in Kameno. Similarly, all exposed healthcare facilities are located in Nesebar. These findings demonstrate that while some infrastructure types exhibit widespread exposure, others are highly localized, creating distinct municipal hotspots of exposure.

It should be noted that this analysis does not account for the presence of local flood protection measures, such as levees, drainage systems, or site-specific adaptations, which may reduce actual impacts in practice. As such, **the results represent a potential baseline of flood exposure, assuming the failure or absence of flood protection structures**.

Under these baseline assumptions, the findings highlight potentially substantial socio-economic risks. Flooding of transport infrastructure may disrupt connectivity, impede emergency response, and isolate communities, while impacts on energy infrastructure could lead to power outages affecting households, businesses, and critical services. The exposure of water and wastewater treatment facilities is particularly concerning, as it may compromise drinking water supply and sanitation systems, posing direct risks to public health and environmental quality. By combining these exposure estimates with information on asset susceptibility to fluvial flooding and the associated asset values, potential annual damages can be derived. This approach enables a more comprehensive assessment of risk by linking physical exposure to economic consequences (see Section 8.1.4 for a detailed description of the methodology). The resulting damage estimates are presented and discussed in the following section.

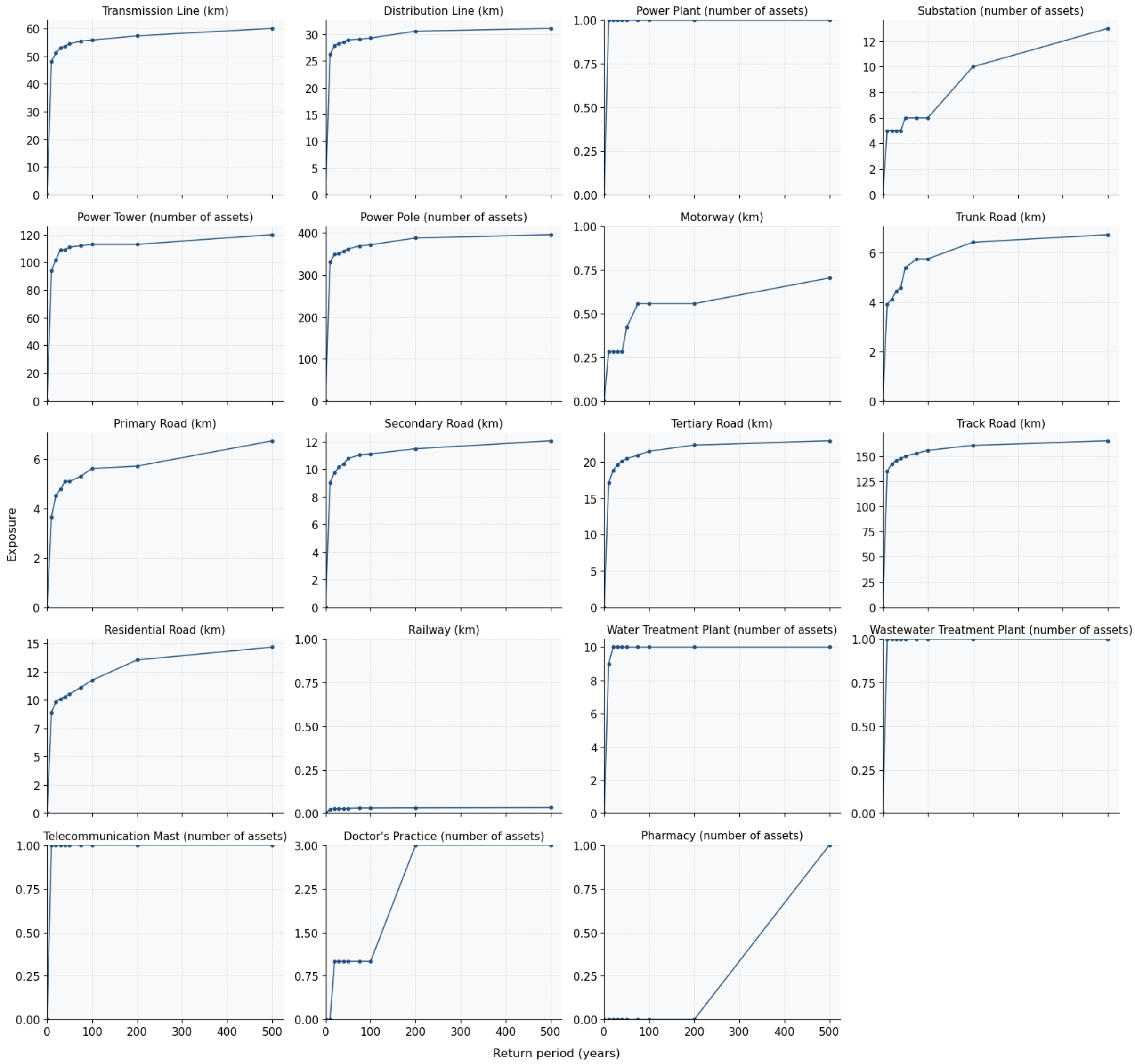


Figure 9: Infrastructure exposure curves across return periods for Burgas under fluvial flood hazard. Each panel represents a specific asset type, illustrating how exposure increases with event rarity. Markers denote simulated return periods. Asset types for which no exposure was simulated are not included in these plots.

Expected Annual Damages to critical infrastructure

The risk, expressed as expected annual damage (EAD), for Burgas Province is estimated at €3.9 million (interquartile range: €2.7–5.4 million; Figure 10a). The highest EAD is observed in the water supply system, amounting to €2.4 million (€1.7–3.4 million), which accounts for 62.5% of the total CI risk (Figure 10b). This is followed by the power and rail systems, each contributing approximately €0.6 million (power: €0.4–0.8 million; rail: €0.5–0.7 million), and the road system with €0.2 million (€0.1–0.5 million). The air transport, solid waste, and education systems show no estimated risk from fluvial flooding, while wastewater, telecommunications, and healthcare contribute only marginally to the remaining risk.

The spatial distribution of EAD across municipalities in Burgas Province reveals a highly uneven pattern, with 63.2% of total EAD concentrated in Kameno municipality, amounting to €2.5 million (€1.7–3.4 million; Figure 10c–d). All other municipalities exhibit EAD values below €1 million, with Karnobat, Malko Tarnovo, Sozopol, Primorsko, Aitos, and Pomorie each showing EAD values below €40,000. Together, these municipalities account for only 1.9% of the total risk in Burgas Province.

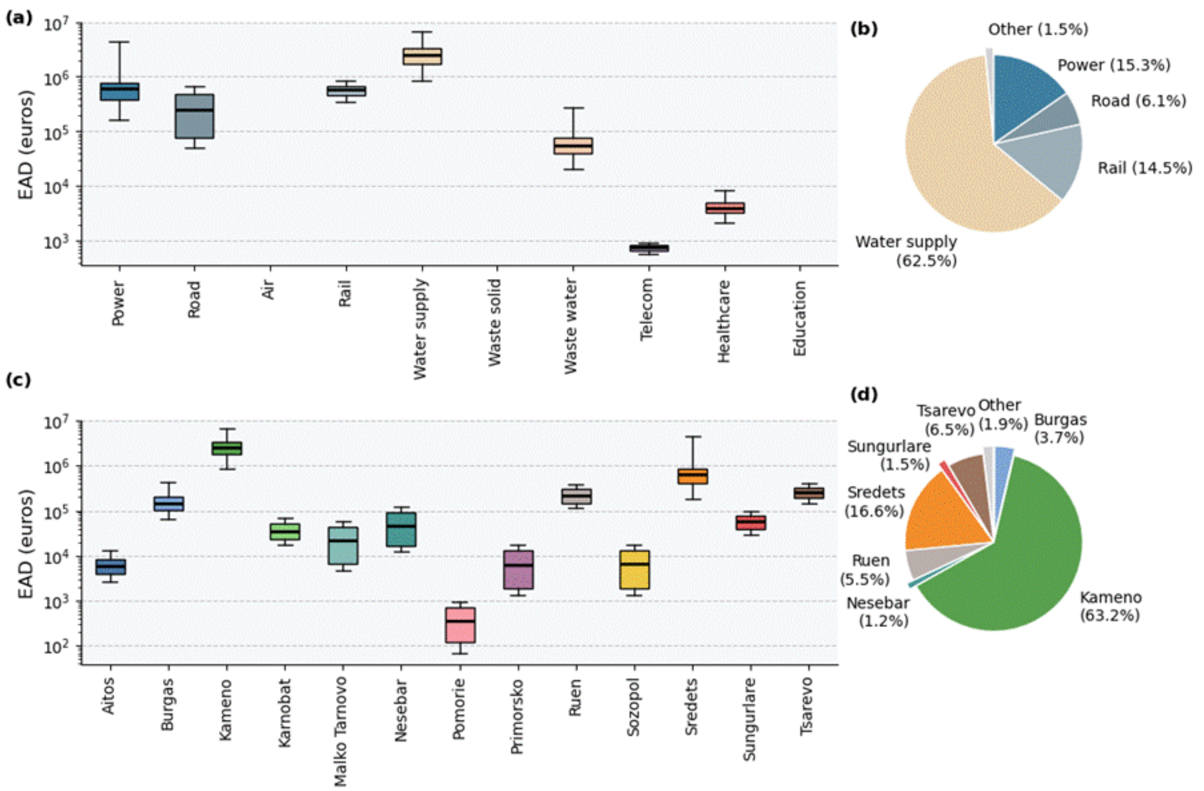


Figure 10: Overview of critical infrastructure (CI) risk across Burgas Province.
Panel (a) shows the distribution of CI risk values across infrastructure systems, shown as boxplots based on minimum, lower quartile (Q1), median (Q2), upper quartile (Q3), and maximum values aggregated at the Burgas Province level, whereas panel (b) shows the relative risk across the sectors. Panel (c) shows the distribution of total CI risk across municipalities within Burgas Province, whereas panel (d) shows the relative contribution of municipalities to total CI risk in Burgas province.

The fluvial flood risk in Burgas Province increases under future warming scenarios relative to historical conditions, with median EAD rising by approximately 13–20%. Figure 11 illustrates the relative change in flood risk across four warming levels (1.5°C, 2.0°C, 3.0°C, and 4.0°C), aggregated per CI sector and municipality. Most municipalities will experience moderate increases of flood risk around 10–25%. However, the relationship between warming levels and flood risk is non-linear: while moderate warming (1.5–2.0 °C) leads to clear increases in EAD, higher warming (3.0 °C) does not uniformly amplify risk. This reflects differences in projected hydrological responses across warming levels, such as changes in the intensity, frequency, and spatial distribution of extreme precipitation and river discharge. Notably, Malko Tarnovo and Tsarevo exhibit declining relative risk at higher warming levels, suggesting a spatial shift in flood patterns. Across CI systems, healthcare, power, and wastewater systems show the largest relative increases, reaching up to approximately 35%, 25%, and 25%, respectively. In contrast, transport-related sectors exhibit more moderate increases, with maximum increases of around 18% for both rail and road infrastructure.

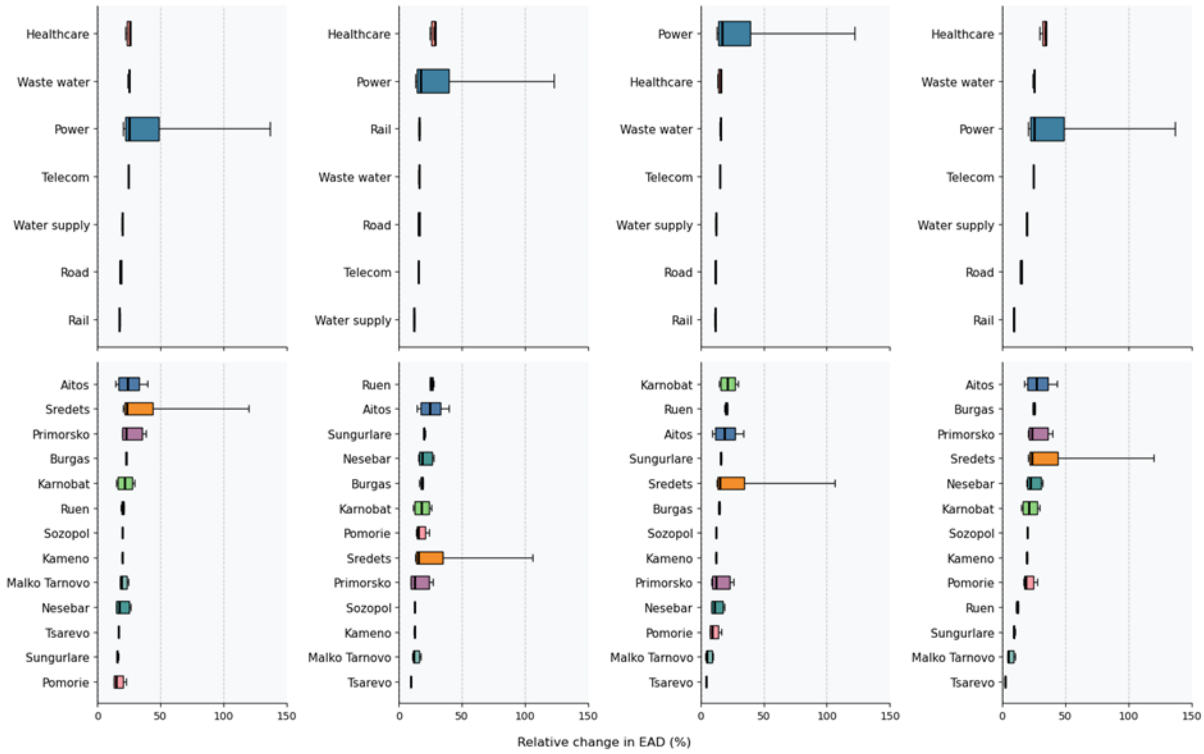


Figure 11: Relative change in expected annual damage (EAD) under future warming scenarios (1.5°C, 2.0°C, 3.0°C, and 4.0°C) in Burgas Province, aggregated by CI sector (top row) and municipality (bottom row).
The figure presents the proportional change in fluvial flood risk relative to historical conditions across four warming levels. Horizontal whisker plots represent the distribution of uncertainty, with boxes indicating the interquartile range (Q1–Q3), vertical lines marking the median (Q2), and whiskers extending from minimum to maximum values.

2.1.4 Socio-economic impacts

To assess the socio-economic impact of major floods on Burgas' economic performance, we compared GDP and poverty trends in the Burgas district with other districts in Bulgaria that were not affected by floods. This approach allows us to estimate what would probably have happened in Burgas if the flood had not occurred. Specifically, we track changes in the year prior to the event, the year in which floods occurred, and the year after the floods. By controling long-term differences between regions and national trends that affect all regions, the method isolates the effect associated with the floods in Burgas. To determine the major floods, relevant for Burgas District, we work with the state of emergency decrees (CRED, 2024).[14]

In this context, in years of flooding and emergency declarations, GDP per capita growth declines by approximately 2.8 percentage points (pp) compared to districts that were not affected by flooding.

Using real GDP per capita levels (constant 2012 prices) from the year prior to each event, we translate the estimated effect on contemporary growth (−2.8 pp) into monetary terms. This results in per capita income losses of BGN 286 (2014), BGN 353 (2017) and BGN 432 (2023), with an average loss of approximately BGN 357 for each flood compared to districts that have never been affected by flooding.

[14] Floods identified by CRED: 2014(x2), 2017, 2023

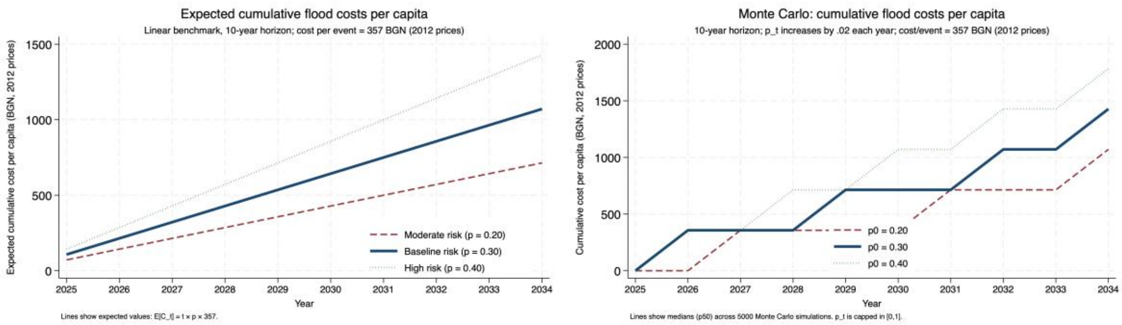


Figure 12: Forecast of per capita costs of major floods.
The left panel (a) presents a linear forecast, whereas the right panel (b) presents a forecast using Monte Carlo).

The Figure (12a) shows the expected average costs of flooding under a linear projection, while the Figure (12b) illustrates how costs may evolve when risk is uncertain and tends to increase over time. Under the linear projections, and considering different probabilities of flooding, the cumulative per capita cost by 2034 is estimated to range between approximately 800 and 1,400 BGN (in constant 2012 prices) if no measures are taken to reduce flood risk in Burgas. However, when uncertainty in the evolution of risk is incorporated through Monte Carlo simulations, the results suggest that cumulative costs could be even higher by 2034. This indicates that, in the absence of adaptation measures, the economic impacts of flooding are likely to increase significantly in the future

In addition to the effects observed on GDP per capita growth, we find that floods also generate regional effects on income inequality. These results are consistent with the evidence reported by Yamamura (2015), who documents short-term increases in income inequality following natural disasters, as well as with Capelli et al. (2021), who highlight that inequality and natural disasters may be mutually reinforcing processes.

Specifically, flood events in Burgas are associated with an increase in income inequality. The Gini index rises by approximately 1.9 points in the year of the event and by about 3.8 points in the following year. While these estimates lie toward the upper bound of the empirical range reported in the disaster literature, they remain broadly consistent with previous findings suggesting that natural disasters can generate heterogeneous income shocks and uneven recovery dynamics across local economic sectors, thereby temporarily increasing regional inequality.

The results indicate that floods affect population welfare by influencing both GDP per capita growth and income inequality. The welfare and inequality literature emphasizes that social welfare depends not only on average income but also on how that income is distributed (Atkinson, 1970). In a similar vein, Ravallion (2001) shows that the impact of economic growth on poverty reduction depends critically on the initial level of inequality, implying that increases in inequality can weaken or even offset the welfare gains associated with growth. In this context, the welfare effects of floods can be understood as operating through two channels: a reduction in average income and a deterioration in the distribution of income.

To provide an intuitive distribution-adjusted interpretation of these effects, we combine the estimated loss in real GDP per capita with the observed increase in the Gini coefficient using the welfare metric $W_t = \mu_t(1 - G_t)$. Where μ_t, denotes real GDP per capita and G_t the Gini coefficient. Under this framework, the welfare impact of floods can be approximated by the joint effect of lower average income and higher inequality. Using the estimated average income loss per capita (357 BGN in constant 2012 prices) and the contemporaneous increase in the Gini coefficient (1.9 points), we obtain a welfare-equivalent loss on the order of approximately 500 BGN per person. This figure should be interpreted as an analytical approximation of the welfare implications of floods rather than as a directly observed monetary loss.

2.1.5 Socio-economic impacts at municipal-level for the agricultural sector

Additionally, to account for the heterogeneity of Burgas district, a municipal-level analysis was carried out for the 13 municipalities in the Burgas district during the period 2014–2023. First, the territorial distribution of agricultural enterprises is analyzed, as this sector is particularly sensitive to extreme weather events such as floods.

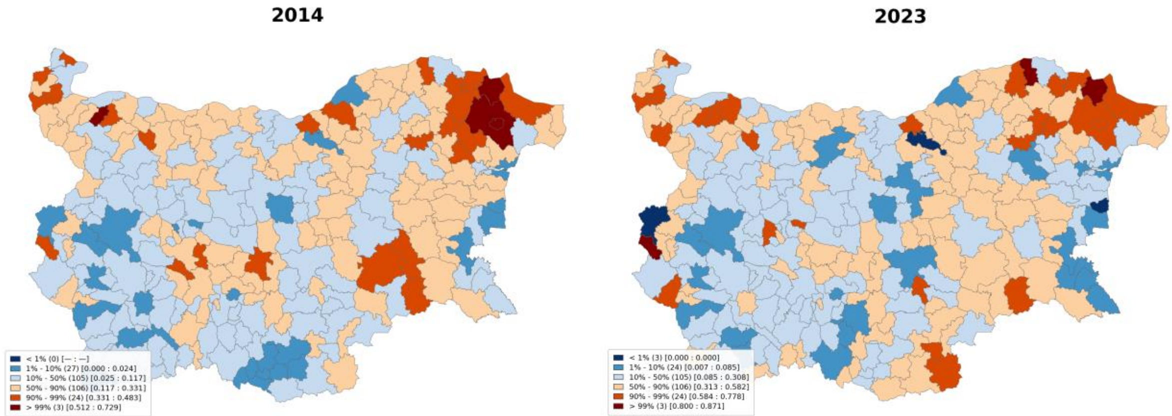


Figure 13: Spatial distribution of agricultural enterprises in Bulgaria (2014–2023)
Note: Blue (red) areas indicate municipalities with lower (higher) shares of agricultural firms; darker shades represent more extreme values
Source: Own elaboration based on information from the National Statistics Office.

A comparison between 2014 and 2023 suggests that the relative weight of the agricultural sector within the municipal economic structure is increasing in several parts of the country, reflecting a general shift towards categories of greater agricultural specialization in some municipalities. In the case of the Burgas district, the map shows that several municipalities have average levels of agricultural specialization, while the sector has a relatively smaller presence in coastal municipalities that are more oriented towards tourism and services.

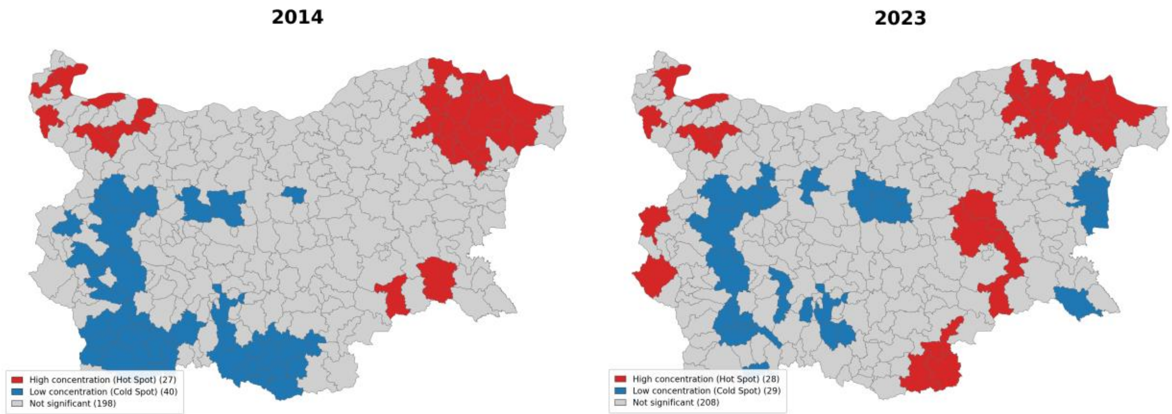


Figure 14: Evolution of territorial clusters of agricultural activity in Bulgaria (2014–2023)
Note: Red (blue) areas indicate municipalities that form statistically significant clusters of high (low) agricultural activity, based on spatial autocorrelation across neighbouring municipalities
Source: Own elaboration based on information from the National Statistics Office.

A spatial cluster analysis (Getis–Ord G*) identifies groups of neighboring municipalities where the presence of agricultural businesses is significantly higher or lower than the national average. On the maps, municipalities in red represent clusters with a high concentration of agricultural activity, while municipalities in blue indicate areas with a relatively lower presence of the sector. A comparison between 2014 and 2023 shows that the main territorial patterns of agricultural specialization remain relatively stable in the country, although some local changes can be observed.

In the Burgas district, variations can be observed in the relative position of some municipalities within these clusters. In particular, Malko Tarnovo becomes part of a cluster with low agricultural presence in 2023, while Sredets is no longer associated with a clear cluster compared to 2014. These changes suggest a slight territorial reconfiguration in the distribution of agricultural activity within the district, which is relevant for interpreting how climate impacts may affect municipalities in the region differently.

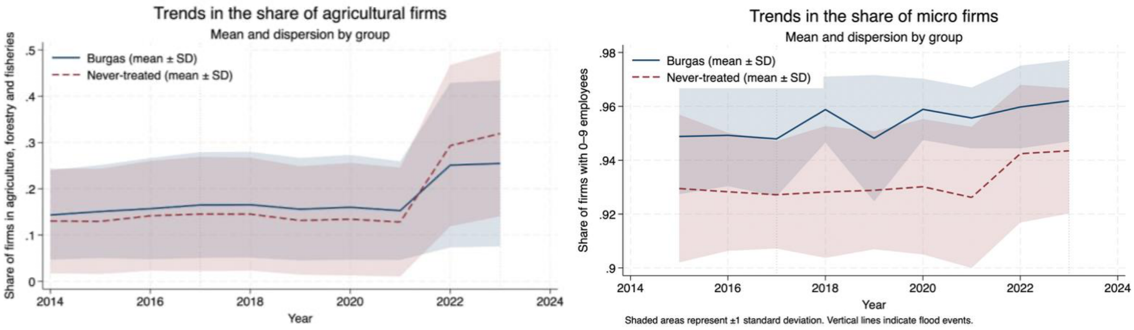


Figure 15: Evolution of firms: Burgas vs control municipalities
Source: Own elaboration based on information from the National Statistics Office

These changes are also evident in Figure 15 (image on the left), which analyses the evolution of the agricultural sector's share of the local business structure over time. The graph shows that the proportion of agricultural businesses gradually increased in Burgas during the period analyzed. However, growth has been more pronounced in the control municipalities, suggesting that flooding events may have partially affected the dynamics of the sector in the exposed municipalities.

Figure 15 (image on the right) shows the evolution of the proportion of micro-enterprises (companies with 0–9 employees) in the district of Burgas compared to municipalities that have not experienced flooding events during the period 2015–2023. In both groups, micro-enterprises represent the vast majority of business fabrics. The trends in both groups are relatively stable over time, although there has been a slight increase in the share of micro-enterprises towards the end of the period. This pattern suggests that the local business structure remains relatively constant, with a strong presence of very small enterprises within the district's economy.

To estimate the specific impact of flooding, the evolution of the affected municipalities is compared with that of similar municipalities that did not experience these events during the same period. This approach makes it possible to identify changes associated with the climatic event by isolating them from other general economic trends.

The analysis focuses on a short time window around the event (one year before, the year of the event, and one year after), which allows for the identification of immediate changes associated with the floods, while controlling for general trends affecting all municipalities.

The results show that floods have negative impacts on the local business structure. Compared to control municipalities, affected municipalities experience an additional decline of approximately 4.6 pp in the share of agricultural businesses in the year of the disaster. In the case of micro-enterprises, the effect is more moderate: the share of small businesses in Burgas decreases by an average of 0.55 pp in the year of the event, relative to their previous trend and to the municipalities it was compared to. These results suggest that floods mainly affect sectors that are more exposed to the climate, such as agriculture, while the impact on business fabric is more limited.

2.2 Wildfire

2.2.1 Observed and projected changes in wildfire potential

The historical trends in fire danger conditions in Burgas Province, based on thresholds of the Canadian Fire Weather Index (FWI), **indicate a modest but increasing signal for more extreme fire weather** (Figure 16). For lower thresholds (FWI > 15), the number of fire danger days shows a clear upward trend of 1.81 days per decade. In contrast, moderate conditions (FWI > 30) remain relatively stable over time, with a slight negative trend (−0.07 days per decade), while very high fire danger days (FWI > 45) show only a marginal increase of 0.10 days per decade. This suggests that, historically, the most pronounced changes have occurred in the frequency of lower-intensity fire weather conditions, with more extreme conditions not yet showing a strong upward trend.

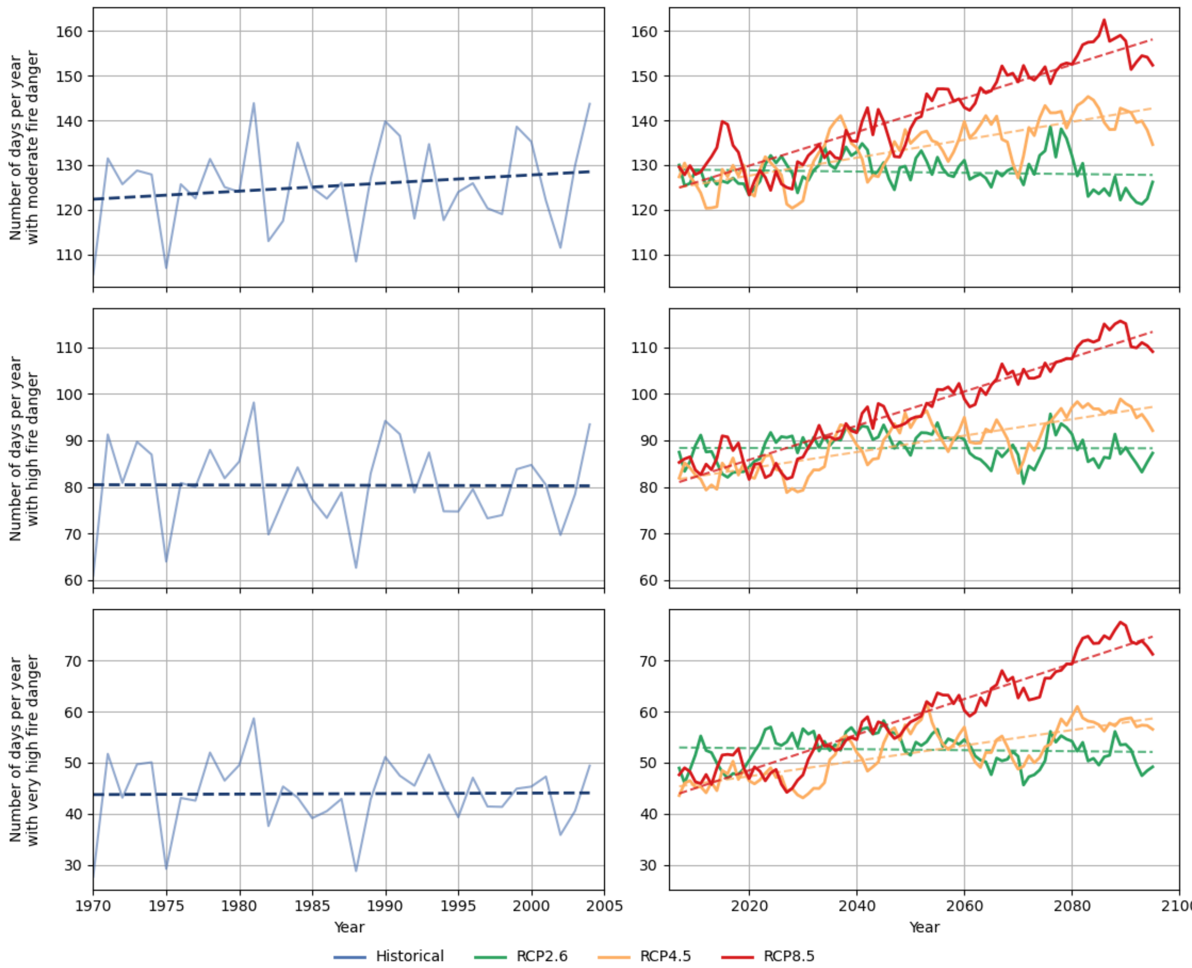


Figure 16: Temporal evolution of fire danger in Burgas Province under historical and future climate conditions. The left column shows historical trends (1970–2005), while the right column presents projected changes (2005–2100) under three emission scenarios (RCP2.6, RCP4.5, RCP8.5). Rows represent moderate (FWI > 15), high (FWI > 30), and very high (FWI > 45) fire danger levels, expressed as the average number of days per year across the study area. Future projections are shown as 5-year moving averages to highlight long-term trends, with dashed lines indicating linear trend estimates.

Future projections, however, indicate a marked divergence depending on emission scenarios. While current emission trajectories are not aligned with a low-emission pathway such as Representative Concentration Pathway (RCP) 2.6, this scenario is retained as a benchmark to illustrate the potential reduction in wildfire danger under strong climate mitigation. Under this low-emission scenario, trends remain stable or slightly negative across all thresholds, suggesting no further intensification of fire danger. In contrast, **under intermediate (RCP4.5) and high-emission (RCP8.5) scenarios, all thresholds show substantial increases of fire danger**. For the **moderate fire** danger category, the number of potential fire danger days is projected to increase by 2.01 and 3.77 days per decade under RCP4.5 and RCP8.5, respectively. A similar pattern is observed for higher thresholds, with the number of days with **high fire danger** increasing by 1.76 (RCP4.5) and 3.67 (RCP8.5) days per decade, and the number of days with **very high fire** danger by 1.51 and 3.49 days per decade. These results indicate that, particularly under higher emission scenarios, Burgas Province is likely to experience a strong increase not only in the frequency of moderate fire weather conditions but also in the occurrence of high and very high fire danger days, pointing to a substantial increase of potential wildfire risk in the future.

The spatial distribution of historical wildfire potential across Burgas Province reveals clear differences between municipalities, with consistently higher fire weather danger observed in the central part of Burgas Province (Figure 17). Kameno emerges as the municipality with the highest wildfire potential across all categories, experiencing on average 172 days per year with moderate fire danger, 118 days with high fire danger, and 75 days with very high fire danger. Aitos also shows consistently high values, ranking second across all thresholds, followed by Burgas for moderate fire danger (151 days), and Karnobat for high (101 days) and very high fire danger (62 days). Overall, these patterns indicate a spatial gradient in wildfire potential, with municipalities such as Kameno and Aitos exposed to persistently elevated fire weather conditions, while Karnobat becomes particularly prominent under more extreme thresholds.

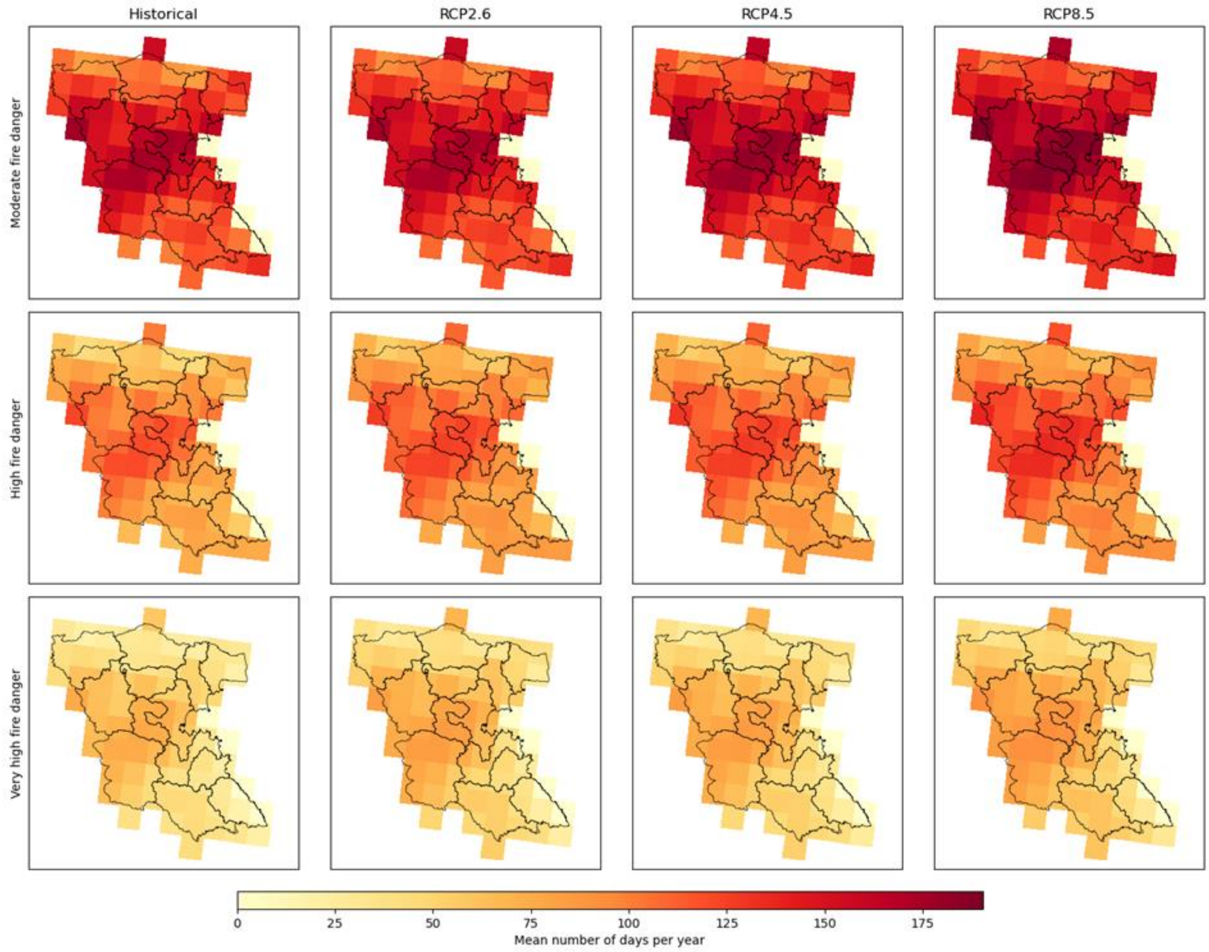


Figure 17: Mean annual number of days with moderate, high, and very high fire danger in Burgas Province, shown for historical (1970–2005) and future climate scenarios (RCP2.6, RCP4.5, RCP8.5; 2005–2100).
Maps represent spatial averages per grid cell, illustrating persistent wildfire-prone areas. Municipal boundaries are included for reference.

Future projections indicate that wildfire danger remains highest in the central parts of Burgas Province, but intensifies under all climate scenarios. Kameno and Aitos consistently remain the municipalities with the highest average number of days exposed to moderate, high, and very high fire danger across all scenarios. While increases are relatively limited under the optimistic RCP, they become substantially more pronounced under higher emission pathways. Notably, the strongest increases are observed for very high fire danger, suggesting a disproportionate rise in the most extreme fire weather conditions.

Burgas Municipality consistently ranks third in terms of **moderate fire danger** under all scenarios (RCP2.6, RCP4.5, and RCP8.5), with projected increases of approximately 1, 8, and 16 additional days of fire danger per year, respectively. Notably, Sredets emerges among the top three municipalities for **very high fire** danger under both RCP2.6 and RCP8.5, with around 71 days per year. This suggests a potential shift in the spatial distribution of the most extreme fire weather conditions, with new hotspots emerging alongside high-risk areas.

2.2.2 Historical wildfire activity

Historical wildfire data are taken from the global fire database developed by Artés et al. (2019), which is based on satellite observations (MODIS) and identifies individual fire events, including their timing, location, and burned area. **Between 2002 and 2023, a total of 648 wildfire events were recorded in Burgas Municipality, resulting in a cumulative burned area of approximately 69,084 hectares.** Figure 18 illustrates the observed wildfire activity in Burgas Province from 2002 to 2023, including the distribution across municipalities. Wildfire activity in the Burgas region shows substantial variation over time. Figure 18a presents the annual number of wildfire events, showing that wildfire occurrence shows strong interannual variability, with peak activity observed in 2006 (149 wildfires), 2007 (98 wildfires), and 2004 (68 wildfires). These years also correspond to the largest burned areas (Figure 18b), with 14,621 ha affected in 2006, 10,170 ha in 2007, and 5,762 ha in 2004, indicating that years with high fire frequency tend to coincide with more extensive burned areas. Notably, from 2012 to 2023, the number of wildfires across Burgas Province was generally lower, with the exception of a peak in 2016, when 30 wildfire events occured.

At the provincial scale, wildfire activity is unevenly distributed across municipalities. **The highest number of historical wildfires between 2002-2023 occurred in Karnobat (198 wildfires), followed by Kameno (166 wildfires) and Burgas (79 wildifres)**, highlighting spatial differences in wildfire occurrence. Within Burgas Municipality specifically, the annual number of wildfires is generally low, typically fewer than 10 wildfire events per year, except for a single peak year 2007 with 29 historical wildfires. These findings broadly align with the spatial patterns of wildfire potential, which consistently identify Kameno, Aitos, Burgas, Karnobat, and Sredets among the top five municipalities, albeit in varying order depending on the scenario, indicating a strong correspondence between observed wildfire activity and areas of elevated fire weather danger identified in the previous section.

Importantly, Figure 18 indicates that the historical wildfire risk has not been constant throughout the years but concentrated in specific high-intensity years, during which the potential direct and indirect economic and environmental damage may be significantly greater. Notably, many of these peak years occur prior to 2013, with fewer extreme years observed in the subsequent period. This may suggest the influence of improved fire management and mitigation measures. Nevertheless, the results highlight that wildfire risk is characterised by extremes, implying that policy responses should prioritise preparedness and rapid response capacity for such high-impact years, as a small number of severe episodes may account for a disproportionate share of total wildfire impact in the district.

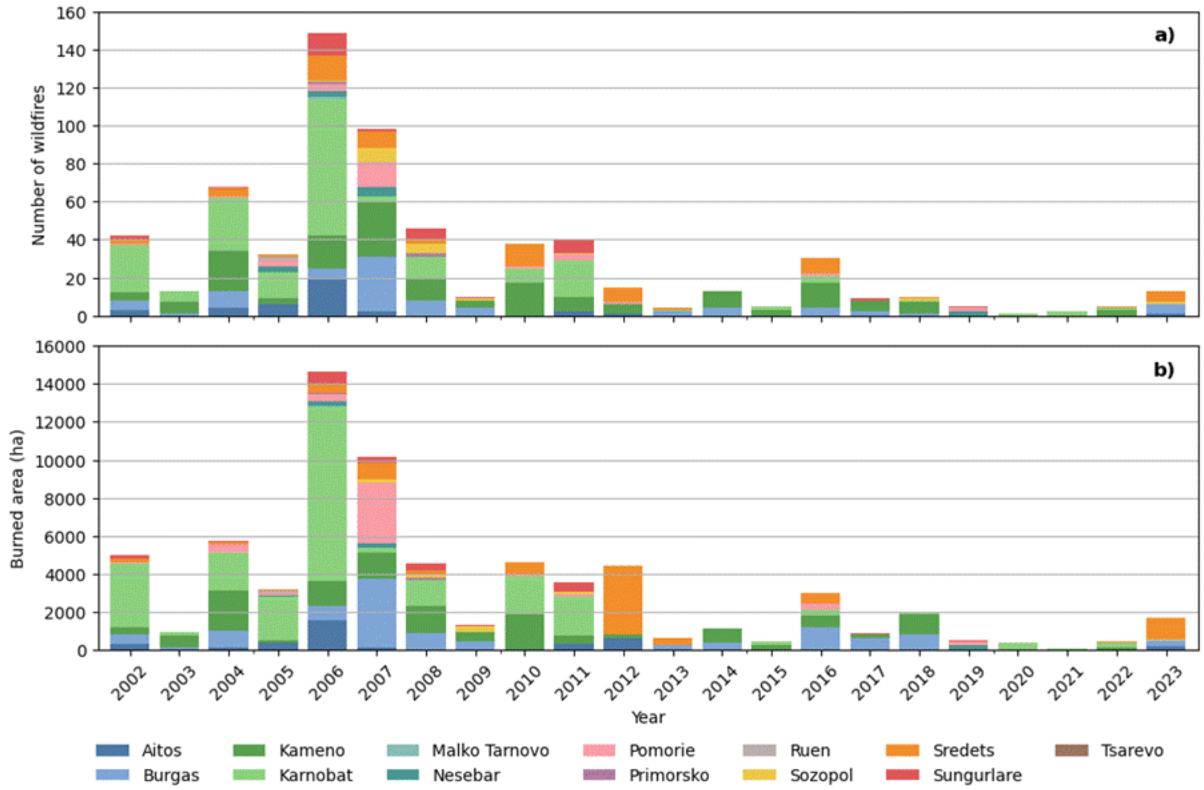


Figure 18: Temporal and distribution of observed wildfire activity in Burgas Province from 2002 to 2023. Panel (a) depicts the annual number of wildfire events, and panel (b) the corresponding burned area (ha), both aggregated at the municipal level (ADM2).

2.2.3 Exposed population

Under historical conditions, the population in Burgas Province is exposed to all levels of fire danger (Figure 19). **For moderate fire danger, the vast majority of the population (approximately 327,400 people) is exposed to more than 90 days per year,** with only a small fraction experiencing 30–90 days of exposure. For high fire danger, exposure is more evenly distributed between the medium (30–90 days; ~194,000 people) and high (>90 days; ~138,000 people) exposure classes. In contrast, very high fire danger is predominantly associated with the medium exposure class, affecting approximately 310,000 people, while a smaller share of the population (~22,000 people) experiences up to 30 days per year of very high wildfire danger.

Future climate scenarios show a clear and systematic shift toward higher exposure frequencies across all wildfire danger levels. For moderate fire danger, the entire population is projected to experience more than 90 days of exposure per year under all future scenarios. For high fire danger, a pronounced shift from medium to high exposure classes is observed, with an increasing share of the population exposed to more than 90 days per year under higher-emission scenarios. A similar pattern is evident for very high fire danger. While the majority of the population remains within the medium exposure class across all scenarios, its magnitude increases further under future conditions, reaching over 320,000 people under RCP4.5. Notably, under RCP8.5, a new group emerges that is exposed to very high fire danger for more than 90 days per year (~12,300 people), a condition that is absent under historical and lower-emission scenarios.

Overall, these results indicate that **exposure shifts toward higher mean annual frequencies across all wildfire danger levels, with an increasing proportion of the population**

experiencing prolonged periods of wildfire-prone conditions. This intensification is most pronounced under higher-emission scenarios and for higher fire danger thresholds.

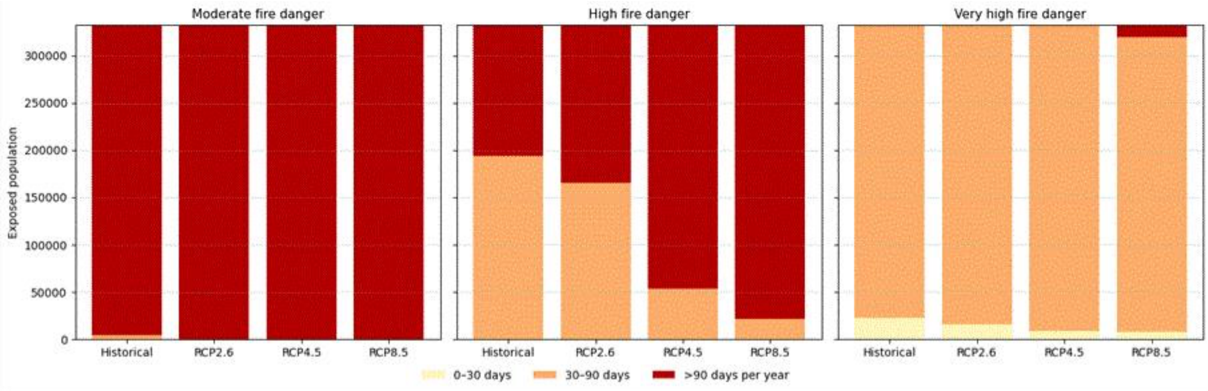


Figure 19: Population exposed to moderate, high, and very high wildfire danger.
Expressed as the mean annual number of days exceeding Fire Weather Index (FWI) thresholds for the historical period (1970–2005) and future climate scenarios (2005–2100). Mean annual exposure is grouped into three classes: 0–30 days, 30–90 days, and more than 90 days per year.

In Burgas municipality, exposure to wildfire danger is already high under historical conditions, with the entire population exposed to more than 90 days per year of moderate fire danger. For high fire danger, exposure is initially split between medium and high exposure classes, but shifts almost entirely to more than 90 days per year under RCP4.5 and RCP8.5. Very high fire danger remains predominantly within the medium exposure class across most scenarios; however, under RCP8.5, a small share of the population (~2,100 people) is projected to experience more than 90 days per year of very high fire danger. Overall, these results indicate a clear intensification of population exposure to potential wildfires in Burgas, particularly for high fire danger levels under future climate conditions.

2.2.4 Socio-economic impacts

For the municipal-level analysis, we employ a panel data approach with fixed effects to control for unobserved characteristics that are constant over time within municipalities, as well as for common shocks that affect all municipalities in a given year. The outcome variable is the share of firms in each economic sector, where sectors are defined according to the NACE classification. The main explanatory variables capture exposure to wildfires and include two measures: (i) the total burned area (in hectares) within the municipality during the period analysed, and (ii) the duration of wildfire events, measured as the number of days the fire lasted. The comparison group consists of municipalities that did not experience wildfires in the same year and are located outside the Burgas district. This allows us to benchmark affected municipalities against comparable but non-exposed areas.

The municipal-level evidence reveals that forest fires generate heterogeneous but systematically patterned impacts across sectors. Sectors such as agriculture (a), utilities (d), transport (h), and real estate (l) emerge as the most consistently affected across municipalities, appearing repeatedly with negative effects under both measures of fire exposure (burned area and duration). Real estate and utilities, in particular, are affected in a large number of municipalities, suggesting a strong dependence on local environmental conditions and infrastructure stability. In contrast, other sectors such as manufacturing (c), construction (f), trade (g), and professional services (m) exhibit more context-specific effects, appearing only in certain municipalities. Importantly, the similarity of results across both exposure measures indicates that the economic impact of fires is not driven solely by their magnitude but also by their persistence. Overall, these findings highlight that while some sectors are structurally more vulnerable to wildfire shocks, the specific combination and intensity of sectoral impacts vary significantly across municipalities within the Burgas district.

Table 3: Sectors affected by forest fires at the municipal level

Municipality	Fire year(s)	Burned area (hectars)	Negatively affected sectors (burned area)	Fire duration (days)	Negatively affected sectors (duration)
Aytos	2023	193,5	A, D, L, S	7	A, D, L, S
Burgas	2014, 2016, 2017, 2018	2.945,7	A, H, L, R	49	A, B, H, L, R
Sredets	2022, 2023	1.204,0	A, D, F, G, H, M, S	31	A, D, G, H, S
Kameno	2016, 2017, 2018	1.892,1	C, D, H, L, N, S	44	C, D, H, J, L, N, S
Karnobat	2018, 2020, 2021, 2022	666,5	A, L, N, R	18	A, L, R
Nessebar	2019	236,5	E, F, I, J, L, N	3	E, F, I, J, L, N
Pomorie	2016	322,5	E, G, H, I, P, R	2	E, G, H, I, P, R
Sozopol	2023	43,0	A, D, J, N, Q	1	A, D, J, N, Q
Sungurlare	2017, 2019	107,5	D, F, H, L, M, P, Q, R	5	D, F, H, L, M, P, Q, R

Note: Sectors with negative coefficients significant at the 10% level (, **, ***). Event year = year with maximum burned area (ha) per municipality. Controls: all municipalities outside the Burgas district.. Two measures of wildfire exposure are used: 1) Burned area (scaled to per-100-ha for coefficient legibility) 2) Fire duration (total days with active fire in municipality-year) Sector classification (NACE-based simplified): a = Agriculture, b = Mining, c = Manufacturing, d = Utilities, e = Water supply & waste, f = Construction, g = Trade, h = Transport, i = Accommodation & food, j = Information & communication, k = Financial activities, l = Real estate, m = Professional activities, n = Administrative services, p = Education, q = Health, r = Arts & recreation, s = Other services*

While the municipal-level fixed effects analysis provides valuable evidence on sectoral heterogeneity and identifies which economic activities are most sensitive to wildfire exposure, these results should be interpreted with caution from a causal perspective. In particular, fixed effects models rely on the assumption that treated and control municipalities would have followed similar trends in the absence of wildfires—an assumption that may be difficult to fully justify given the structural differences across territories and the uneven distribution of wildfire exposure.

To address this limitation and strengthen the causal interpretation of our findings, we complement the analysis with a Synthetic Difference-in-Differences (SDiD) approach, method developed by Arkhangelsky et al. (2021). This method allows us to construct a more credible counterfactual by reweighting control municipalities so that they closely match the pre-fire trajectories of treated municipalities. In doing so, SDiD explicitly accounts for differences in pre-existing economic trends and reduces the risk that estimated effects are driven by underlying structural characteristics rather than wildfire shocks.

From a policy perspective, this means that the estimated impacts can be interpreted more confidently as the effect of wildfire exposure rather than general economic fluctuations. The method is especially useful when analysing geographically uneven shocks, such as forest fires, because it captures both the average impact across municipalities and sector-specific adjustments within local economies.

The pooled SDiD estimates confirm that forest fires have a statistically significant negative impact on local economic activity, primarily through reductions in both the overall number of firms and in specific sectors. In particular, total firm activity declines following wildfire exposure, alongside significant contractions in agriculture, construction, and real-estate sectors that are closely tied to land use, environmental conditions, and local investment dynamics. These effects are consistent with the disruption of productive capacity, damage to physical assets, and increased uncertainty affecting location-specific economic activities. Importantly, the concentration of negative impacts in these sectors suggests that wildfires do not affect the local economy uniformly, but rather disproportionately weaken activities that depend on natural resources, infrastructure, and long-term capital commitments.

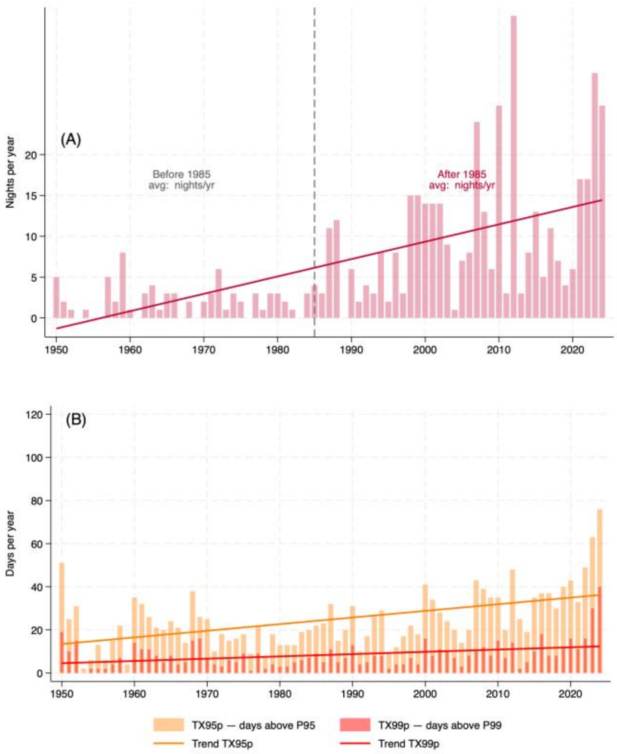
To provide a policy-relevant estimate of the economic cost of wildfires, we translate the SDiD results into changes in the number of firms and express the losses under conservative assumptions. The empirical analysis indicates that wildfire exposure leads to an average reduction of approximately 6% in the number of firms. Complementary results on firm size suggest that these losses are concentrated among small businesses. To avoid overstating the economic impact, we therefore adopt conservative assumptions regarding the average economic value per firm. Under a low benchmark of €25,000 per firm, the total estimated loss amounts to approximately €42 million, while a more conservative scenario of €15,000 per firm yields a loss of around €25 million. Expressed in per capita terms at the district level, this corresponds to an estimated cost ranging between roughly €65 and €110 per resident. These results should be interpreted as order-of-magnitude estimates rather than precise accounting values.

2.3 Extreme heat

2.3.1 General description

Analysis of 75 years of climate data (1950–2024) confirms that Burgas Oblast is experiencing a statistically significant and sustained increase in extreme heat events across all indicators examined. The number of days with exceptionally high temperatures and the duration of heat spells have risen consistently, and this trend is not explained by natural variability — formal econometric testing rules out random fluctuation as the cause.

The most striking finding concerns tropical nights: this phenomenon was nearly non-existent in Burgas before the 1980s and has become increasingly frequent since, pointing to a fundamental shift in the regional climate rather than a gradual change. These results provide a robust statistical basis for climate adaptation planning, particularly in areas such as public health preparedness, energy infrastructure, and urban heat mitigation.



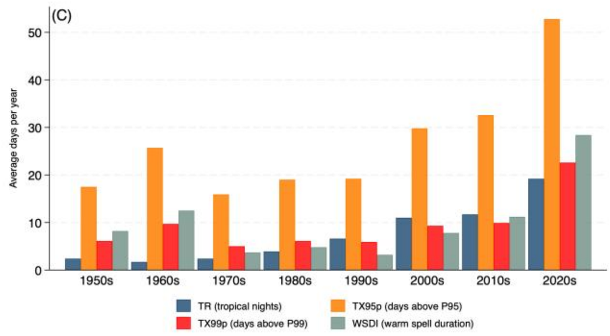


Figure 20: Heat indicators for Burgas Oblast, 1950–2024.
(A) Annual number of tropical nights (minimum temperature above 20°C); the dashed line marks the 1985 structural shift.
(B) Annual number of extreme heat days above the 95th and 99th percentiles, with linear trends over the full period.
(C) Decadal averages of key heat indicators, including tropical nights (TR), extreme heat days (TX95p and TX99p), and warm spell duration (WSDI).
Source: Own elaboration based on E-OBS v32.

The analysis examines the evolution of temperature-related climate extremes in the Burgas district using annual level indicators, including the number of tropical nights (TN > 20°C), heatwave duration (WSDI), and the frequency of very hot days (TX above the 95th and 99th percentiles). These indicators focus on extreme conditions rather than average temperatures, as they are more directly linked to economic and social impacts. The results reveal a clear upward trend across all measures, particularly since the early 2000s, indicating a sustained intensification of heat extremes over time. While there is some year-to-year variability, the overall pattern is consistent with a structural shift in local climate conditions, affecting all municipalities in the district to varying degrees.

To ensure that the observed patterns reflect genuine structural changes rather than short-term fluctuations, the analysis combines a non-parametric trend test (Mann–Kendall; Mann, 1945; Kendall, 1975) with a robust estimator of trend magnitude (Theil–Sen; Theil, 1950; Sen, 1968) to assess changes in extreme heat indicators over time. The Mann–Kendall test is used to detect the presence of a systematic trend without relying on strong distributional assumptions, while the Theil–Sen estimator provides a median-based measure of trend magnitude that is robust to outliers and extreme observations. This approach is widely used in the climate extremes literature (e.g. Alexander et al., 2006) and allows us not only to identify whether climate extremes are increasing, but also to express their evolution in intuitive terms.

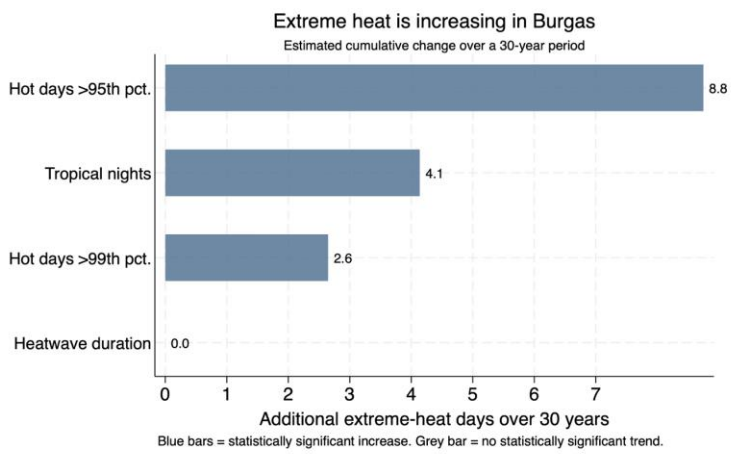


Figure 21: Additional extreme-heat days over 30 years in Burgas

The results indicate an increase in the frequency of extreme heat events in Burgas. In particular, the number of hot days above the 95th percentile has increased by approximately

8.8 days over a 30-year period, while tropical nights have risen by around 4.1 days, reflecting a substantial increase in nighttime temperatures. Extremely rare heat events (above the 99th percentile) also show a positive, though more moderate, upward trend. In contrast, no change is detected in the duration of heatwaves (WSDI). These findings suggest that climate change in Burgas is primarily characterized by a rising frequency of extreme heat events rather than a systematic increase in their duration.

To assess whether the observed increase in extreme heat represents a gradual and continuous process or a series of discrete structural shifts, we apply the multiple structural break methodology developed by Bai and Perron (1998). Unlike a simple linear trend, this approach identifies the timing and number of structural changes endogenously, without imposing prior assumptions. Each detected breakpoint divides the historical record into segments with distinct trend rates, allowing us to distinguish between a slow background warming, a transitional acceleration, and a recent intensification.

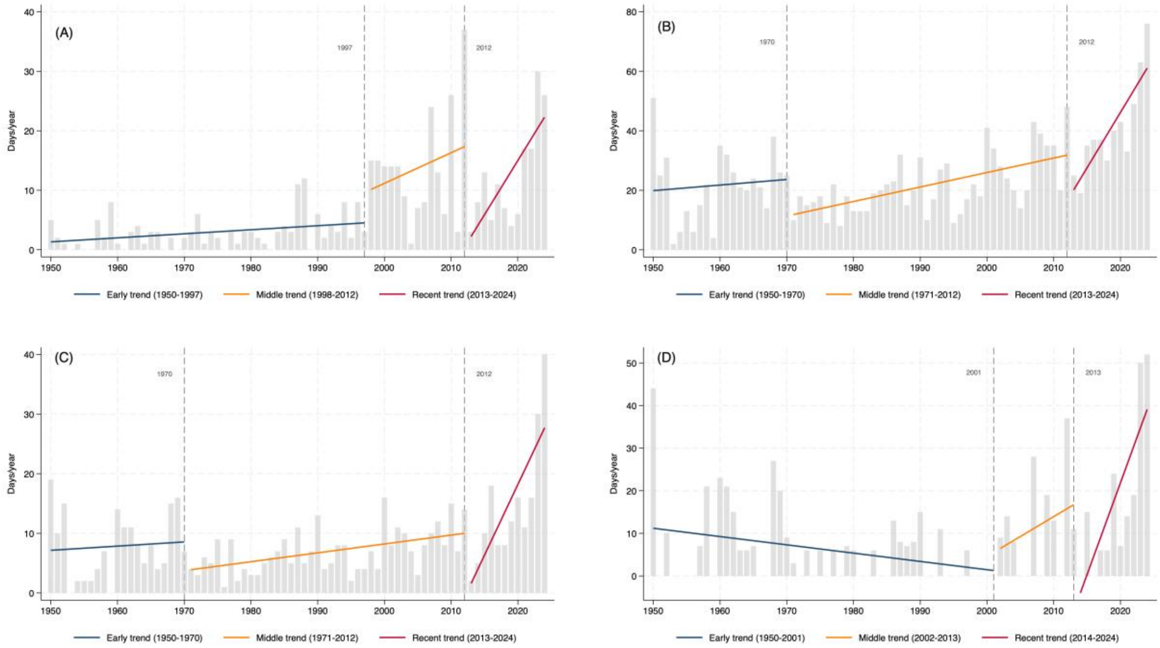


Figure 22: Structural breaks for extreme heat indicators for Burgas Oblast, 1950-2024
(A) Tropical nights (TR), with breakpoints in 1997 and 2012.
(B) Extreme heat days above the 95th percentile (TX95p), with breakpoints in 1970 and 2012.
(C) Extreme heat days above the 99th percentile (TX99p), with breakpoints in 1970 and 2012.
(D) Warm spell duration index (WSDI), with breakpoints in 2001 and 2013. Bars show annual values, and lines report the estimated linear trends for each segment. Dashed vertical lines mark structural break dates identified using Bai and Perron multiple break tests via xtbreak.
Source: Own elaboration based on E-OBS v32.

The analysis reveals a consistent and alarming pattern across all indicators: each successive period shows a steeper upward trend than the one before. For tropical nights and warm spell duration, the most recent segment — beginning around 2012–2013 — shows a near-vertical acceleration, with the trend line rising sharply in just over a decade. Days above the 95th and 99th temperature percentiles show an earlier onset, with the first structural break detected as far back as 1970, meaning extreme hot days have been intensifying across three distinct phases spanning more than 50 years. Taken together, these results suggest that Burgas is not simply warming gradually: the climate system has undergone repeated step-changes, each one raising the baseline from which the next acceleration departs. Under this pattern, projections that assume a single historical trend will systematically underestimate the pace of future change.

Scenario projections are constructed by anchoring all trajectories at the observed 2024 value and extrapolating forward using alternative trend estimates derived from the historical data. We consider two scenarios. The central scenario reflects the long-run trend of the series, estimated using the full-period Sen slope from the Mann–Kendall test, and can be interpreted as a continuation of average historical dynamics. The accelerating scenario captures the most recent regime, using the post-2012 slope identified through structural break analysis, and reflects a continuation of the recent acceleration in extreme temperature events.

To characterize uncertainty, we construct bands around each projected path using the residual standard deviation from a post-2012 OLS regression, allowing variability to increase with the projection horizon. The shaded areas represent ±1 and ±2 residual standard deviations and capture the magnitude of recent year-to-year fluctuations rather than formal statistical confidence intervals.

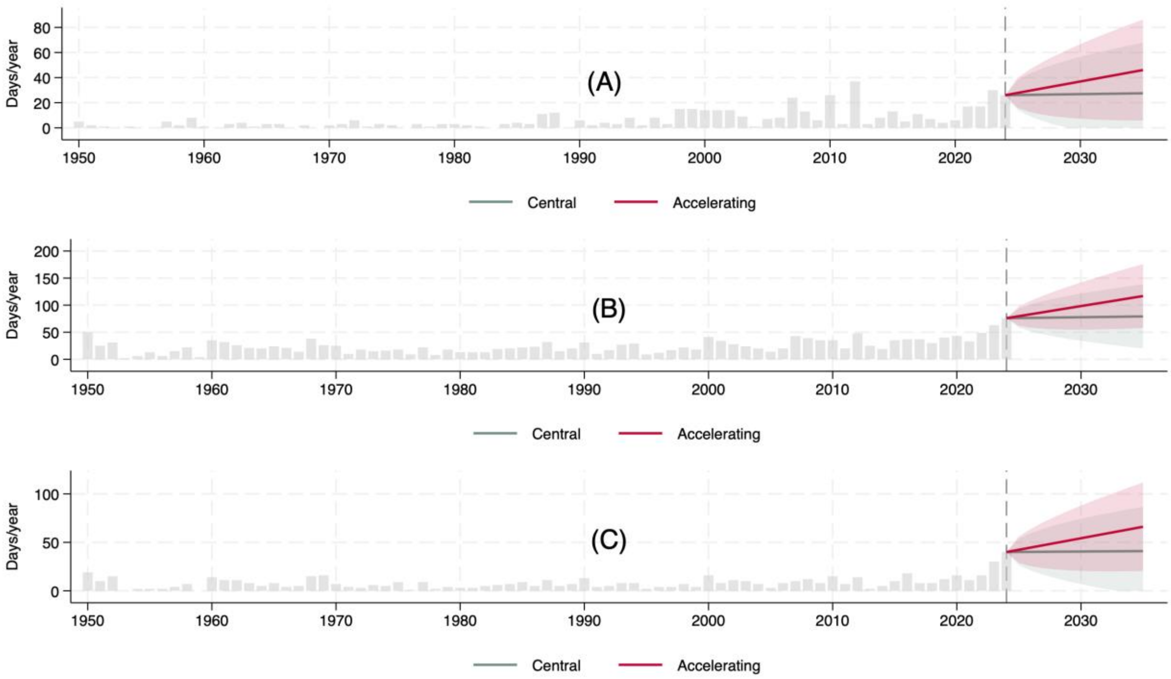


Figure 23: Scenario projections for heat indicators in Burgas Oblast, 1950–2035.
(A) Tropical nights (TR); (B) Extreme heat days above the 95th percentile (TX95p).; (C) Extreme heat days above the 99th percentile (TX99p). Bars show observed annual values up to 2024. Projection lines are anchored at the 2024 observed value and report two scenarios: central and accelerating. Shaded areas represent uncertainty bands based on the variability of the post-2012 period, widening over time. Source: Own elaboration based on E-OBS v32.

The projections reveal a clear divergence between the two scenarios over the 2024–2035 horizon. The central scenario, which reflects the average long-run trend, suggests relatively moderate changes in extreme temperature exposure. In contrast, the accelerating scenario, based on the recent post-2012 dynamics, points to a substantial increase in the frequency of extreme heat days. The gap between both trajectories widens over time, indicating that recent trends, if sustained, could lead to significantly higher levels of heat extremes. While uncertainty increases with the projection horizon, as shown by the widening bands, the qualitative pattern remains robust across all indicators.

The magnitude of the projected changes differs across indicators but follows a consistent pattern. For TR (tropical nights), projections increase from approximately 26 days in 2024 to around 28 days under the central scenario and up to 46 days under the accelerating scenario by 2035. For TX95p (very hot days above the 95th percentile), projections rise from about 78 days in 2024 to roughly 80 days under the central scenario and up to 117 days under the accelerating scenario. Similarly, TX99p (extreme heat days above the 99th percentile) increases from around 40 days in 2024 to about 41 days under the central scenario and up to 66 days under the accelerating scenario by 2035.

2.3.2 Exposed population to tropical nights

Tropical nights, defined as nights during which minimum temperatures remain above 20 °C, are a key indicator of heat stress with direct implications for human health. Unlike daytime heat, elevated nighttime temperatures limit the body's ability to recover from thermal stress, leading to cumulative physiological strain. This has been linked to increased risks of heat-related morbidity and mortality, particularly among vulnerable groups such as the elderly, young children, and individuals with pre-existing health conditions. In addition, tropical nights are closely associated with poor sleep quality, which can further exacerbate health impacts during prolonged heat events.

Across Burgas Province, **the majority of population exposure to tropical nights occurs under very high conditions (>30 days/year), affecting approximately 263,000 people.** This is followed by high (20–30 days), with around 55,000 people, and moderate (10–20 days), with approximately 43,000 people. In contrast, low exposure (5-10 days) is substantially lower, affecting approximately 7,000 people, while very low exposure (0-6 days) remains negligible. Figure 24 shows the relative population exposure to tropical nights by municipality under historical conditions. Population exposure to very high numbers of tropical nights is largely driven by Burgas municipality, where exposure is dominated by very high conditions, affecting approximately 190,000 people. Coastal municipalities such as Nesebar, Pomorie, Sozopol, and Tsarevo also exhibit substantial shares of high to very high exposure. In contrast, more inland municipalities, including Karnobat, Ruen, and Sungurlare, show a greater proportion of moderate to high exposure, with comparatively limited or no very high exposure. Municipalities such as Malko Tarnovo stand out, with predominantly low to moderate exposure levels, indicating lower overall heat stress.

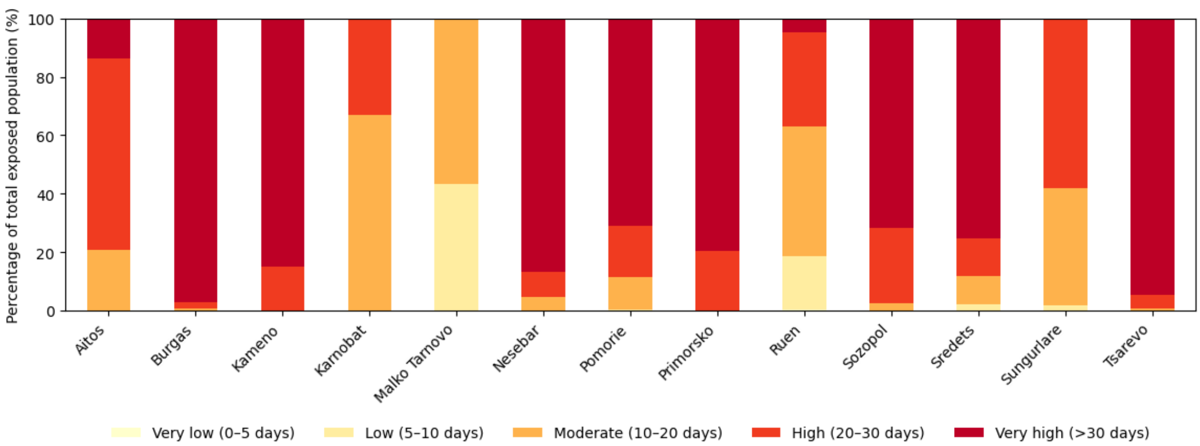


Figure 24: Relative population exposure to historical tropical nights by municipality in Burgas Province.
Based on the mean of annual tropical nights over the period 1990–2024. The stacked bars show the percentage distribution of population exposure across tropical night intensity classes, defined as: very low (≤5 days/year), low (5–10), moderate (10–20), high (20–30), and very high (>30).

2.3.3 Sectoral economic impacts

Building on the projection results, the expected increase in extreme heat exposure has direct implications for the economic structure of the Burgas district. Under the accelerating scenario, the frequency of extreme heat days rises sharply across all indicators, particularly in the upper tail of the temperature distribution. This implies that the types of temperature conditions are currently associated with observable economic effects. To explore this channel, we estimate the relationship between extreme heat anomalies and sectoral economic activity using municipality-level data on the number of firms.

The results suggest a heterogeneous pattern consistent with the projected intensification of heat extremes. In particular, the construction sector shows a robust negative association with extreme heat, while retail activity displays a positive response, potentially reflecting increased demand during hot periods. These patterns are broadly in line with the existing literature. Deschênes and Greenstone (2011) show that weather shocks can generate measurable economic and welfare consequences even when adaptation is possible, while Graff Zivin and Neidell (2014) document that high temperatures reduce labor supply in climate-exposed sectors and induce reallocations in time use. Burgas evidence is consistent with a broader mechanism through which extreme heat affects local economies by weakening activity in exposed sectors and shifting demand and resources across activities.

Table 4: Economic effects of extreme heat by sector

Economic sector	Heat indicator	Estimated effect	Robustness (bootstrap)	Interpretation
Construction	TX95p	−1.2%	Yes (5%)	Decline in activity in a climate-exposed sector
Retail trade	TX95p	+0.4%	Yes (5%)	Increased demand during hot periods

As shown in Table 4, the most consistent and policy-relevant finding concerns the construction sector, where extreme heat is associated with a statistically significant decline in firm activity. This result is robust to conservative inference methods and aligns with the expectation that sectors relying on outdoor labor are particularly vulnerable to rising temperatures. By contrast, the positive association observed in the retail sector suggests that extreme heat may also generate localized demand effects. This highlights that climate change does not affect all sectors uniformly, but rather induces a process of sectoral reallocation, where some activities contract while others expand.

Importantly, these results should be interpreted considering several methodological limitations. The empirical analysis relies on a relatively small number of clusters (13 municipalities) and a limited time dimension. To mitigate this concern, we implement wild cluster bootstrap procedures following Cameron, Gelbach and Miller (2008) and Roodman et al. (2019), which provide more reliable inference in settings with few clusters. Despite these adjustments, the estimates should be understood as robust partial correlations rather than definitive causal effects.

3 Climate Adaptation Governance Structures

3.1 Stakeholder Landscape

Stakeholder Map — Climate Change Adaptation, Burgas District

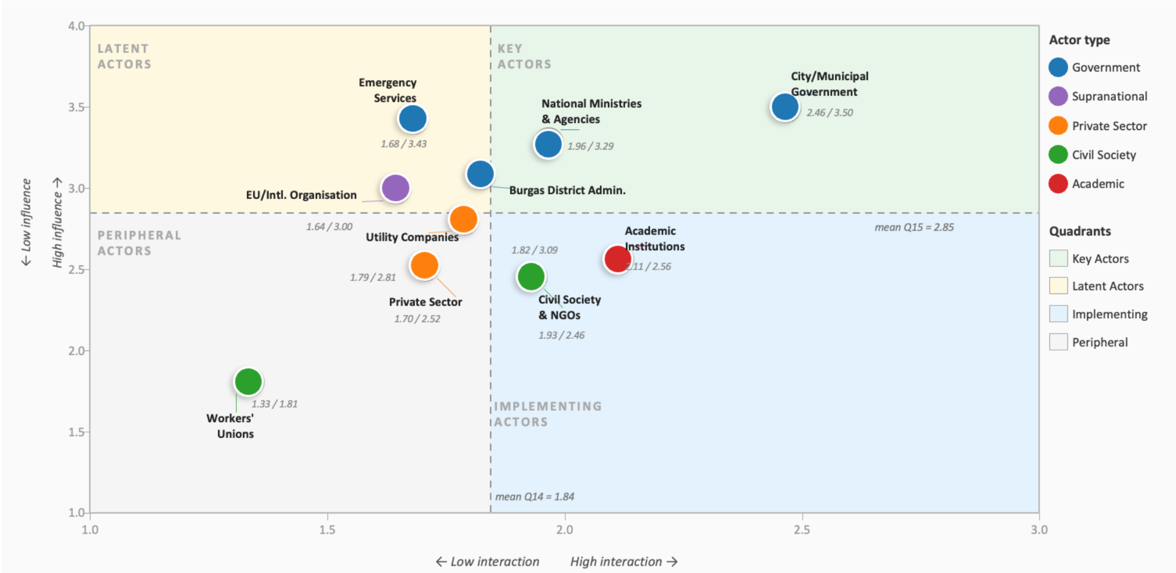


Figure 25: Stakeholder Groups Influence-Interaction Matrix, Burgas District
Note: The graph was developed based on the responses to questions Q14 and Q15 in the survey on barriers to CCA, n=30 (see Chapter 5 or Annex 8.4 for more information).

As part of a survey among key organizations involved in climate adaptation in Burgas District, we examined their interactions with other stakeholder groups and how they perceive their influence over decision-making. Figure 25 summarizes the results by showing an influence-interaction matrix that places stakeholder groups in four groups. **Municipalities** emerge as central actors in climate change adaptation policies, both in terms of interaction with other stakeholders and perceived influence. **National institutions** are perceived as similarly influential despite interacting less with local groups; their role is primarily in strategic alignment and funding. The **district administration and regional branches of national institutions,** both representatives of the national government, support local initiatives mainly with sectoral expertise and data. **Civil society organizations, NGOs, and academic institutions** are well embedded in local networks - evidenced by frequent interactions - yet their perceived influence is relatively limited. **Private sector actors, utility companies, and workers' unions** are seen as having low influence and are engaged relatively infrequently. Despite limited direct contact with the **EU**, it is perceived as having high influence on CCA actions, mostly through its funding decisions, which are particularly important for NGOs.

The following chapters explore these dynamics in depth, drawing on interviews with 15 representatives from Burgas District, including municipal officials, NGOs, research institutions, and district-level authorities.[15]

3.1.1 Competences & Stakeholder Interaction

At the **district level**: The **Oblast Burgas** (NUTS-3) is a **state administrative district** headed by a centrally (nationally) appointed governor and comprising 13 municipalities. Formal capacities with regards to climate change adaptation at the district level can be summarized as follows: First, the district administration directly employs an **expert for disaster and**

[15] For the purposes of this interim report, the stakeholder landscape offers detailed coverage of policy and civil society actors, with other groups (research, industry) to be addressed later.

defense preparedness and mobilization. Dealing with climate disasters, such as flooding or wildfires, are a part of that structure. Additionally, there is a regional committee for risk and disaster management. This structure supports the work of the district governor with regards to organization, coordination, prevention actions, whenever there are any natural disasters occurring. They work closely with regional agencies such as the *Fire Safety and Protection of the Population Service*, regional representatives of the *Ministry of the Interior* to which police forces belong, and with the disaster departments of all the municipalities.

Second, **specialized regional directorates and branches of the national ministries** gather knowledge and expertise on CCA and analyze environmental data. This analytical work feeds into the drafting and enforcement of regulations, permits, and legal instruments, e.g., flood management plans. They also take up an intermediary function between the municipal and the national level with regards to collecting and sharing data. They are usually divided according to different sectoral competencies on the NUTS3 level (e.g., Regional Forestry Directorate, Regional Directorate of Environment and Water, Regional Agricultural Directorate; for more info, see Figure 26).

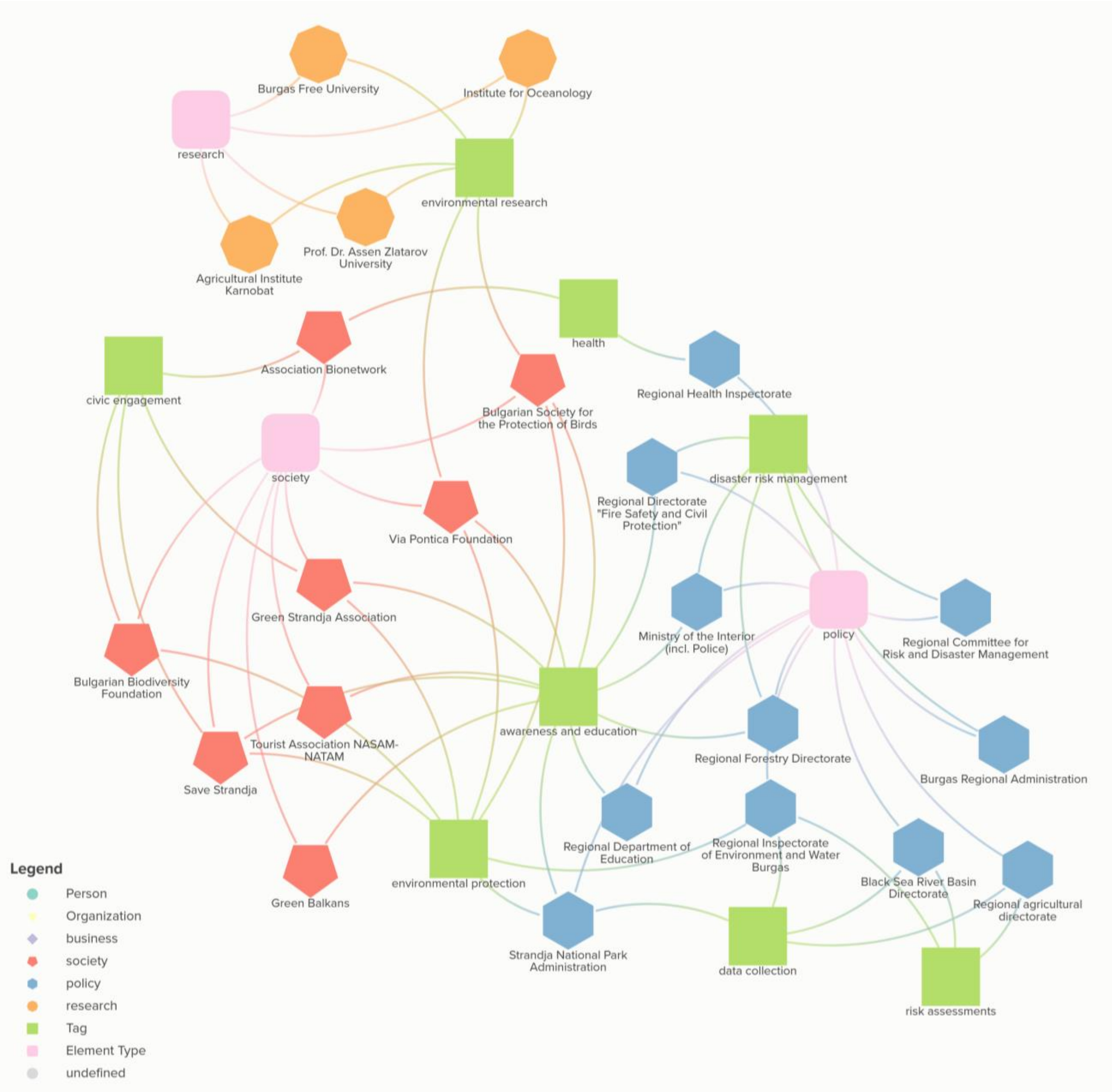


Figure 26: Organizations involved in CCA activities in Burgas District (also cross-regional partners)

The **13 municipalities** are the **primary drivers and initiators of CCA ideas or measures**. The measures need to be aligned with national strategic plans, and they can get additional support from the district and national level:

> *"Everything starts with the municipalities. If they have a vision, the district governor will be able to support them in implementing that vision. […] When they want to apply for state funding or EU funding, the district governor will issue a positive statement to support that. The district governor can intervene only […] in state-owned or church-owned land sites."* [Expert at the district administration]

Throughout the interviews, **Burgas Municipality** is considered as one of the "*frontrunners*" or "*champions*" of CCA, not only within Burgas District, but in Bulgaria and "*even compared to the capital*". They are mentioned for acquiring lots of EU projects on matters of climate change mitigation and climate change adaptation. The Municipality also has dedicated CCA plan as part of their Sustainable Energy and Climate Plan (SECAP). Other municipalities are not that often mentioned with regard to climate adaptation measures.

> *"Being slightly aside from the bigger town, like the city of Burgas, they don't have the capacity and the financial resources and also, they have different priorities."* [NGO expert]

So far, interviewees have not mentioned any formal efforts to synchronize CCA activities across municipalities. Interviewees from Burgas Municipality see synchronization efforts as the district's responsibility, while the district's responsibilities point to the barrier that they cannot impose CCA actions on municipalities. This effort is also difficult since there are no **forums specifically directed at improving collaboration on climate adaptation** at the district level.

Nevertheless, communication is happening, respondents pointed out formal and informal communication channels for climate change adaptation, or as one interviewee puts it:

> "*We absolutely talk to each other – otherwise we wouldn't even be here talking to you*" [expert at a regional sectoral institution].

As **formal channels** on the national level, Burgas Municipality mentioned that they are part of the National Assembly of Municipalities and work with different Bulgarian cities as partners in different projects, i.e., on climate adaptation. Another formal channel is the "Regional Committee for Disaster Risk Management" (that includes but is not confined to climate disasters) and the Regional Development Council. In the latter, "*every topic that is important for the region*" can be discussed with the district governor and all mayors of the district. It does not happen regularly though but "*at least once per year*".

Informal or project-related channels of communication on CCA on the policy district level seem to play a more important role: Within the sectoral regional branches of the ministry: there is communication with the municipalities regarding environmental **data and knowledge** and exchange: the Agricultural, Forestry, regional directorate of environment and water and Black Sea Basin directorates systematically collect and analyze climate-relevant statistics from the municipalities and act as intermediaries to transfer to the national level. They also implement concrete programs or projects together, also cross-sectoral:

> *"Together with the Executive Forestry Agency and the Ministry of Agriculture, we annually conduct a program which is aimed at adaptation of the forests*." [expert at a regional sectoral institution]

Another important informal channel is through international and EU projects: As a benefit of EU projects, it was mentioned:

> "*The opportunity to meet […] different experts from different institutions. We work together, but we do not know each other. Then we do something together. Which is very useful for us and I believe for the municipalities*" [expert at the district level]

In summary, the interviews reveal a **largely cooperative stakeholder ecosystem** that is nevertheless **constrained by legal, institutional, and political barriers**. Below, we distill the main challenges that were mentioned in the interviews.

3.1.2 Challenges

Dependences from the national government: Since the regional governor is appointed by the national government, the regional strategies operate within the constraints of national policy frameworks. Participation in adaptation projects requires **approval from the national government**, and the district administration is limited to engaging in **only one project during the programming cycle**. This top-down oversight can make it difficult to interact with local actors on climate adaptation that is often driven through projects. Moreover, the NUTS3 district administration **does not have their own budget,** making it complicated to participate in EU projects that require own funds.

> *"The regional district administration is an administration, it's not an enterprise, so we don't have the human resources or the financial resources to act […]. And whenever we want to gain financial resources, this is related to very burdensome and difficult tender procedures."* [expert at the district level]

While the initiative needs to come from the municipal level, the national level also often needs to be approved due to **centrally managed funding.** Compared to other CEE countries, in Bulgaria the municipal finances are still strongly dependent on transfers from the central government. This is particularly relevant given that the proportion of municipalities' own-source revenues in Bulgaria declined significantly, falling from more than 40% during 2015–2017 to under 25% by 2024 (Foundation Institute for market economics, 2025).

Moreover, there has been a **centralization of responsibilities in the last years**. This has among others led to some external agencies being closed and their responsibilities being transferred to a different head (in the case of the agricultural directorate); some competencies were shifted from NUTS-3 to NUTS-2 level (e.g., the regional development plan), leaving the district with less competencies, even though not all changes are viewed negatively by interviewees.

As another governance problem, it was mentioned that **rules, regulations and recommendations for climate preparedness are in place, but they are not being followed or not implemented**. The competencies lie either with the municipalities or the state, depending on which type of land it is (state- or municipality-owned land or private land). The issue seems to be complex as in some interviews with more than one interviewee, interviewees were discussing among themselves whose responsibility it is to ensure that regulations are being followed.

> *"We face challenges with implementation. Last year, in autumn, there were floods in the Burgas region, because our recommendations haven't been implemented."* [expert at a regional directorate]

> *"We would like to increase powers, expansion of powers with regards to regulations and exercising control"* [expert at a regional directorate]

> *"We're very good at writing proposals, reports, risk assessments, but really, it's up to the authorities and their will and providing the necessary funding."* [expert at a regional directorate]

Fragmented (sectoral) competencies: At the district level, some of the interviewees point to a **"chamber-style" approach** where each body works within its own remit: *"We are all enclosed with our responsibilities."* This fragmentation is most visible when CCA actions require coordination across sectors. For instance, effective riverbed cleaning demands coordination among the agencies overseeing the water body, surrounding forests, and the land it occupies. This has led to problems in the past. Another example: The National Park authority governs the parc, but the municipality makes the spatial development decisions – both authorities, however, are also spatially quite distant from each other - there could be more collaboration, from the opinion of a non-governmental actor. The interviews sometimes point out that each institution possesses a narrow, well-defined competence, with a risk of siloed working - but mostly due to legal barriers and not a general lack of cooperation. The sectoral approach continues to the national level. There are no regional adaptation plans, but a **National Climate Change Adaptation Strategy and Action Plan (2019 - 2030)** to assess climate risks and vulnerabilities across sectors (Agriculture, Biodiversity and Ecosystems, Energy, Forests, Human Health, Transport, Tourism, Urban Environment and Water). Most interviewees on the district level were not familiar with the plan, pointing to difficulties in implementing this plan. The current Regional Development Plan on the NUTS2 level includes a chapter on mixed CCM and CCA measures, even though adaptation takes a minor role compared to the clear focus on mitigation.

Lack of an institutional forum on CCA at the district level: Although a disaster risk management committee exists at the regional level, there is no official platform for exchange on climate change adaptation. Experts who manage, for example, wildfire emergencies can advise on prevention, but they lack a formal forum or mandate to coordinate integrated action across municipalities, indicating that DRM and CCA are largely treated as separate domains. This fits with the impression that generally, in most policy institutions, when asked about climate adaptation, a clear focus on avoiding disasters is visible compared to dealing with slow-burning crisis, such as increasing temperatures.

3.2 Non-governmental organizations

NGOs play an essential role as **knowledge providers**, **community mobilisers**, actors representing "*the interests of society and nature*". Even though there is no NGO working solely on topics of CCA, there are two strong national NGOs with offices in Burgas District: The Bulgarian Biodiversity Foundation (BBF) and the Bulgarian Society for the Protection of Birds (BSPB). These NGOs are well connected through informal networks, nationally and internationally (e.g., through the national network "For the Nature Bulgaria"). This landscape is completed by several smaller, locally or topic-focused NGOs or associations, sometimes on sustainable or nature-based tourism, like Green Strandja, Save Strandja or Green Balkans or youth-led organizations like GreenBurg. These smaller volunteer associations might have less capacities and less activities. For them, it is harder to get access to formal policy engagements; they must address the municipalities to get access. In contrast, stronger, professional and research-based NGOs are invited to forums and strategic policy sessions by the municipalities as organizations that are "working very professionally and research-based".

That NGOs increasingly take up CCA as a topic **is also driven by EU funding decisions, as one interviewee mentions:**

> *"Because of the economic and social situation in our country, we are mainly a project-funded organization. So, we have many mainly EU-funded projects […] and as you know in the last decades, […] there is a significant component connected to climate changes, so we are trying to be in line with the current situation on this issue.* [NGO expert]

All NGO experts who were interviewed agreed that in the current time, there is momentum for civil society actors:

> *"Until 89, […] we didn't have these civil society organizations [...], but yes, now, civil societies are very much active, and they are active especially, in places or in sectors, in domains where the state, or the government, or the local authorities are weak. There, the civil society organizations, start to be more active to bring changes to the society, or to the economy, or to the climate."* [NGO expert]

All NGOs highlight relationships with the municipalities as they are perceived as strong actors. Cooperation of NGOs happens mostly at the level of the municipalities; cooperation with the district is incidental when specific issues come up (mostly related to expertise on concrete disasters).

> *"To implement initiatives, in many cases, […] you need the support of the local government or local authority."; "The municipal governments are very powerful, especially in this region. You need to have a good rapport to get anything done. It's essential."* [two different NGO experts]

Also here, most NGOs say that most cooperation happens with Burgas Municipality. Some smaller projects are also with other municipalities, but sometimes it is harder to work with them due to different positions.

"Political priorities differ in the other municipalities - So, to some extent, in the past, we had problems instead of cooperation."

3.3 Recommendations for areas of improvement:

Use increased public awareness after climate disasters: According to multiple interviewees, the consecutive severe floods of the past two years in Burgas District with damage to infrastructure and the loss of human lives have started to shift public discourse. The connection to overdevelopment and irregular buildings along the coastline were equally questioned, due to the flooding of a seaside resort that was irregularly built in an old riverbed (Elenite). Policymakers can use this heightened awareness for a broader (regional) CCA initiative, tying adaptation measures directly to flood protection needs. Different interviewees mentioned:

"Farmers, fishermen, company owners now talk about the climate change."; "when you see the floods […] Climate skepticism becomes less important, I think."

Bridging the knowledge gap: Even though there is a heightened awareness, notably in areas affected by recent climate disasters, interviewees equally pointed to the fact that **many residents lack clear understanding and knowledge of climate-change**, especially the distinction between mitigation (CCM) and adaptation (CCA). Even though communities at the coast have environmental knowledge, e.g., about sea patterns, they don't necessarily connect it to specific climate terminology.

"As we have worked on this project, we found that people are still in need of a lot of information - for the process, for the adaptation, what they are able to do to prevent or to be able to survive on the coast." [NGO representative]

It is therefore recommended to continue programs of many regional directorates on climate and climate disaster education from pre-school age onward and extend them.

Residents as knowledge producers, not only knowledge-users: People living in flood-affected areas have visions and ideas of how their villages should look like experts may overlook. Organizing community workshops where residents share ideas, discuss challenges, and co-design projects. Here, NGO expertise is relevant. Multiple non-governmental stakeholders and community organizations have mentioned that they have established or tried to establish longer-lasting relationships with the local population. So, even though it was often mentioned that public participation appears challenging because of low trust in institutions and a more recent history with civil society that only started to build after the 1989, local NGOs with good connections to small municipalities or villages, have opportunities to gain trust.

"No one is making the effort to gather the data, the ideas of the people, no one approaches them."; "Once they [the people] open up, they have goood ideas." [NGO expert]

As examples, surveys or community workshops to develop common visions were mentioned, often also in community houses "*Chitalishte*" - traditional cultural spaces that exist in even smaller villages, where NGO did events on environmental or health education before.

NGOs bring expertise and extensive networks; recognizing their role through advisory committees or formal climate-adaptation committees would make use of this knowledge while maintaining accountability and transparency. Burgas Municipality is currently revitalizing its *"Local unit of climate change adaptation and sustainability"* that assembles policymakers, NGOs, academia and other interested individuals with a certain level of expertise on these topics. This should be monitored and if successful, it could serve as a blueprint for other municipalities wanting to work on similar issues.

These forums could also help to **increase transparency and communication from the municipality towards the public:** Some interviewees mentioned that they feel it is unclear what the municipality is planning regarding urban development connected to environmental protection. The main concern is not necessarily the decisions themselves, but the lack of clear communication and transparency about them:

"The main argument of the people is that they don't have information because the municipality publicized its plan for renovation […] five years ago and there is […] the information file […] but it's five years ago. You may have read this, but you don't remember that this will happen." [NGO expert]

Mayors / Experts forum on CCA: Coastal municipalities face similar climate risks, including more frequent flash floods and stronger winds. Similarly, rural municipalities have problems with droughts in the agricultural sector or increasing wildfires in forested areas. A regional council already brings together all mayors, but it currently lacks a dedicated climate (adaptation) policy session. Establishing a standing session would create an official forum to steer climate action, better align adaptation and disaster risk management, and address spatial disparities in CCA between Burgas Municipality and other municipalities in the district. It would also enable more systematic outreach to smaller municipalities to ensure that they can learn from Burgas Municipality, as one NGO expert formulated:

"Burgas Municipality should be a pilot and should be a mentor [...] to all the smaller municipalities because they [Burgas Municipality] really have a lot of staff and projects"

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:

Table 5: Forms of justice in climate adaptation

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/Transitional Justice	justice in the way in which existing or previous injustices are accounted for and rectified.

Within **distributive justice** specifically people 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. A non-exhaustive list of common perspectives on when a distribution is just are:

- **Outcome Egalitarians** – distributions are just when all people in a society can expect approximately similar outcomes in the important metrics of how their lives are going.
- **Opportunity Egalitarians –** distributions are just when inequalities resulting from chance are eliminated, and all people have the same opportunity to succeed.
- **Utilitarians –** distributions are just when resources are used to produce the greatest possible benefit for the greatest number of people, even if the results they produce are unequal.
- **Sufficientarians –** distributions are just when everyone achieves a share above a minimum threshold, and where inequalities are justifiable after everyone has met this minimum standard.

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

- A review of the strategic planning context for CCA at the National and Municipal Level utilising the Adaptation Justice Index.

- Issues identified through the semi-structured interviews conducted with stakeholders in CCA planning and implementation in Burgas 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. An analysis of the incorporation of justice into existing CCA strategies at the National and Municipal level were conducted. These strategies included in the analysis are the:

- Sustainable Energy and Climate Strategy and Action Plan 2021-2030 (Burgas Municipality)
- National Climate Change Adaptation Strategy and Action Plan 2021-2030 (Republic of Bulgaria

The Adaptation Justice Index 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.

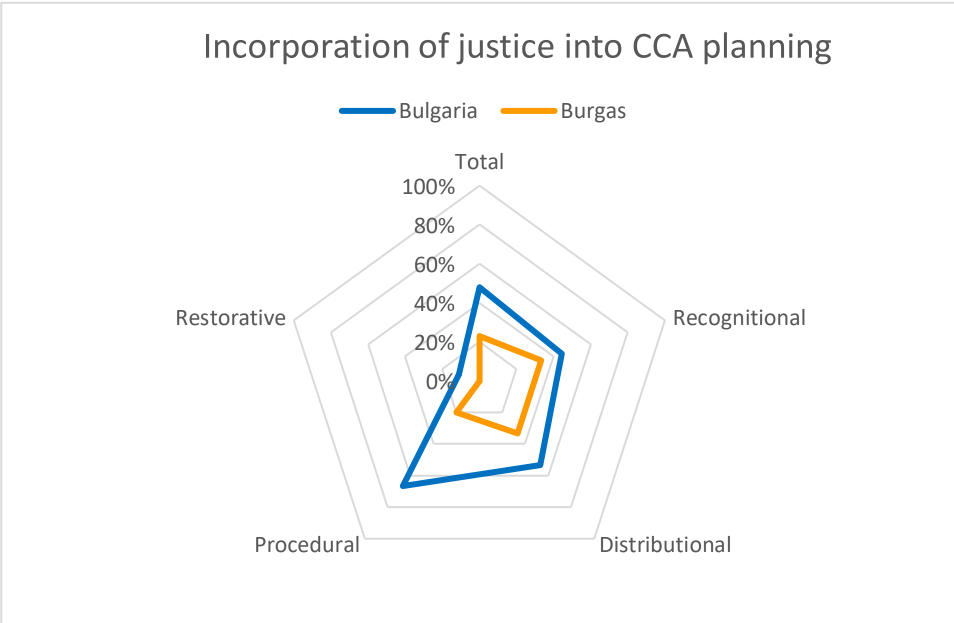


Figure 27: Evaluation of CCA Plans at the National and Municipal level based on the Adaptation Justice Index.

The radar chart presents as a percentage the extent to which each plan achieved the indicators for each form of justice. The results show that the Burgas Sustainable Energy and Climate Strategy and Action Plan (SECAP) scored lower on all forms of justice from the National CCA Strategy and Action Plan, but that there is significant room for improvement in how justice issues are planned for at both the national and municipal scales, with the national level plan still scoring at approximately 50% of all available points.

4.1.1 Distributive Indicators

- Both National and Municipal level plans included risk mappings and vulnerability assessment and identified adaptation measures to target specific identified hazards. Further marks could have been gained by linking the vulnerability assessments to the adaptation planning and monitoring processes in the plans. (Indicators 2.1 & 2.2)
- The National CCA plan contained substantial cost-benefit analysis (CBA) of identified measures across economic sectors, which provided some indication of where the benefits of adaptation might be distributed. But in both cases more points could have

been achieved by assessing which groups of people, districts, or regions would benefit from planned adaptation measures; and by committing to monitoring this throughout the project implementation. This goes beyond CBA and requires governing organisations to assess how the benefits of municipal actions are being shared (including spending, but also the benefits of CCA measures). (Indicator 2.3)

- The National CCA plan included some discussion of how the costs of adaptation should be distributed, including recommending the "polluter pays principle" be adopted to divert funds for CCA within vulnerable sectors; and in section 4.5 contained an assessment of the financial resources and potential sources (public and private) for each of the measures identified. Specific notice is given of the need for public resources to "assist vulnerable groups that cannot adapt sufficiently themselves". While there is an identification of funding sources in the Burgas SECAP further points could have been gained by assessing the costs of CBA and their distribution within society (Indicator 2.4).
- Risks of potential negative impacts of CCA measures (maladaptation) were poorly incorporated into both plans. Further efforts should be made to anticipate potential negative outcomes from specific adaptation measures and assess how these impacts may be distributed. (Indicator 2.5).

4.1.2 Procedural Justice Indicators

- There are notable disparities in the achievement of the "procedural justice" indicators between the national and municipal level; which reflected differences in the extent to which stakeholders were involved in the planning and implementation of the CCA strategies.
- The Burgas SECAP was created in line with the guidance of the "Covenant of Mayors for Climate and Energy Initiative" which commits signatories to "engage citizens, businesses and local and national authorities in achieving the set goals and vision and in the transformation of social and economic systems". However, no evidence could be found to indicate that the plan was developed with expertise from outside of the public sector. At the national level it was evidenced that sectoral expert stakeholders had been involved in the planning through invitation and at multiple stages of the process. In both cases involving a greater variety of stakeholders, including vulnerable groups, in planning and at different stages of the process would have yielded a higher score (Indicators 3.1 & 3.2).
- At the national level, the CCA plan clearly delineates who is responsible for the implementation of adopted measures to the departmental level, or notes where for particular sectors responsibilities are held by local and non-governmental authorities. In the SECAP there is no specific departmental breakdown of responsibilities (although this may be common knowledge to the municipalities). Budget responsibilities for all measures are identified in 6.2 which highlights which actions fall under municipal budgets or EU funds. In both cases further points could have been gained by clarifying or assigning clear and transparent responsibilities for implementation of the plan. (Indicator 3.3)
- Both plans give a strong role to informing the public and different groups of stakeholders about CCA and the measures adopted in the plan at the implementation stage. For instance, in the SECAP CCA Policy, Priority 4 is listed as "*promotion and public engagement on the topic of adaptation to climate change"* At the National level, the Government of the Republic of Bulgaria adopts a commitment in the CCA plan to "*Carry out adaptation in partnership. All stakeholders like from public institutions, civil society, and private sector, at all levels, should be identified and engaged. It should be ensured that they are well-informed and encouraged to work on adaptation."* However, both plans could have gained additional points by going beyond informing stakeholders and finding ways for including their participation in the implementation of the plan. (Indicator 3.4)

- In the SECAP, CCA Policy Priority 1 requires: "Establishing a legal and administrative framework for local climate change adaptation policies… [including] Monitoring of adaptation policies" however no clear explanation or methodology for the evaluation and updating of the plan could be found. The highest points could be achieved in plans which involve stakeholder and civil society input into the monitoring and evaluation activities (Indicator 3.5)

4.1.3 *Recognitional Justice Indicators*

- Both plans recognise and clearly state that adaptation needs and/or preferences can vary between different groups across society. In both cases these differences in needs were identified through expert assessments (including vulnerability assessments). The highest points could have been achieved by including opportunities in the development of the plan for different societal groups to identify their own adaptation needs to the planners. There is some evidence that the National CCA plan begins to take this approach when they bring stakeholder input into the sectoral prioritisation of measures activities, but it is important to go beyond expert stakeholder input. (Indicator 1.1)
- Both plans made sporadic references to the role in which existing social structures play in conditioning vulnerability in a general manners. For example, the SECAP states that: *The vulnerability of the economy and population to the impacts of climate change is exacerbated by the relatively high poverty rate in the most affected areas, the continued concentration of the country's population in a few industrial and urban areas, and the various consequences of the transition from a state-controlled economy to a free market economy.* However, neither the National CCA Plan nor the SECAP adopt measures that link decreasing the impact of these social structures to raising adaptive capacity. (Indicator 1.2).
- At the National Level the link between successful CCA and achieving broader social objectives and promoting human rights is mentioned in the discussion of the linkages between effective CCA and achieving the Sustainable Development Goals. Both strategies could have reached higher marks by explicitly linking the outcomes of the CCA measures to broader social objectives.

4.1.4 *Restorative Justice Indicators*

- Neither the National CCA plan or the SECAP scored above 1 point in the Restorative Justice Categories. This is in line with the comparatively lower scores achieved in this category in other regions where the Adaptation Justice Index has been utilised (England, Canada, Finland, Sweden).
- These indicators require ambitious commitments to compensate affected groups for both the diverging impacts of climate change (4.1), for the impacts of potential maladaptation (4.2), for existing disparities in resources and social outcomes which lead to inequalities in adaptive capacities (4.3).
- Some of the requirements for meeting these indicators may sit outside of the authorities of City/Regional authorities.
- Nonetheless *Transformative Climate Change Adaptation* should aim at meeting some of these indicators. Possible options may include earmarking funds to compensate communities in the case of maladaptation; or seeing measures which reduce poverty or social exclusion as *a part of* their CCA planning, when such actions are affective at increasing the adaptive capacities of these communities.

At neither the National or the City/Regional level is "justice" explicitly mentioned or defined in the CCA plans. However, at the National Level the Republic of Bulgaria adopts two principles ("i" & "j") which clearly relate to procedural justice in their CCA transitions planning:

- (i) Adaptation needs to be transparent. The effects of various adaptation options, both in the near and long term, should be communicated in full, providing as much detail as possible which, among others, include the level of risk to be accepted, as well as to agree on solutions that are *fair* and balanced. *[emphasis added]*

- (j) Continuously review the effectiveness, efficiency, *equity*, and legitimacy of adaptation decisions. This will allow for their gradual improvement in line with the evolution of evidence and knowledge on climate change impacts. *[emphasis added]*

At a national level these commitments to considering justice (fairness & equity) are welcome, but further efforts should be committed to defining these terms through dialogues with communities and different groups of stakeholders, as it is evident that (a) **different groups of people have different conceptions of when a policy is fair/jus**t (e.g., different conceptions of how the costs of adaptation policies should be shared); and (b) these **perceptions of policy fairness are key drivers of policy acceptability and success**.

There are several limitations to this analysis. Firstly, it **focusses only on the extent to which different indicators of justice can be identified from reviews of planning documents**. While these documents play a key role in framing and shaping how implementation develops, **some justice considerations may only be known in the implementation stage**. The Adaptation Justice Index is not equipped to provide advice on how to implement projects justly, and likewise project implementation may diverge from what is planned/strategized for. Secondly, **The Adaptation Justice Index is built around one vision of justice** which may not align with the perceptions of justice that are present in different social contexts. While it was developed through a scientific literature review of theoretical accounts of CCA justice, its indicators contain normative presumptions that may not have the same importance in other social and political contexts (e.g., in the centrality it places on participatory inclusion over achieving measurable changes in distributive outcomes).

4.2 Justice Considerations Identified in Interviews

We conducted semi-structured interviews with stakeholders in Burgas' 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 Burgas 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.

4.2.1 Procedural and Recognitional Justice:

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 group**s in their interviews and acknowledged how their conditions generated specific or diverging needs, preferences in CCA contexts. Groups identified were young people and youth organisations; ethnic minorities (Roma; Sinti; Ethnic Turks) and immigrant communities; the elderly; communities in poverty. Some participants also **identified specific CCA relevant initiatives targeting these vulnerable groups**; including: initiatives focusing on Roma & Sinti communities; and special disaster risk measures for elderly people, groups with health and mobility issues, and rural/isolated communities. Further information on these drivers of social vulnerability may be found in Section 1.

Interview participants often spoke of **difficulties in engaging the public in participatory processes**. Different explanations were given for this phenomenon. Some participants attributed it to a lack of desire/experience/interest from the public in being involved in participatory governance. For instance, one participant spoke of their experience in running a public consultation about sustainable tourism, and told us that

> *"we did an event, thinking about the future of the village and the region: we used an UN [developed] sustainable tourism diagnosis tool…, people were so afraid to speak honestly about these topics"*

Another attributed this to a specifically Bulgarian "national characteristic":

> *"In fact, it's also difficult to explain to people from different countries. But Bulgarians, due to our national characteristics we are not the most team working people, the other way around we are single players and this is another big problem, being in many countries in the world i have seen how they have communities. It's difficult for me to say the word community for the villages in the area around Burgas"*

The concern about community cohesion and lack of community institutions was repeated and identified as a material reason why efforts to bring communities into governance face challenges:

> *"we don't have any neighborhood communities [and] this is one of the big issues for us that people in the in the neighborhoods -some of them they organize in the social media- but it's nothing well-organized or with some certain rules or meetings or discussions… this is one of the one of the problems [for doing participatory governance] and that's why very often the citizens they don't have enough information…"*

Two participants linked this to changing expectations of how the public sees its relationship with governing institutions stemming from its pre- 1989 history:

> *"The civil society, doesn't have such a long-standing, history and traditions in Bulgaria... [Until] 89 we didn't have these civil society, organizations… [After 89] civil society organizations, start to be more active, because they see that the… the local authorities, or the local governments, or the state governments are not capable of finding solutions"*

We heard about this sense of public mistrust in governing institutions/administration as a factor hindering participatory governance from both a representative of a civil society organization:

> *"often it is the last resort to any situation to go to the administration…As a consequence - or maybe it's the cause - participatory democracy and these things don't really work in Bulgaria, participatory instruments don't really work."*

and from an administrative department representative:

> *"[the public] are not very trusting as a society. When we go to a smaller village and try to explain something, we encounter a lot of distrust"*

To the extent that participatory styles of governance are understood to be a requirement of procedural and/or recognitional justice in CCA governance; the existence of this purported disinterest amongst the public in engaging in these processes may represent challenges to the City/District administration in pursuing procedural justice. Nonetheless, if we focus on understanding *perceptions of justice (i.e. what features drive public perceptions of fairness)* the evidence presented here might also reflect the fact that in the in the Burgas context public perceptions of fairness are not primarily driven by the extent to which people are involved in participatory governance/public decision-making, but may instead be driven by other factors such as the perception that the governing administration acts transparently, impartially, in accordance with the rules, or is able to deliver material benefits to the right people/distribute costs fairly. Further research is needed to draw these conclusions.

Nonetheless one participant told us directly that, in their opinion, publics in Bulgaria were more driven by tangible material improvements than involvement in government

> *"the lower expectations come from the fact that people expect people on the ground tangible things (road, playground, this is where my money went")*

Another comment from a member of an administrative body however made an illustrative point on the difficulties that are caused by (their perceptions of) the competing expectations from the public on how they expect the administration to behave:

"The problem is the implementation - to even get to that stage. [The administration] are very good at gathering information and writing documents. For implementing an idea, [the public] would need to accept that there are also drawbacks/ disadvantages.

"For Example – …People need access to water. But they think that free access to water means that there [should be no efforts to control demand] from the state. But then, when there is a drought and the water disappears, they want the government to solve the problem"

And likewise when an administrative official told us in regard to flood prevention:

"When [the Department] try to warn the [private property] owners, they don't care, but if they get affected by a flood, they expect the Government to replace the damage."

Some participants noted perceptions that administrative **decision-making processes lacked transparency** or failed to live up to **expectations of impartiality**.

"maybe the government is doing its job… although [we cannot] always see it. Maybe [the challenge for trust in government is] more about transparency of decisions. We don't know what they are doing. It's more about proper communication and transparency of decisions."

Other participants emphasized the importance of that they placed on "**following the rules**" as a virtue of proper governance and expressed their frustration over a perceptions rules were not properly followed.

"You have to follow regulation. I think that all regulation in this country has to be followed. This is the main problem of the hour."

The importance placed on rule-following was particularly clear when a participant related an occasion where their department faced public criticism when an elderly couple was tragically killed after choosing to ignore a flood evacuation order. The interviewee emphasized that:

"…when a disaster like this happens, people tend to blame local authorities or the state for not cleaning the riverbeds, etc. But this wasn't the case. This was a decision made by the people there. We did what we had to do, and we worked very closely with the fire brigade, and the mayor was there, and the district governor was there as well. So, from our point of view, we did what we had to do… there was nothing to criticize because we had followed all the procedures."

The transparency and "rule-following" expectations converge when some participants expressed **concerns over corruption and illegality** in the way that way governance had occurred at all levels of Bulgarian politics:

"after year 2000, there was a rapid building development along the black seacoast, so these small municipalities, unfortunately are now under, how to say, the influence of [euphemistically] *"these tendencies" … they not only built illegally [but also] built up some natural areas"*

and,

"environmental legislation should be followed… during last 25 years we all the time [saying the same thing:] that the illegal, the over building, the illegal constructions - it's something which will turn against us the people… This autumn there there was a big case [of flooding] in Elenite resort - one huge hotel, totally illegal, [blocking] the river - totally illegal and finally the institutions discovered this after the big flood - when everything was destroyed, And it's terrible because now the people are left to manage everything."

and,

"[the state and its governance institutions] is not totally on the on the side of the nature, on the side of the interest of society because of corruption. It's not a secret it's more

> *than obvious and many if you search in the electronic sphere you will see many such cases."*

While we did not try to substantiate these allegations (evidence on regional corruption is supplied in Section 1), it is evident that these perceptions of corruption are an important factor in how procedural (in)justice is understood within the municipality and region.

4.2.2 *Distributive Justice:*

While distributive justice issues were reported less frequently in the interviews, this may reflect a lack of dedicated questions on the topic rather than a lower interest in these concerns*:*

Interviewees often spoke about **rural isolation and a resourcing gap** between rural and urban areas. One interviewee mentioned this succinctly as:

> *"aside from the bigger town, like the city of Burgas, they [small towns/villages] don't have the capacity and the financial resources [to fund climate measures]."*

As noted in section 1, Burgas district has a highly rural population and whether a person lives in a rural area or an urban area can have a measurable impact on: whether they experience poverty, are employed, the amount of time it takes for them to receive emergency services, access to healthcare, and whether their administration has an adaptation plan and funds available for adaptation measures. The fact that where someone lives can have measurable differences in these important life outcomes may indicate a distributive injustice for many perspectives on distributive justice, especially as most rural residents in the region are unlikely to have chosen to live there and are to this extent victims of circumstance rather than choice. CCA measures that involve making new investments in rural areas, especially those aimed at reducing social vulnerability and raising adaptive capacities could serve a dual purpose in narrowing existing inequalities.

We heard that there are some initiatives from an Employee of Burgas Municipality to target infrastructural improvements onto areas that were identified as being vulnerable:

> *"[The department] are trying to include all parts of infrastructure in the Municipality and all community representatives no matter their affiliation, but with a focus on vulnerable groups, because sometimes they get overlooked/ missed by normal measures."*

Lack of financial resources was brought by several interviewees. For instance:

> *"lack of funding is an issue. As long as we have funding, we will be able [implement adaptation measures). And of course, there is the human factor. The regional district administration is an administration, it's not an enterprise, so we don't have the human resources or the financial resources to act or the equipment."*

A lack of resources is not on its own evidence of a distributive injustice, as distributive justice is about how we share scarce resources within our societies. Likewise, administrations will have many competing demands on their resources and have limited abilities to influence how national governments will allocate budgets. However, distributive justice can become relevant in these discussions if resources are not being prioritized to the right causes, especially if lack of adequate resources results in people being exposed to climate risks. Both the data on hazard exposure and indicators of social vulnerability are important sources to draw upon to ensure that CCA measures are distributively just, as they provide the information required to ensure that new measures can be targeted at: improving outcomes for those who are currently worst off (either vulnerable or exposed to hazards) and that risk exposure is equalized throughout society (egalitarian) or no group faces a unacceptably high standard of risk (sufficientarian). Chapter 2 of this report supplies evidence of how in post- disaster contexts the inequalities in income can increase, and so adequate CCA measures can also be a preventative measure for stopping climate change exacerbating existing inequalities.

Principles for **cost sharing** did not appear directly in our interviews but are related to the questions of financial resources and is a core feature of analyzing distributive justice. City/Regional authorities have differing abilities to raise financing for adaptation action (e.g.

through local taxes) and this is an opportunity to think about how the costs of adaptation measures will be shared within a society. Groups within a society will have different abilities and willingness to pay for adaptation measures. The requirements of private financers to seek returns on their investment can also raise distributive justice challenges if some communities/regions in need of protection do not present attractive investment opportunities. CCA planning should consider how costs will be shared and potentially involve the public in discussions of cost-prioritization/participatory budgeting.

Compensatory measures for the harm of climate change or for maladaptation is another element of distributive justice which city/regions could consider. Compensatory measures were discussed briefly in the interviews:

> *"if there is a place, where Agricultural Activity is harmful to the environment, then there should be no, or limited, Agricultural Activity there, and there are compensations for the Farmers."*

Climate change will impact the kinds of economic activities that it is viable to perform in a country or region, and cities/region should consider in their CCA planning how to respond to the needs of people who's livelihoods are no longer viable; including for instance resources and training for farmers in climate adapted farming (e.g., which crops to grow), or retraining for people redeployed from unsustainable industries. This is sometimes what the term "just transition" refers to.

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 Burgas. 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 30 local stakeholders, including representatives of government agencies, civil society organizations, research institutes, and the private sector. The survey questions can be found in Annex 7.1. In addition, the information gathered in the survey was supplemented in a targeted manner by semi-structured interviews with selected stakeholders.

Figure 28 shows how survey participants are distributed across different stakeholder groups. Out of 30 respondents, 8 are government actors, 7 are civil society actors, 4 are academic and 4 are economic actors. 7 participants defined themselves as “other”[16].

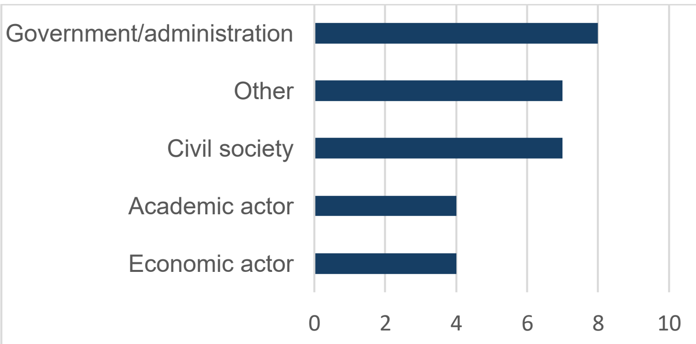


Figure 28: Distribution of stakeholder groups
Question: What stakeholder group do you attribute yourself to? n = 30

15 of 30 participants assessed the situation of barriers to climate change adaptation from the perspective of Burgas Municipality. 4 respondents took the perspective of another municipality in the Burgas district,[17] and 11 respondents took the perspective of the Burgas district as a whole.

The following analysis points to differences in results when looking at individual subgroups. It is, however, important to keep in mind that these subgroups are very small and do not necessarily reflect generalizable results.

[16] The category “other” included citizens (mentioned twice), representatives of the Southeast State Enterprise DP Silven, a citizen-firefighter, a non-governmental organization, a commercial company and the state enterprise “Port Infrastructure”.

[17] These included Tsarevo, Sredets (mentioned twice) and Nesebar.

5.2 Barriers to Climate Change Adaptation

The following barriers were the ten most relevant[18] according to the survey participants (for a full overview of barriers, see Figure 29 or the questionnaire in Annex 8.4):

1. General mistrust of national government among the public
2. Lack of collaboration and cooperation across different departments and sectors ("silo thinking")
3. Climate skepticism
4. Lack of awareness of the links between climate change and other issues
5. Difference in risk perception between governing authorities and economic actors or broader public
6. Lack of staff knowledge on the science of climate adaptation, specific local adaptation needs and/or existing adaptation options
7. Lack of knowledge on how to start and follow an adaptation planning process
8. Lack of leadership on climate issues by the national government
9. General mistrust of European institutions among the public
10. Lack of collaboration and cooperation across different governance levels

This implies that the identified barriers are very diverse in terms of topic and belong to different categories of barriers (as indicated in parentheses):

- There is some **mistrust** towards national and European institutions (attitudes, values and motivation),
- The **risk perceptions** are low and there is climate **scepticism** (attitudes, values and motivation);
- There is also a **lack of awareness** of the links between climate change and health, productivity etc. (awareness and communication);
- There is a **lack of staff knowledge** on climate change adaptation and adaptation planning process (resources);
- And there is a **lack of cooperation** across different departments, sectors and governance levels (governance and institutional constraints) and not enough **leadership** on the national government side (leadership);

The majority of the interviewees agreed with the identification of these barriers, with a few exceptions of diverging opinions on individual barriers. One interviewee explicitly stated that all barriers had already been overcome. Interviewees also provided initial explanations on some of the barriers:

- "General mistrust of national government among the public" is explained by an interviewee with the lack of stability in the government, constant changes and many elections. This causes an inability to plan long-term.
- "Lack of collaboration and cooperation across different departments and sectors" is, according to an interviewee, not caused by a lack of will, but by legal obstacles. Another interviewee added on this barrier that authorities do often not implement rules and policies developed by others.
- "Climate scepticism" is, according to one interviewee, an important barrier among the population, but also within political parties.
- "Lack of staff knowledge" is, according to an interviewee, caused by the fact that government jobs are low-paid and therefore not attracting qualified staff.

[18] 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=30

Figure 29 provides an overview of the relevance of different categories of barriers.

Figure 29: Overview of relevance of barrier categories
n=30; 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).

Looking at the different categories of barriers and specific subgroups of respondents, the following observations seem relevant:[19]

The category of "**attitudes, values and motivation**" is rated as most relevant overall. Interestingly, while the barriers "climate scepticism", "general mistrust of district government among the public" and "general mistrust of municipal government(s) among the public" are rated relevant overall, academic actors do not agree with this assessment. Furthermore, the barrier "suppression of scientific knowledge and professional expertise" is rated as mostly relevant by all actors except economic actors.

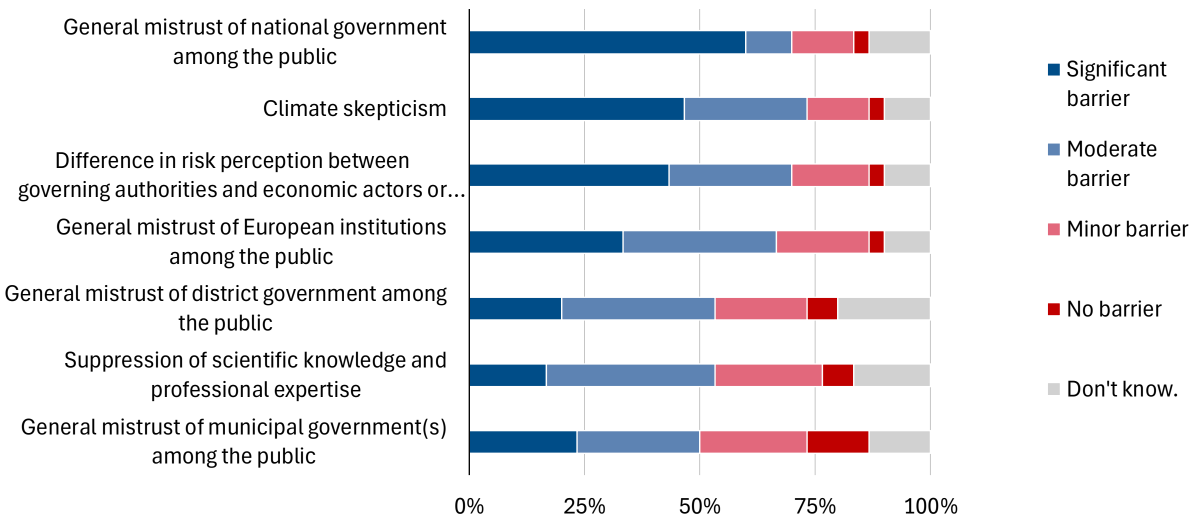


Figure 30: Overview barriers "attitudes, values and motivations"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2

[19] Note, however, that the sample sizes of these subgroups are very low and general conclusions at this level are therefore limited.

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 second most relevant category of barriers is "**awareness and communication**". The related barriers are considered relevant by most respondents, whereas the two barriers specifically related to communication of adaptation need within district or municipal governments are not considered relevant by government actors themselves.

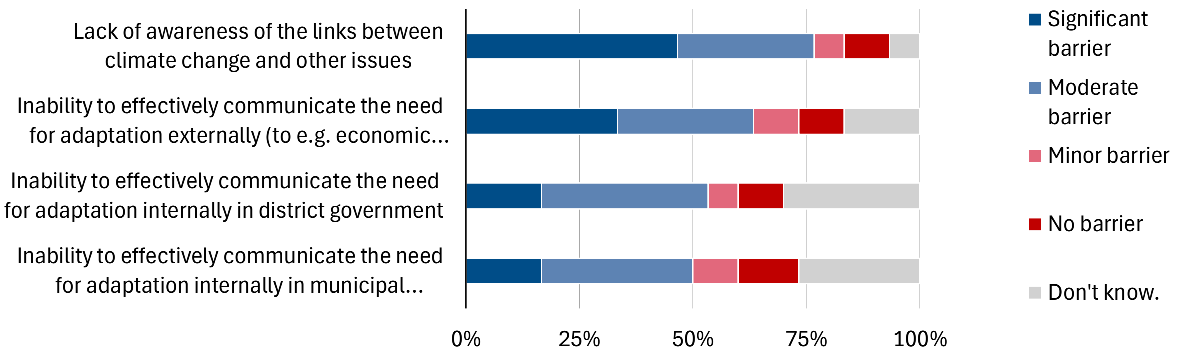


Figure 31: Overview barriers "awareness and communication"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

In the category "**conflict of interest**", all barriers are considered relevant. "Lack of engagement by the private sector" and "Adaptation competes with other more immediate priorities" are, however, considered less relevant by government actors.

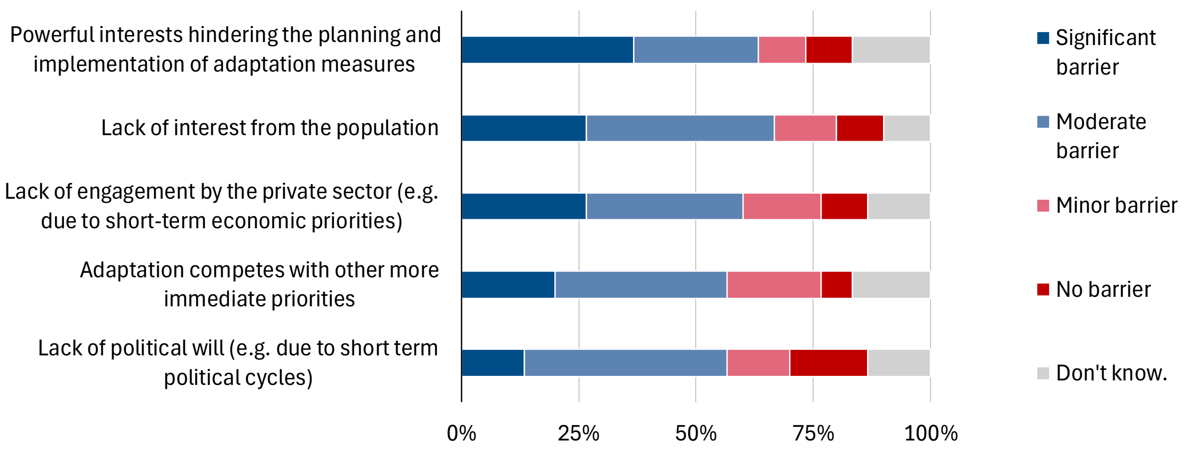


Figure 32: Overview barriers "conflict of interest"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

Barriers related to "**governance and institutional constraints**" are mostly considered relevant by civil society and economic actors, and less so by government actors.

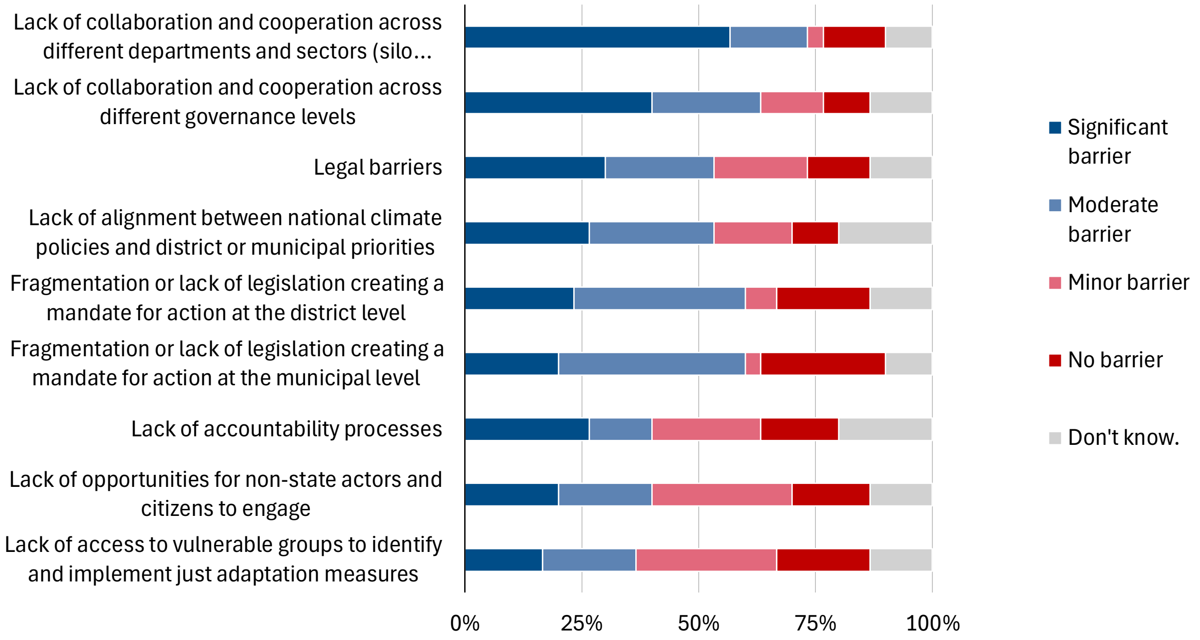


Figure 33: Overview barriers "governance and institutional constraints"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (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.

Barriers related to "**resources**" are considered mostly relevant, with a few exceptions. "Lack of district and municipal government staff time", "lack of tools, technology, methods and similar" and "lack of financial and/or staff resources of non-state actors" appear to be less relevant. Generally, considering the responses of government authorities only, 5 out of 10 most relevant barriers revolve around the topic of "resources".

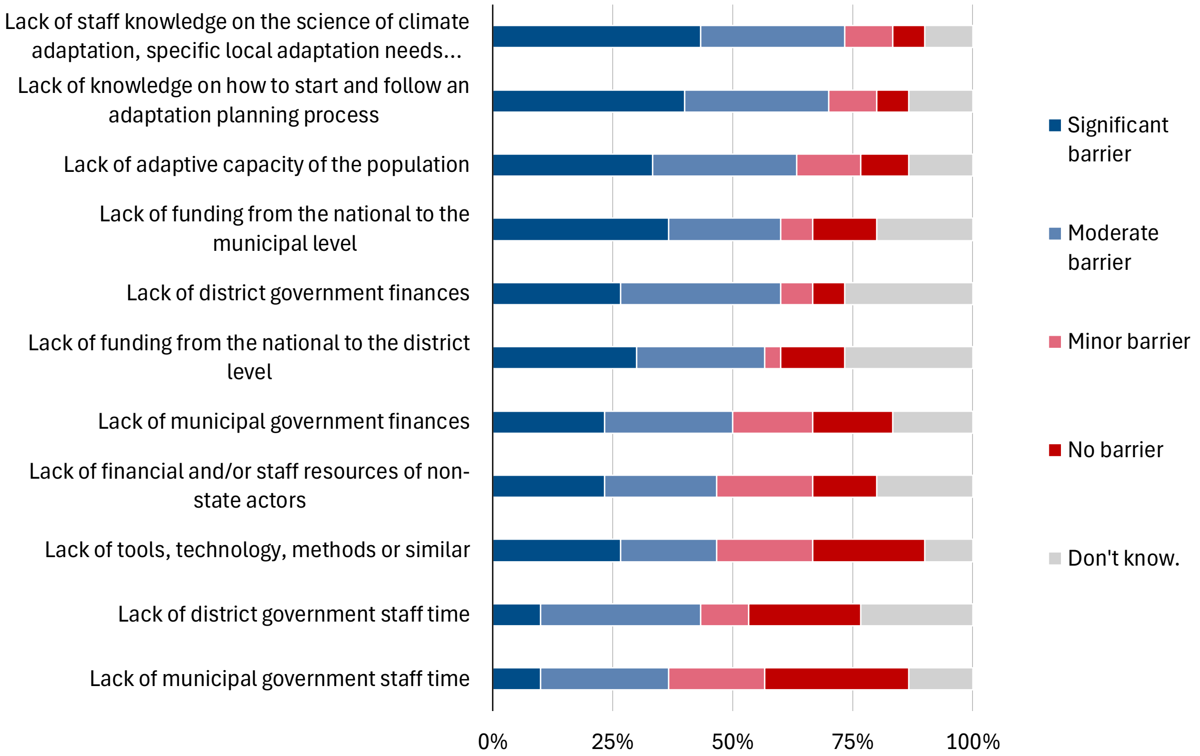


Figure 34: Overview barriers "resources"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

Barriers related to "**science and data**" seem to be relevant overall, with the exception of "high uncertainties related to climate scenarios" and "high uncertainties related to adaptation interventions and their impacts/effects", which are not considered relevant by the majority of participants. This assessment is, however, driven by government actors, who did not agree with these two barriers at all.

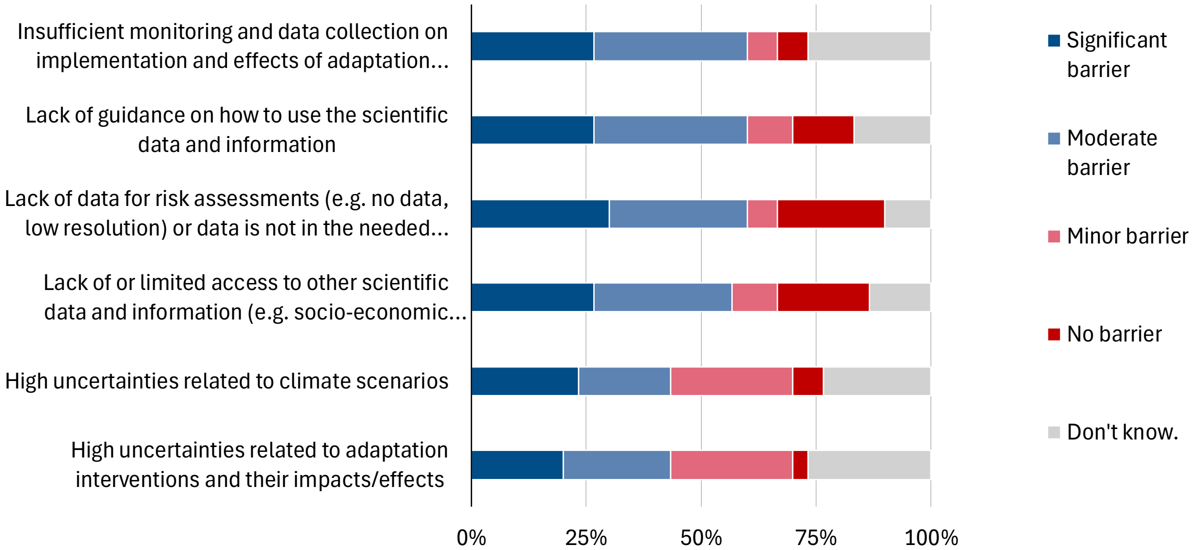


Figure 35: Overview barriers "science and data"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (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. In this category, only one barrier – "lack of leadership on climate issues by the national government" – is considered relevant by the majority of the participants.

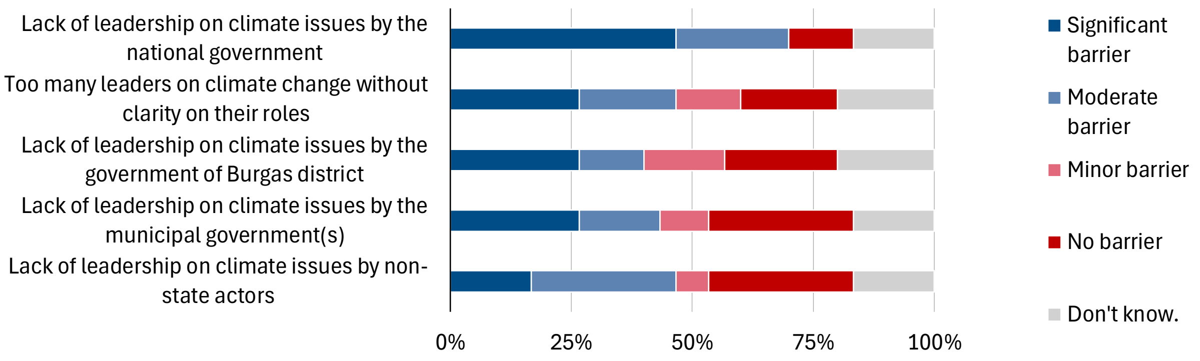


Figure 36: Overview barriers "leadership"
n = 30. The barriers are sorted along their relevance according to the survey. The relevance of a barrier is calculated based on the relative frequency with which the barrier was described as significant (equals 3 points), moderate (equals 2 points), minor (equals 1 point), non-existent (equals 0 points), or "don't know" (implies low relevance and equals 0.5 points). Figure INFRAS.

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 Figure 37).

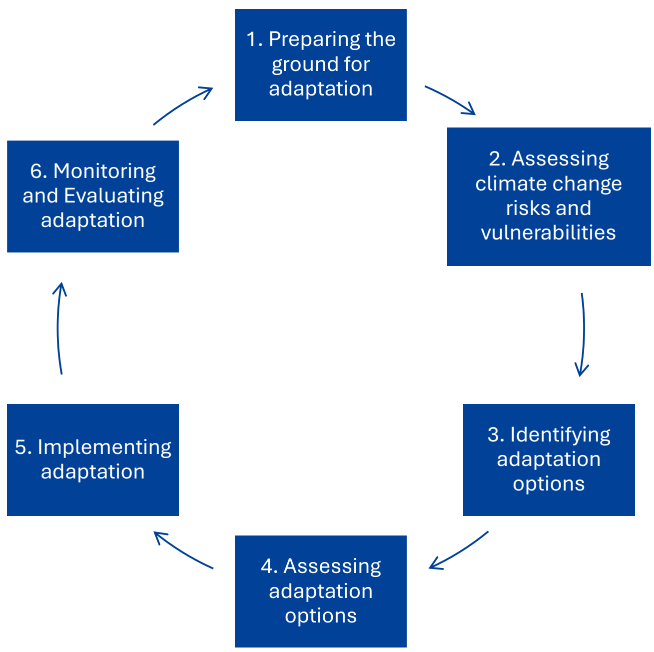


Figure 37: Policy cycle of climate change adaptation
Ideal-type stages of the adaptation decision-making process; Source: ClimateADAPT 2025

The barriers that respondents identified as most important in their own words mostly revolved around the topics of lack of awareness, information and interest among population and political actors, followed by a lack of data and different priorities of decision-makers. These responses largely correspond with the results presented in chapter 5.2. The results also show that phase 2, the phase of assessing climate change risks and vulnerabilities, seems to be the phase in which most barriers occur. Sorting the different phases according to how often they were mentioned by survey participants looks as follows:

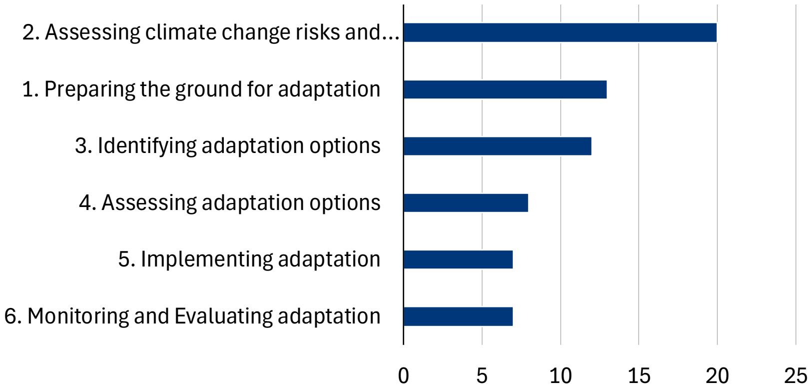


Figure 38: Barriers along the CCA policy cycle, sorted according to relevance
Question: In your own words, which are the most important barriers to climate change adaptation (max. 3), and in which stage of the process are they located? Select the respective stage(s) and note down the specific barrier(s). Figure INFRAS.

5.4 Sectors affected by barriers to Climate Change Adaptation

The sectors most affected by barriers to CCA in Burgas, according to survey respondents, are water management and agriculture. From the Burgas district level perspective, the sectors of land use / spatial planning and disaster risk reduction (DRR) also seem very relevant.

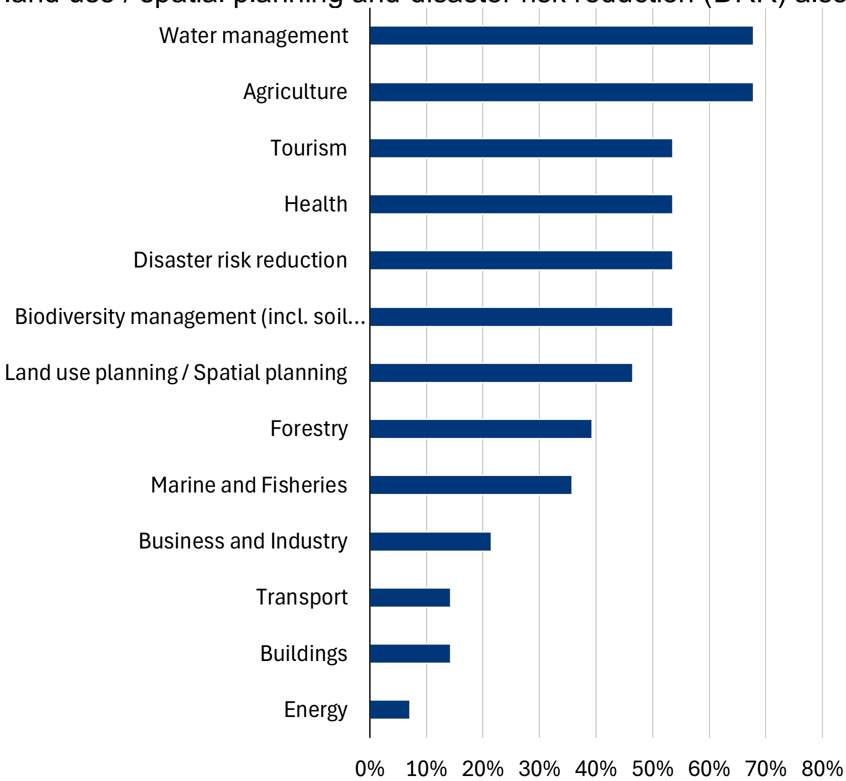


Figure 39: Sectors affected by barriers to CCA
Question : Which sectors are particularly affected by barriers that hinder the planning and implementation of necessary measures for climate change adaptation? n = 28, multiple responses possible

5.5 Overcoming barriers to climate change

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

1. **Awareness, education & public engagement**: Raising public understanding on climate change and related risks, promoting behavior change. Engaging communities and stakeholders.
2. **Governance, coordination & strategic planning**: Strengthening cross-actor coordination between different government entities but also between state and non-state actors. Developing long-term strategies, laws and plans.
3. **Financing & economic instruments:** Ensuring sustainable funding and insurance instruments, creating incentives for businesses to adopt innovative approaches.
4. **Data, research & technology**: Building knowledge, data infrastructure, and applying new technology.
5. **Administrative reform & anti-corruption:** Improving administrative capacity and efficiency, streamlining processes, and integrity.
6. **Sector-specific measures** (Agriculture, Water, Transport, Tourism)

6 Adaptation for climate resilience in Burgas

6.1 From risk to climate action

Climate change adaptation refers to the process of adjusting natural and human systems in response to present or expected climate and their effects (IPCC, 2022). The aim is to moderate harm, reduce vulnerability, and, where possible, take advantage of potential beneficial opportunities. Adaptation measures can take many forms, including technical interventions (e.g. flood protection infrastructure), nature-based solutions (e.g. wetland restoration), institutional and policy measures (e.g. land-use planning regulations), and behavioural or societal responses (e.g. changes in water use practices or heat risk awareness campaigns).

Adaptation can be understood along a spectrum from incremental to transformative change. Incremental adaptation focuses on maintaining existing systems and reducing risks within current structures (Clarke & Murphy, 2023; IPCC, 2022), for example by upgrading drainage systems or constructing higher flood barriers. In contrast, transformative adaptation involves more fundamental changes to attributes of a social-ecological system in anticipation of climate change and its impacts (IPCC, 2022), such as rethinking land use, relocating exposed assets, or redesigning urban development pathways to better align with long-term climate risks.

In this study, adaptation measures are grouped into four categories: **structural measures, behavioural change measures, institutional measures** and **nature-based measures**. This categorisation is based on the framework of the Intergovernmental Panel on Climate Change, which distinguishes between different types of adaptation responses across structural or physical, ecological, governance, and social domains (IPCC, 2022). **Structural measures** refer to engineered or technical interventions aimed at reducing climate risks, such as flood protection infrastructure or drainage systems. These measures are often implemented within specific sectors or infrastructure systems (e.g. the elevation of power infrastructure). **Behavioural change measures** involve shifting actions by individuals and communities, norms, and practices that reduce vulnerability or exposure, such as water-saving practices, heat risk awareness, or responses to early warning systems. **Institutional measures** encompass policies, regulations, and governance arrangements that enable and guide adaptation, including land-use planning, building codes, and climate integration into sectoral policies. **Nature-based measures** utilise ecosystems and natural processes to enhance resilience, for example through wetland restoration or urban greening. Nature-based solutions have gained increasing attention in recent years and are explicitly recognised in the IPCC Sixth Assessment Report as a key adaptation approach with multiple co-benefits.

6.2 Climate change adaptation considerations

To support informed decision-making on adaptation strategies, it is essential to systematically assess key characteristics of each adaptation option. In this study, a set of indicators is defined to capture both the scope and the performance of adaptation measures. Together, these indicators provide a structured basis for comparing options and identifying those most relevant for the local context.

First, a set of measure scope indicators is used to describe where and how adaptation options apply. These include the types of climate or geophysical hazards addressed (e.g. flooding, heat, or coastal risks), the domains in which the measure is implemented (e.g. agriculture & food systems, Health & Wellbeing, or Water resources & Flood risk), and the target sectors to which the measure is relevant. In addition, identifying the core stakeholders involved is essential, as effective adaptation often requires coordination among public authorities, private actors, and local communities. The scale of implementation is also considered, referring to the organisational level at which a measure is applied, ranging from local or asset-level interventions to regional or national strategies.

Second, a set of measure characteristics is used to evaluate the feasibility, effectiveness, and broader implications of each adaptation option. Feasibility & local applicability assess the extent to which a measure can be realistically implemented, taking into account factors such as financial resources, institutional and technical capacity, social acceptability, and local environmental conditions. Effectiveness refers to the degree to which a measure is expected to reduce climate risks and impacts and can be assessed qualitatively (e.g. low, medium, high). Co-benefits capture additional social, economic, or environmental advantages beyond the primary adaptation objective. Justice considerations are not inherent to the adaptation measure but arise in how the measure was planned for and implemented within the social context. Distributive and Restorative justice can be evaluated by assessing how the benefits and costs of an adaptation measure are distributed across different sectors of society and how harms (both existing injustice, and new harms arising from the implementation of a measure) are compensated for. Procedural and Restorative justice examines the fairness of the processes used to reach decisions about the measure; including who was involved in the decision-making process, the extent to which they could make an impact, the kinds of information that was used in the decision-making process, and how well it matched peoples preferences, interests, and needs. Furthermore, adaptation measures also vary in terms of costs and required investments, which depend on factors such as the type of intervention and local conditions, and can be expressed in relative terms (e.g. low, medium, high). The time span of implementation distinguishes between short-, medium-, and long-term measures. Finally, potential maladaptation and implementation vulnerabilities are considered, including factors that may hinder effectiveness or lead to unintended consequences.

Together, these indicators provide a comprehensive and transparent framework for assessing adaptation options and support the identification and prioritisation of strategies in subsequent steps. An overview of the ongoing work on a list of adaptation options taking into account this set of measure characteristics can be found here: Adaptation_Measures_1703.xlsx (most recent, still being worked on, only accessible for members of TiCCA4Danu) or in the Annex, Chapter 8.5.

6.3 Climate change adaptation strategies for Burgas

In the context of Burgas, moving from risk assessment to adaptation action requires linking identified vulnerabilities, climate risks, and barriers to targeted and feasible measures. The following sections therefore present a set of potential adaptation options that may be relevant for Burgas, based on the previous analysis. These options are intended to inform further discussion and will be refined and tailored during a subsequent stakeholder workshop.

The analysis identifies three major climate-related risks affecting the Burgas district: floods, wildfires, and extreme heat, each with distinct but interrelated socio-economic impacts.

- **Floods** represent an immediate and recurrent risk, leading to declines in GDP growth and increases in income inequality, with measurable welfare losses. Future projections suggest that, without adaptation measures, cumulative economic costs will rise substantially, particularly under increasing uncertainty.
- **Wildfires** pose a growing structural risk. While historically concentrated in a few high-intensity years, future scenarios indicate a marked increase in fire danger conditions. For moderate fire danger, the entire population of Burgas District is projected to experience more than 90 days of exposure per year under all future scenarios. Their economic impact is equally significant, reducing firm activity - especially in agriculture, construction, and real estate - and generating non-negligible aggregate losses.
- **Extreme heat** reflects a long-term and accelerating trend, with a clear increase in the frequency of extreme temperature events. This poses a serious risk for the population; especially for the large share of vulnerable groups: those without health insurances or the large share of older people over 65 years (22.53% in 2024), who are more likely to suffer from stronger heatwaves. Extreme heat also negatively affects climate-exposed economic activities such as construction (traditionally strong sector in Burgas District), while potentially shifting demand toward other sectors.

Overall, these risks are intensifying over time, with heterogeneous impacts across sectors and municipalities, and are likely to compound in the absence of targeted adaptation policies, increasing the region's economic vulnerability.

In Burgas District, feasible climate adaptation masures should be initiated and led by municipalities, with regional branches providing data, technical expertise, and coordination. At present, cooperation between municipalities is limited (except for disaster risk coordination); therefore, municipalities that face similar climate risks should collaborate to share knowledge, resources, and capacities through joint projects or shared data platforms. Chapter 2 offers an overview of how the different municipalities are affected by climate risks. This could serve as a baseline to argue for stronger cooperation.

Outreach to NGOs, academia and volunteer groups is equally important, as they have strong community relationships, knowledge and can co-design measures, improve citizen engagement, enhance transparency, and expand climate literacy. A municipality-led, district-supported, and civil-society-engaged approach is transformative because it addresses multiple obstacles at once: low climate awareness (identified as a barrier in chapter 5), difficulties with citizen participation (section 4), limited inter-municipal collaboration on shared risks (section 3 and 5), low education levels and the urban–rural divide (section 2).

When selecting measures for climate change adaptation, potential barriers to implementation and follow-up of such measures should be identified and ideally addressed as part of or alongside the measure itself. Many of the identified barriers to climate change adaptation already come up during the early stages of the adaptation policy cycle - when preparing the ground for adaptation, assessing climate change risks and vulnerabilities, and identifying adaptation options. This includes barriers such as lack of awareness on climate risks, lack of data, limited cooperation across different sectors and actors, or different priorities of decision-makers. For climate change adaptation to be sustainable in the region beyond this project, it makes sense to include cross-cutting measures that reduce these barriers and create the conditions necessary for a successful adaptation. Such measures do not have a direct, visible impact, but an indirect one.

Cross-cutting measures revolve around the following topics:

- Establishing a data infrastructure,
- Institutionalizing the issue,
- Defining collaboration processes,
- Education, communication, and awareness-raising,
- Creating a system for ongoing development and monitoring

Table 6 presents a set of potential adaptation measures for Burgas. These measures provide an initial overview of possible responses across key risk domains, including urban heat, riverine flooding, and wildfire. The measures are categorised by type of intervention (structural, behavioural, institutional, and nature-based) to illustrate the range of approaches available to address climate risks. A longer list can be found in the Annex (Chapter 8.5).

The presented options are indicative and are not intended as a final or exhaustive list. Rather, they serve as a starting point to support discussion and decision-making. By combining different types of measures, the matrix highlights opportunities for integrated and cross-sectoral approaches that can enhance overall resilience and generate co-benefits.

These adaptation measures will be further refined, prioritised, and tailored to the local context of Burgas during a subsequent stakeholder workshop. This process will allow for the incorporation of local knowledge, stakeholder perspectives, and practical considerations, ensuring that selected strategies are both feasible and effective in addressing current and future climate risks. Similary, justice considerations are not inherent to the adaptation measure but arise in how the measure was planned for and implemented within the social context. As such, recommendations and assessments follow after the measures have been chosen.

Table 6: Indicative adaptation measures for key climate risks in Burgas, categorised by type of intervention

Risks	Structural measures	Behavioural change measures	Institutional measures	Nature-based measures
Urban heat	- Cool roofs and reflective materials - Shading infrastructure (e.g., shading in public spaces, bus stops) - Improved building insulation and ventilation	- Heat-health awareness campaigns - Training in climate change and health for the public health and wider health workforce - Public guidance on hydration, cooling, and behaviour during heatwaves	- Heat action plans (e.g., to mitigate health risks) - Integration of heat risk into urban planning and building codes - Early warning systems and emergency response protocols	- Urban greening (trees, parks, green corridors) - Green roofs and walls - Increasing permeable surfaces to reduce heat retention
Riverine flooding	- Flood protection infrastructure (levees, dikes, floodwalls) - Drainage and stormwater systems - Flood-proofing buildings (elevation, barriers)	- Flood risk awareness campaigns - Household preparedness (e.g., emergency kits, evacuation readiness) - Uptake of early warning systems	- Flood risk zoning and land-use planning - Flood risk management plans - Insurance schemes and financial risk-sharing mechanisms	- Floodplain restoration - Wetland restoration - Upstream water retention and reforestation
Wildfire	- Firebreaks and fuel breaks - Fire-resistant building materials - Water supply infrastructure for firefighting	- Ignition reduction (e.g., safe use of fire, restrictions during high-risk periods) - Evacuation planning and drills - Public awareness campaigns	- Land-use planning in wildfire-prone areas - Fire management policies and monitoring systems - Emergency response coordination and early warning systems	- Forest management (e.g., controlled burns, thinning) - Landscape management to reduce fuel loads - Restoration of fire-resilient ecosystems

To further support the interpretation of the adaptation matrix, a selection of adaptation measures is described in more detail below. These examples illustrate how different types of measures can be assessed using the scope indicators and measure characteristics introduced in this Chapter.

Urban greening (nature-based measure – urban heat)

Urban greening, including the expansion of tree cover, parks, and green corridors, is a widely applied measure to reduce urban heat through shading and evapotranspiration. In terms of scope, this measure primarily addresses heat-related risks and is implemented within the urban development and public space domain, with relevance for sectors such as public health, spatial planning, and infrastructure. Key stakeholders include municipal authorities, urban planners, and local communities. The measure can be implemented at multiple scales, ranging from neighborhood-level interventions to city-wide greening strategies. In terms of characteristics, urban greening is generally associated with high co-benefits, including improved air quality, biodiversity enhancement, and increased livability. However, feasibility may depend on available space, maintenance capacity, and water availability. Equity considerations are also important, as access to green spaces may be unevenly distributed across the city.

Floodplain restoration (nature-based measure – riverine flooding)

Floodplain restoration aims to reconnect rivers with their natural floodplains, thereby increasing water retention capacity and reducing downstream flood risk. This measure addresses riverine flooding and is typically implemented within the water management and land-use planning domains, often requiring coordination across administrative boundaries. Stakeholders include water authorities, local governments, landowners, and environmental organisations. The scale of implementation is typically regional or catchment-wide. Floodplain restoration can be highly effective in reducing flood peaks and offers significant ecological co-benefits. However, it may involve high upfront costs and trade-offs with existing land uses, such as agriculture. Institutional feasibility and stakeholder acceptance are therefore key considerations.

Heat-health action plans (institutional measure – urban heat)

Heat-health action plans are institutional measures designed to reduce health impacts during extreme heat events through coordinated planning, early warning systems, and targeted interventions. These plans address heat risks and are primarily situated within the public health domain, while also interacting with emergency management and social services. Key stakeholders include public health authorities, municipalities, healthcare providers, and community organizations. These measures typically operate at municipal or regional scales. In terms of characteristics, heat-health action plans are relatively low-cost and can be highly effective when well implemented. They also have strong equity implications, as they can target vulnerable populations such as the elderly or socially isolated groups. Their effectiveness, however, depends on awareness, coordination, and the responsiveness of institutions and communities.

Fire risk management through fuel reduction (structural and nature-based measure – wildfire)

Fuel reduction measures, such as controlled burns or vegetation management, aim to reduce the availability of combustible material and thereby limit wildfire spread. These measures address wildfire risks and are typically implemented within forestry, land management, and civil protection domains. Stakeholders include forestry agencies, local authorities, and landowners, and implementation often occurs at landscape or regional scales. Fuel reduction can be effective in lowering fire intensity and spread but requires ongoing maintenance and careful planning to avoid unintended ecological impacts. Costs and technical capacity can be significant, and public acceptance may vary depending on perceived risks.

6.4 From adaptation options to climate-resilient pathways

Based on the findings presented throughout this report, a range of adaptation strategies has been identified that may be relevant for Burgas. The upcoming workshop in April will aim to prioritise key risks and identify adaptation strategies for further exploration. In addition, Section 10.2 outlines a set of considerations to support the evaluation and selection of these strategies. Building on this, the present section highlights potential next steps towards strengthening long-term and sustainable climate resilience in Burgas.

Given the uncertainty associated with future climate conditions, adaptation is increasingly approached through the concept of adaptation pathways (Haasnoot et al., 2024). This approach explicitly recognises that climate risks evolve over time and emphasises flexible, staged decision-making. Measures are implemented in sequences, allowing for adjustment as new information becomes available or as conditions change. In this way, adaptation pathways help to avoid maladaptation, reduce the risk of lock-in, and ensure that investments remain effective under a range of future scenarios. This approach is particularly relevant for decisions with long-term impacts, high levels of uncertainty, and the potential for path dependencies to emerge (Haasnoot et al., 2024). Furthermore, the development of adaptation pathways is recognised as an effective approach to enable transformative adaptation (Cools et al., 2024), hence representing a key component in TiCCA4DANU. The potential application of adaptation pathways should therefore be further explored in the context of Burgas.

While incremental adaptation focuses on reducing risks within existing systems, transformative adaptation involves more fundamental shifts in structures, functions, or development pathways. To support the identification of such transformative strategies, the development of adaptation pathways for Burgas can build on key characteristics of transformative adaptation identified in recent literature. Drawing on studies by Biesbroek et al. (2026) and Cools et al. (2024), the following elements and criteria can be considered:

- Depth: transformative climate actions are expected to deliver a deep change, which should be *path-shifting*, *restructuring* of existing structures, processes, or relationships, and *innovative*, while addressing the *root causes* that created vulnerabilities and risks, and aligning with existing sustainable development goals, thereby delivering synergetic co-benefits.
- Scope: transformative climate actions are expected to deliver a *systemic* and *multiscale* change, across sectors, governance levels and geographical areas, to effectively respond to cascading impacts, and the compound effect derived from multiple climate hazards, while tailoring responses to *context-specific* needs and conditions of each place.
- Impacts: transformative climate actions are expected to generate *social and economic impacts*. This could entail changes in governance, institutions, and organisational structures, in economies, and in the forms of collaboration and co-production across local actors, or in their individual and community norms, practices, values, and beliefs.
- Temporality: transformative climate actions should be a *dynamic process*, to generate *long-term* impacts and needs, and benefits over time, while acknowledging future climate scenarios and uncertainties. This flexible approach should avoid *lock-ins* and prevent path dependencies.
- Justice and inclusivity: transformative climate actions should generate *just outcomes*, ensuring fair and equitable distribution of impacts and resources, with attention to the most marginalised and less vocal communities, preventing *maladaptation.* These measures should be informed and co-created through the *integration of knowledges.* (see Section 4).

In parallel, climate-resilient development refers to the integration of adaptation, mitigation, and sustainable development objectives to reduce climate risks while promoting long-term social, economic, and environmental well-being for all (IPCC, 2022). As highlighted by the IPCC, this approach emphasises aligning climate action with broader development trajectories, ensuring that investments and policies not only address current risks but also avoid locking in future vulnerabilities. In practice, this requires embedding climate considerations into spatial planning, infrastructure development, and sectoral policies, as well as strengthening institutional capacity and cross-sectoral coordination (McEvoy et al., 2025). For Burgas, advancing climate-resilient development could involve prioritising adaptation measures that deliver multiple co-benefits, engaging stakeholders across governance levels, and maintaining flexibility to adjust strategies over time. It may also require creating enabling conditions, such as access to finance, data, and knowledge, to support implementation. Ultimately, this approach can help inform pathways through which Burgas may be better prepared for future climate impacts while supporting sustainable and inclusive growth.

7 References

Alexander, L. V., et al. (2006), Global observed changes in daily climate extremes of temperature and precipitation, J. Geophys. Res., 111, D05109

Artés, T., Oom, D., de Rigo, D., Durrant, T. H., Maianti, P., Libertà, G., & San-Miguel-Ayanz, J. (2019). A global wildfire dataset for the analysis of fire regimes and fire behaviour. *Scientific Data*, *6*(1), 296. https://doi.org/10.1038/s41597-019-0312-2

Atkinson, A. B. (1970). On the measurement of inequality. Journal of economic theory, 2(3), 244-263.

Baugh, C., Colonese, J., D'Angelo, C., Dottori, F., Neal, J., Prudhomme, C., & Salamon, P. (2026). *River flood hazard maps for Europe and the Mediterranean Basin region* [Dataset]. European Commission, Joint Research Centre. https://doi.org/10.2905/JRC.WPE5YRR

Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. Econometrica, 66(1), 47–78; Bai, J., & Perron, P. (2003). Computation and analysis of multiple structural change models. Journal of Applied Econometrics, 18(1), 1–22.

Biesbroek, R., Engbersen, D., Bonenkamp, J., Broek, E., Boon, E., Meijering, J., Nalau, J., Ford, J. D., Totin, E., Leiter, T., Gilmore, E., & Ebi, K. L. (2026). Expert agreement on key elements of transformational adaptation to climate risks. *Nature Climate Change*, *16*(3), 273–280. https://doi.org/10.1038/s41558-025-02548-y

BNR news. (2024, May 10). *Bulgaria sees increase in the number of Ukrainian refugees*. Radio Bulgaria. https://bnrnews.bg/en/post/106660/bulgaria-sees-increase-in-the-number-of-ukrainian-refugees

BNR news. (2025, September 3). *Bulgaria sets monthly poverty line at €391 for 2026*. Radio Bulgaria. https://bnrnews.bg/en/post/384185/bulgaria-sets-monthly-poverty-line-at-391-for-2026

Bogdanova, M. (2026, February 17). *The Bulgarian real estate market will undergo significant changes in 2026*. Fakti.bg - Да извадим фактите наяве. https://fakti.bg/imoti/1035358-the-bulgarian-real-estate-market-will-undergo-significant-changes-in-2026

Cappelli, F., Costantini, V., & Consoli, D. (2021). The trap of climate change-induced "natural" disasters and inequality. Global Environmental Change, 70, 102329.

Cameron, A.C., Gelbach, J.B. y Miller, D.L. (2008). Bootstrap-Based Improvements for Inference with Clustered Errors. *Review of Economics and Statistics*, 90(3), 414–427.

CCDS. (2025). *Fire danger indicators for Europe from 1970 to 2098 derived from climate projections* (Version V2.0) [Dataset]. Copernicus Climate Data Store. https://cds.climate.copernicus.eu/datasets/sis-tourism-fire-danger-indicators?tab=overview

Charron, N., Lapuente, V., & Bauhr, M. (2024). The Geography of Quality of Government in Europe. Subnational variations in the 2024 European Quality of Government Index and Comparisons with Previous Rounds. QoG Working Paper Series, 2. ISSN: 1653-8919.

Clarke, B., Otto, F., Stuart-Smith, R., & Harrington, L. (2022). Extreme weather impacts of climate change: An attribution perspective. *Environmental Research: Climate*, *1*(1), 012001. https://doi.org/10.1088/2752-5295/ac6e7d

Clarke, D., & Murphy, C. (2023). Incremental adaptation when transformation fails: The importance of place-based values and trust in governance in avoiding maladaptation. *Journal of Environmental Psychology*, *88*, 102037. https://doi.org/10.1016/j.jenvp.2023.102037

CoCliCo. (2025). *CoCliCo platform*. CoCliCo Platform. https://www.openearth.nl/coclico-workbench/

Cools, J., Bjørnåvold, A., Fabri, C., Zorita, S., Castellani, C., Breil, M., Johnson, K. S., Sedlar, M., Simonet, S., Pérez-Blanco, D., Stepišnik Perdih, T., Capela Lourenço, T., Peinhardt, K., Schmidt, G., & Goicolea-Güemez, E. (2024). *Understanding Transformational Adaptation: A*

Shared Vision Across EU Horizon Projects. Projects' policy brief under the EU Mission on Adaptation to Climate Change's Implementation Platform (MIP4Adapt). https://futurium.ec.europa.eu/en/eu-mission-adaptation-community/resources-and-outputs/twg-output-policy-brief-understanding-transformational-adaptation-shared-vision-across-eu-horizon

CRED. Centre for Research on the Epidemiology of Disasters. (2024). *EM-DAT: The International Disaster Database*. Université catholique de Louvain. www.emdat.be

Deschênes, O. y Greenstone, M. (2011). Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US. American Economic Journal: Applied Economics, 3(4), 152–185.

Dottori, F., Salamon, P., Bianchi, A., Alfieri, L., Hirpa, F. A., & Feyen, L. (2016). Development and evaluation of a framework for global flood hazard mapping. *Advances in Water Resources*, *94*, 87–102. https://doi.org/10.1016/j.advwatres.2016.05.002

EUETS.INFO. (n.d.). Retrieved 16 March 2026, from https://www.euets.info/installation/BG_112

European Commission. Directorate General for Regional and Urban Policy. (2024). *Ninth report on economic, social and territorial cohesion.* Publications Office. https://doi.org/10.2776/264833

European Commission: Directorate-General for Research and Innovation. (2025). *Regional Innovation Scoreboard 2025*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/2313906.

Eurostat. (2023). *Population grid (GEOSTAT)—Census grid 2021* (Version Version 2021 (13 March 2023)) [Dataset]. European Commision. https://ec.europa.eu/eurostat/web/gisco/geodata/population-distribution/population-grids

Foundation Institute for market economics. (2023, May 8). *Five Trends for the Municipalities of Burgas Region | News*. Regional Profiles. https://www.regionalprofiles.bg/en/news/five-trends-for-the-municipalities-of-burgas-region/

Foundation Institute for market economics. (2024, May 10). *Five trends for the municipalities of Varna and Burgas | News*. Regional Profiles. https://www.regionalprofiles.bg/en/news/five-trends-for-the-municipalities-of-varna-and-burgas/

Foundation Institute for market economics. (2025, June 26). *The municipalities need more own resources and a share of revenues from personal income taxation | News*. Regional Profiles. https://www.regionalprofiles.bg/en/news/the-municipalities-need-more-own-resources-and-a-share-of-revenues-from-personal-income-taxation/

Graff Zivin, J. y Neidell, M. (2014). Temperature and the Allocation of Time: Implications for Climate Change. *Journal of Labor Economics*, 32(1), 1–26.

Haasnoot, M., Di Fant, V., Kwakkel, J., & Lawrence, J. (2024). Lessons from a decade of adaptive pathways studies for climate adaptation. *Global Environmental Change*, *88*, 102907. https://doi.org/10.1016/j.gloenvcha.2024.102907

Hall, J. W., Aerts, J. C. J. H., Ayyub, B. M., Hallegatte, S., Harvey, M., Hu, X., Koks, E. E., Lee, C., Liao, X., Mullan, M., Pant, R., Paszkowski, S., Rozenberg, J., Shen, F., Stenek, V., Thacker, S., Väänänen, E., Vallejo, L., Veldkamp, T. I. E., … Zorn, C. (2019). *Adaptation of Infrastructure Systems: Background Paper for the Global Commission on Adaptation*. Environmental Change Institute, University of Oxford. www.gca.org

Hallegatte, S., Rentschler, J., & Rozenberg, J. (2019). *Lifelines: The Resilient Infrastructure Opportunity*. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-1430-3

Intergovernmental Panel On Climate Change (Ipcc). (2022). *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report* *of the Intergovernmental Panel on Climate Change* (1st ed.). Cambridge University Press. https://doi.org/10.1017/9781009325844

Kendall, M. G. (1975). Rank correlation methods (4th ed.). London: Charles Griffin.

Koks, E. E., & de Bruijn, J. (2026). *DamageScanner: Python tool for natural hazard damage assessments* (Version V1.0.1) [Python]. VU-IVM. http://doi.org/10.5281/zenodo.2551015 (Original work published 2019)

Mann, H. B. (1945). Nonparametric tests against trend. *Econometrica*, 13(3), 245–259.

McEvoy, S., Langendijk, G., Jeuken, A., & Haasnoot, M. (2025). What is needed to make climate resilient development pathways planning actionable in cities? *Environmental Research Communications*, *7*(8), 082501. https://doi.org/10.1088/2515-7620/adf9c9

Meyer, V., Becker, N., Markantonis, V., Schwarze, R., Van Den Bergh, J. C. J. M., Bouwer, L. M., Bubeck, P., Ciavola, P., Genovese, E., Green, C., Hallegatte, S., Kreibich, H., Lequeux, Q., Logar, I., Papyrakis, E., Pfurtscheller, C., Poussin, J., Przyluski, V., Thieken, A. H., & Viavattene, C. (2013). Review article: Assessing the costs of natural hazards – state of the art and knowledge gaps. *Natural Hazards and Earth System Sciences*, *13*(5), 1351–1373. https://doi.org/10.5194/nhess-13-1351-2013

Nirandjan, S., Koks, E. E., Ward, P. J., & Aerts, J. C. J. H. (2022). A spatially-explicit harmonized global dataset of critical infrastructure. *Scientific Data*, *9*(1), Article 1. https://doi.org/10.1038/s41597-022-01218-4

Nirandjan, S., Koks, E. E., Ye, M., Pant, R., Van Ginkel, K. C. H., Aerts, J. C. J. H., & Ward, P. J. (2024). *Review article: Physical Vulnerability Database for Critical Infrastructure Multi-Hazard Risk Assessments – A systematic review and data collection*. https://doi.org/10.5194/nhess-2023-208

Novinite. (2025, July 2). *How Bulgaria's Property Market Could Shift After the Euro Adoption*. Sofia News Agency. https://www.novinite.com/articles/233189/How+Bulgaria%E2%80%99s+Property+Market+Could+Shift+After+the+Euro+Adoption

NSI. (2014). *Population grid, 1 sq.km, Census 2011* [Dataset]. National Statistical Institute. https://www.nsi.bg/en/statistical-data/151/486

NSI. (2025). *Population by districts, municipalities, place of residence and sex* [Dataset]. National Statistical Institute. https://www.nsi.bg/en/statistical-data/206/651

Paprotny, D. (2025). *HANZE database of historical flood impacts in Europe, 1870-2025* [Dataset]. Zenodo. https://doi.org/10.5281/zenodo.17226475

Ravallion, M. (2001). Growth, inequality and poverty: Looking beyond averages. *World Development*, 29(11), 1803–1815.

Rodríguez-Pose, A., Dijkstra, L., & Poelman, H. (2024). The Geography of EU Discontent and the Regional Development Trap. *Economic Geography*, *100*(3), 213–245. https://doi.org/10.1080/00130095.2024.2337657

Roodman, D., Nielsen, M.Ø., MacKinnon, J.G. y Webb, M.D. (2019). Fast and wild: Bootstrap inference in Stata using boottest. Stata Journal, 19(1), 4–60.

Sen, P. K. (1968). Estimates of the regression coefficient based on Kendall's tau. *Journal of the American Statistical Association*, 63(324), 1379–1389.

Slavova, Z., Nikolov, A., & Nedev, T. (2024). *Regional Profiles—Indicators of deveolpment 2024*. institute for market economics. https://www.regionalprofiles.bg/var/docs/Reg-profiles-2024-ENG-final.pdf

Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., O'Regan, N., Rozenberg, J., Watkins, G., & Hall, J. W. (2019). Infrastructure for sustainable development. *Nature Sustainability*, *2*(4), 324–331. https://doi.org/10.1038/s41893-019-0256-8

Theil, H. (1950). A rank-invariant method of linear and polynomial regression analysis I, II, III. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen*, 53, 386–392, 521–525, 1397–1412.

UNDRR. (2015). *Sendai Framework for Disaster Risk Reduction 2015—2030* (pp. 1–37). United Nations Office for Disaster Risk Reduction.

United Nations Office for Disaster Risk Reduction. (2009). *Global Assessment Report on Disaster Risk Reduction 2009*. United Nations Office for Disaster Risk Reduction. https://www.preventionweb.net/english/hyogo/gar/2011/en/home/gar09.html

Van Ginkel, K. C. H., Dottori, F., Alfieri, L., Feyen, L., & Koks, E. E. (2021). Flood risk assessment of the European road network. *Natural Hazards and Earth System Sciences*, *21*(3), 1011–1027. https://doi.org/10.5194/nhess-21-1011-2021

Yamamura, E. (2015). The impact of natural disasters on income inequality: Analysis using panel data during the period 1970 to 2004. *International Economic Journal*, 29(3), 359–374.

8 Annex

8.1 Methodology for Climate Risk Analysis

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 impacts of natural hazards and climate change in Burgas municipality using spatial analysis. Such a spatial risk assessment requires geospatial data about the extent and severity of natural hazards. This may include historical hazard data or hazard information expressed in terms of return periods, which signify the statistical likelihood of an event occurring. The latter type of data is used to assess risk in a probabilistic manner and is commonly applied to hazards such as flooding and earthquakes. The spatial extent of the hazard is overlaid with data on population distribution, assets, or infrastructure to determine exposure to the event. When this exposure is combined with information on the vulnerability, the risk can be calculated.

In the remainder of this section, we will outline the data that is used for the three components, and explain the risk calculation.

8.1.1 Hazard data

Natural hazards are caused by environmental factors and include events that occur due to geological, meteorological, and climatic processes. These can lead to the loss of life, and widespread damage and disruption to day-today activities. In this risk assessment for Burgas municipality, we include the following hazards: flooding, wildfires, extreme heat, drought and landslides.

Flooding

There are three types of flooding: pluvial flooding (which is also referred to as surface flooding or flash flooding), fluvial flooding and coastal flooding. Surface flooding occurs when intense rainfall overwhelms drainage systems, while river flooding occurs when rivers overflow their banks. Coastal flooding can also occur due to storm surges and rising sea levels. The Coastal Climate Core Services (CoCliCo) platform provides the latest state-of-the-art coastal flood data for Europe (CoCliCo, 2025), including future flooding using sea-level rise projections based on the latest scientific assessments from the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6). Unfortunately, flooding along the coastline of the Black Sea has not been included in these data. Pluvial flood data are generally only available through commercial flood model companies.

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.

Future fluvial flood risk was assessed by incorporating climate change projections into the flood hazard modelling framework. Projected changes in climatic conditions were used to adjust the frequency and intensity of flood events across a range of warming scenarios (e.g. 1.5°C to 4.0°C). These changes were translated into modified damage–probability relationships (Section 8.4.1.), reflecting shifts in flood extent and depth for different return periods. Exposure and vulnerability were assumed to remain constant, allowing the analysis to isolate the effect of climate change on flood hazard. Resulting impacts were quantified using expected annual damage (EAD), enabling comparison between historical and future conditions.

Wildfires

Wildfires, often triggered by droughts and extreme heat, can have severe impacts on both communities and infrastructure. These fires can threaten human lives and health, damage homes and public buildings, and disrupt essential services such as electricity, telecommunications, transportation, water, and fuel supply. As climate change progresses, the frequency and intensity of these events are likely to increase (Clarke et al., 2022). Therefore, there is growing concern as to how exactly these hazards affect communities. In wildfire-prone areas, both settlements and critical infrastructure need to be planned, designed, and managed to reduce vulnerability and mitigate the risks associated with fire.

The GlobFire database is a global dataset of historical wildfire events that occurred between 2002-2024 (Artés et al., 2019). The database is derived from the MODIS burned area product (MCD64A1) and uses a data-mining workflow to group daily burned area pixels into individual fire events based on their spatial and temporal proximity. This approach allows the identification of single wildfire perimeters and associated characteristics such as fire size and duration. The resulting dataset provides a consistent global record of historical wildfire events and is distributed through the Global Wildfire Information System (GWIS).

To explore the fire danger potential, we use a dataset of harmonised, climate-based indicators of wildfire danger across Europe covering the period 1970–2098, available from the Copernicus Climate Data Store (CCDS, 2025). The Fire Weather Index is used to assess the fire danger, which is a meteorologically driven index that accounts for the influence of fuel moisture and weather conditions on fire behaviour using the Canadian Forest Service Fire Weather Index rating system.

The required meteorological variables (e.g., daily noon values of air temperature, relative humidity, wind speed, and 24-hour accumulated precipitation) are obtained from an ensemble of global climate model projections that are dynamically downscaled using regional climate models and subsequently used as input to the Global ECMWF Fire Forecast (GEFF). To assess the impacts of climate change, the GEFF model is run under four climate scenarios: a historical baseline (1970–2005) and three Representative Concentration Pathways (RCPs). These include a low-emission scenario (RCP2.6), in which emissions decline after 2020; an intermediate scenario (RCP4.5), with emissions peaking around 2040; and a high-emission scenario (RCP8.5), where emissions continue to increase throughout the century.

In this study, the dataset is used to quantify the frequency of high and very high fire danger days in the Burgas region, with three threshold levels used to represent increasing fire danger: moderate (FWI > 15), high (FWI > 30), and very high (FWI > 45). Furthermore, we use the mean annual number of days exceeding each FWI threshold, averaged over the simulation period. This approach represents long-term climatic conditions and reduces the influence of interannual variability. The resulting values capture the frequency of wildfire-prone conditions throughout the year, rather than continuous or consecutive exposure periods. Additionally, to facilitate interpretation, mean annual exposure was grouped into three classes: 0–30 days, 30–90 days, and more than 90 days per year, representing low, medium, and high levels of recurrent exposure, respectively. These classes provide an intuitive measure of how often populations are exposed to wildfire danger and enable consistent comparison across fire danger levels and climate scenarios.

Extreme heat

Prolonged periods of extreme heat can have significant impacts on both human health and CI. Heatwaves increase the risk of heat-related illnesses and mortality, particularly among vulnerable populations such as the elderly, children, and those with pre-existing health conditions. At the same time, extreme heat can strain infrastructure systems, for example by increasing electricity demand for cooling and raising the risk of power outages. High temperatures can also affect transportation networks, causing railway tracks to warp and roads to soften, which may disrupt mobility.

Extreme heat conditions were assessed using high-resolution gridded climate data from the EMO-1 dataset (1981–2024; ~1.8 km resolution). A set of standard heat-related indices was derived to capture both the intensity and duration of extreme temperature events. These include the Warm Spell Duration Index (WSDI), defined as the number of days within periods of at least six consecutive days with maximum temperatures (TX) exceeding the 90th percentile, as well as the number of days with TX above the 95th and 99th percentiles. In addition, the frequency of tropical nights, defined as nights with minimum temperatures (TN) above 20°C, was calculated to assess sustained heat stress conditions

8.1.2 Exposure data

Exposure refers to the presence of people, infrastructure, assets, and other elements in areas that could be adversely affected by natural hazards. The level of exposure determines the potential for damage or disruption when a hazard event occurs. We use information on the spatial distribution of populations, and critical infrastructure to identify which elements may be impacted in Burgas municipality.

Population data

The National Statistical Institute (NSI) publishes population data and projections aggregated at regional levels (NSI, 2025); however, these data lack the spatial detail required for spatial analyses. The most recent Bulgarian population grid was produced in 2011 as part of the second phase of the GEOSTAT project, an initiative of the European Statistical System and the European Forum for Geography and Statistics (NSI, 2014). The GEOSTAT project aims to harmonize population data across Europe by transforming census-based population statistics into a standardized grid format, enabling consistent spatial analysis and comparison between regions. In this study, we use the most recent census grid data released in 2021, which represents key demographic characteristics (e.g., sex, age, and current activity status) from the 2021 Census on a harmonized EU-wide 1 km² grid (Eurostat, 2023).

Critical infrastructure

CI refers to the essential services and assets that form the backbone of a functioning society and economy. These infrastructure systems are vital for public health, safety, and economic well-being, supporting various daily activities ranging from transportation to energy distribution. CI systems are susceptible to a wide range of threats, both natural and human-made, including natural disasters, terrorism, and poor maintenance. We categorize the infrastructure network into seven overarching sectors: transportation, energy, water, waste, telecommunication, education, and health. This classification aligns with widely accepted frameworks in the literature (Hall et al., 2019; Hallegatte et al., 2019; Thacker et al., 2019; UNDRR, 2015), and highlights the growing recognition of the importance of educational and health-related infrastructure (UNDRR, 2015).

OpenStreetMap (OSM) provides free and openly accessible geospatial data on a wide range of features worldwide through a Volunteered Geographic Information (VGI) approach. Due to its broad thematic coverage, the dataset also includes many types of infrastructure assets represented as vector data. OSM features are stored using several basic data types: nodes, ways, areas (polygons), and relations (Figure 40). A node represents a single point defined by geographic coordinates (e.g., a telecommunications tower). Ways consist of line segments connecting two or more nodes and are typically used to represent linear features such as roads. Areas or polygons are closed ways, created when the first and last nodes coincide, and are used to represent features such as buildings or hospitals. Relations are structured collections of nodes, ways, or other relations that together represent more complex geographic entities. We formulated 132 OSM tags in order to specifically extract geospatial data for 43 infrastructure types that represent the aforementioned key sectors.

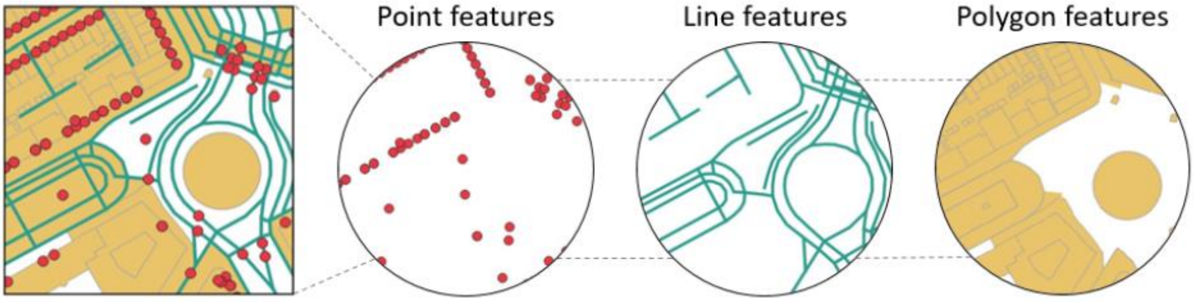


Figure 40: Visualization of vector datatypes: nodes (point features), ways (line features) and polygons (area features). Source: Nirandjan et al. (2022).

8.1.3 Vulnerability data

Despite its importance in understanding risk, accurately determining the vulnerability remains a challenge. When assessing the physical damage to a structural element due to direct contact with a hazard, a common approach to account for vulnerability of assets is through the use of "vulnerability curves" (Meyer et al., 2013). These curves relate given levels of a hazard intensity measure (e.g. flood inundation depth) to the potential physical damage of an asset (Figure 41b). The potential damage can be expressed either in absolute monetary terms or in relative numbers that are often referred to as the mean damage ratio (MDR), which is commonly expressed as the ratio of the expected repair cost to the replacement costs of a structure. In the latter case, the MDR is then multiplied by the replacement costs of an asset to obtain the potential damage for a given hazard intensity level. In addition to vulnerability curves, fragility curves are also commonly used in risk assessments (Figure 41a). These curves describe the probability of reaching or exceeding one or more damage states for a given hazard intensity measure. A damage state represents a specific level of damage (e.g., "extensive") and is typically defined using qualitative descriptions of physical impacts (e.g., major cracks in walls).

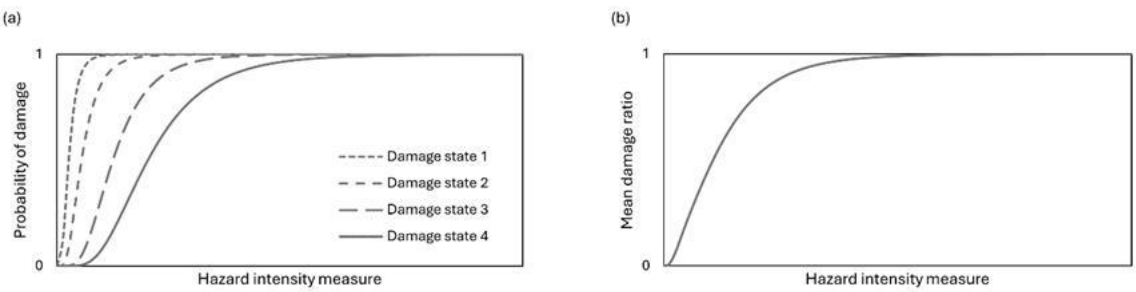


Figure 41: Damage assessment framework for CI. Source: Nirandjan et al. (2024).

These curves are developed using empirical, analytical, and expert judgement approaches, or a combination of these approaches. Empirical approaches rely on records of damage data from past events, offering grounded insights based on real-world events. However, empirical data is often scarce, fragmented, or context-specific, limiting its transferability. Analytical approaches use physical modelling to simulate damage processes and produce curves that can be systematically validated. While these methods allow for a more theoretical and transparent understanding, they cannot fully represent real-world processes and rely on simplifications. Expert-judgement approaches draw on experience of specialists and are less resource-demanding, especially in data-poor regions, but they can introduce biases and are more difficult to validate or replicate.

To support infrastructure risk assessments, a comprehensive open-access database is developed by Nirandjan et al. (2024) which provides over 1,500 vulnerability and fragility curves for CI across multiple natural hazards, including flooding, earthquakes, windstorms and landslides. The database was compiled through a systematic review of scientific literature and engineering reports, ensuring that existing curves are compiled into a standardized database for CI in the seven key infrastructure sectors. For this analysis, a range of vulnerability curves was selected to represent the susceptibility of assets to flooding and to account for uncertainties in the potential damage caused by the hazard. Namely, the level of damage to infrastructure assets when subject to an extreme hazard depends on their design and site-specific conditions. Where relevant, fragility curves were converted into vulnerability curves so that they could be directly related to flood hazard intensities in the risk assessment.

8.1.4 Exposure, damage and risk calculation

The general approach applied to estimate exposure, damage and risk is illustrated in Figure 42 using flooding to roads as an example. We perform an exact overlay of the exposure input data (e.g., population distribution, power plants or other types of assets) with the extent of natural hazard data to determine the exposure (e.g., 10 km of primary roads are exposed to a 1-in-10 years flood). Within the analysis, we identify the unique hazard intensities an asset is exposed to (e.g., a road may be exposed to various inundation depths). To estimate the damage, we combine the information about exposed area or length of the affected asset and the identified hazard intensities with vulnerability curves. These steps are performed using the DamageScanner which is a Python toolkit for direct damage assessment for natural hazards (Koks & de Bruijn, 2026).

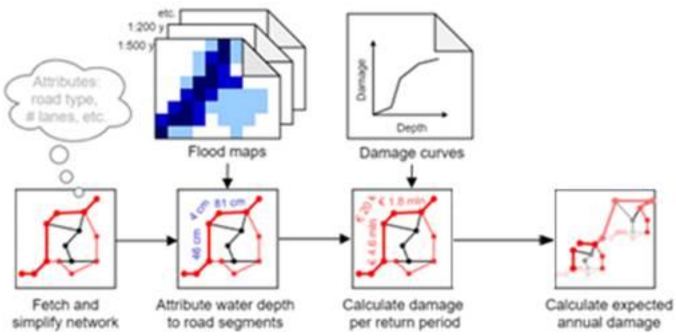


Figure 42: Damage assessment framework for CI. Adapted from van Ginkel et al. (2021).

Expected Annual Damage (EAD) represents the average economic damage expected per year due to a given hazard, taking into account events with different probabilities of occurrence. It is calculated by combining the estimated damage per return period with their probability of occurrence. By integrating the damage–probability relationship across all considered return periods, EAD provides a single metric that reflects the long-term average risk posed by the hazard. The concept can be expressed mathematically as shown in Equation 1:

$$EAD = \sum_{h=1..n}^{rp} \left(\frac{(P_{rp} - P_{rp+1}) * (D_{rp+1} - D_{rp})}{2} \right) + (P_{rp} - P_{rp+1}) * D_i \qquad [1]$$

Here, *h* is the specific hazard event, *P* the probability for the hazard event and *D* the damages for the natural hazard event

8.2 Overview of interviewed organizations

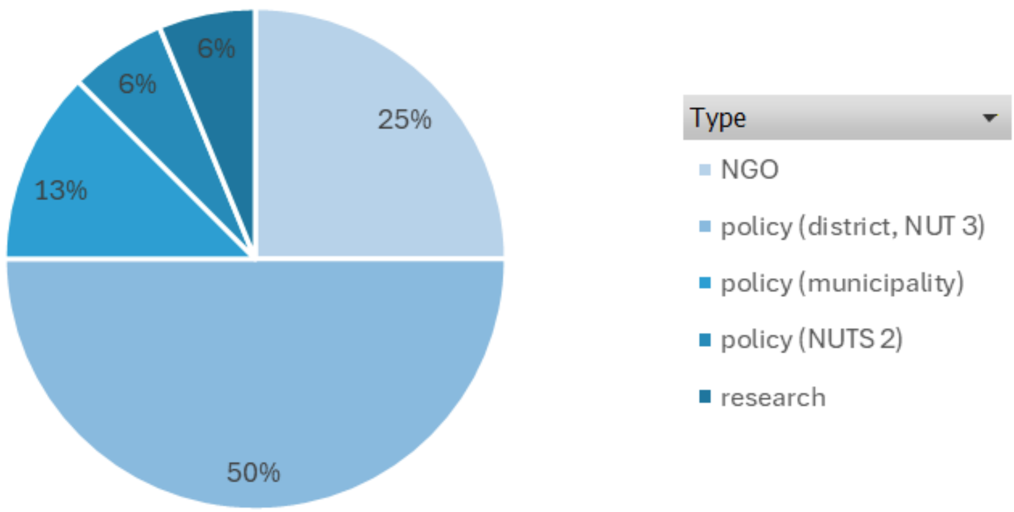


Figure 43: Overview of interviewed organizations (acc. to stakeholder type), n=16

8.3 Detailed Evaluation of Justice in CCA Plans

Table 7: Detailed Evaluation of Justice in CCA Plans

Indicator	Scoring	BUR	BUL
1. Recognitional justice			
1.1. The strategy acknowledges that adaptation needs are different across groups in society	No		
	The strategy states that adaptation needs are different		
	The strategy takes into account different adaptation needs based on expert review	2	2
	The strategy is built on different groups identifying their adaptation needs		
1.2. The strategy acknowledges the impact of existing societal structures on vulnerable groups in adapting to the impacts of climate change	No		
	The existence of structures is mentioned in general manner	1	1
	There are measures to decrease the impact of structures		
	There is a structured plan to assess the impact of societal structures on vulnerability		
1.3. The strategy acknowledges adaptation as a way to secure basic rights	No	0	
	Adaptation as a way to secure basic rights is mentioned		1
	The strategy describes how adaptation can secure basic rights in general		
	The strategy has measures to secure basic rights		
	Total scores:	**3/9**	**4/9**
2. Distributional justice			
2.1. A risk mapping/assessment is conducted	No		
	Yes, risk assessment is mentioned but results are not used		

	Yes, risk assessment is conducted and measures are identified for some risks	2	2
	Risk assessment is conducted and measures are identified for all risks		
2.2. Vulnerability assessment is conducted and there is a process for identifying vulnerable groups	No		
	Vulnerable groups are identified.		
	There is a vulnerability assessment that will be updated.	2	2
	Vulnerability assessment is connected to adaptation planning and monitoring.		
2.3. There is a process that assesses the distribution of benefits from adaptation	No		
	The strategy identifies the distribution of benefits of adaptation measures in general	1	1
	Distribution of benefits is assessed as part of the strategy process.		
	Distribution of benefits is monitored continuously		
2.4. There is a process that assesses how costs of adaptation are divided	No	0	
	The strategy identifies the distribution of costs of adaptation measures in general		
	Distribution of costs is assessed as part of the strategy process.		2
	Distribution of costs is monitored continuously		
2.5. The strategy identifies the possibility of the distribution of negative impacts, i.e., maladaptation, of adaptation measures	No	0	
	The strategy identifies (at least implicitly) the distribution of negative impacts of adaptation measures in general		1
	Distribution of negative impacts of some adaptation measures are identified		
	Distribution of negative impacts of all adaptation measures are identified		
	Total scores:	**5/15**	**8/15**
3. **Procedural justice**			
	No participation outside the public sector	0	

3.1. Adaptation plan details who participates in the strategy process	Participation through invitation for experts, private sector		1
	Participation of experts and citizens through open invitation		
	Participation and measures to enable participation of vulnerable groups		
3.2. The adaptation strategy has involved participation during different phases of the process	No participation	0	
	The strategy process has involved information provision (about adaptation at least once during the process before the final output publication)		
	The strategy process has involved consultation.		2
	The participation in the strategy process has been collaborative and continuous.		
3.3. The strategy allocates responsibilities related to adaptation	No		
	Responsibilities are mentioned	1	
	Responsibilities for some adaptation measures are allocated		
	Responsibilities for all adaptation measures are allocated		3
3.4. The adaptation strategy has a structured plan for participation in the implementation.	No participation in the implementation plan		
	The implementation plan involves informing different stakeholders	1	
	The implementation plan involves stakeholder consultation		2
	The implementation plan involves stakeholder participation in collaborative and continuous manner.		
3.5. The adaptation strategy has a plan for updating and evaluating the strategy	No		
	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		
	Total scores:	**3/15**	**10/15**
4. **Restorative justice**			
4.1. The strategy acknowledges the need to compensate for the diverging impacts of climate change	No	0	
	The strategy acknowledges the need to compensate		1
	The strategy has compensation measures for some impacts of climate change		
	The strategy has compensation measures for all relevant impacts of climate change		
4.2. The strategy has compensation measures to deal with maladaptation	No mention of the need to compensate	0	0
	The need to compensate is mentioned		
	There are compensation measures for some maladaptation		
	There are measures to compensate for all groups		
4.3. The unequal distribution of resources for adaptation is compensated by redistribution	No mention of unequal distribution	0	0
	The need for reallocation of resources for adaptation is acknowledged (at least partially)		
	There are measures for reallocation of adaptation resources		
	There are measures for the reallocation of adaptation resources to develop adaptive capacity		
	Total scores:	**0/9**	**1/9**
Grand Totals		**23/48**	**11/48**

8.4 Questionnaire for the survey on barriers to CCA

Table 8: Questionnaire for the survey on barriers to CCA

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 Burgas Municipality ▪ In another municipality of the district of Burgas (please specify): ▪ On the district level of Burgas	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 Burgas district 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 district level of Burgas.	▪ 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 district level of Burgas.	▪ Lack of leadership on climate issues by the government of Burgas district ▪ 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 district level of Burgas.	▪ Lack of alignment between national climate policies and district or municipal priorities ▪ Fragmentation or lack of legislation creating a mandate for action at the district 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, district, 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 district level of Burgas.	▪ Lack of district government finances ▪ Lack of municipal government finances ▪ Lack of district government staff time ▪ Lack of municipal government staff time ▪ Lack of funding from the national to the district 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 district level of Burgas.	▪ 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 district level of Burgas.	▪ 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 district government ▪ 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 district level of Burgas.	▪ 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 district government 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	Multiple choice question

		▪ Transport ▪ Water management ▪ Others (please specify): ▪ I don't know.	
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 ▪ Burgas district administration ▪ Bulgarian 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 Burgas District or its municipalities.	▪ City / municipal government ▪ Emergency services / disaster risk management authorities ▪ Burgas district administration ▪ Bulgarian 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 Burgas District or its municipalities?	▪	Open question
Q16	Which actor(s) do you think should have more influence (or a stronger role) in climate adaptation in Burgas District 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. 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.	Multiple choice with open text fields.

8.5 Overview of adaptation options

Table 9: Overview of measure scope characteristics. Please note that the ID matches with Tables 9-11.

ID	Measure scope Adaptation option	Hazard type	NAS theme	Adaptation category	Description	Target sectors	Core stakeholders	Scale
1	Coastal vegetation, mangroves, and marshes	Coastal flooding	Water resources & Flood risk	Structural measures	Coastal vegetation functions by attenuating waves as they approach the shoreline, reducing wave height and consequently inundation depth			Regional
2	Beach nourishment, tidal river management and dune systems	Coastal flooding	Water resources & Flood risk	Nature-based measures	Different strategies can be used to increase the size of coastal formations with the intention of reducing coastal flooding intensity. The interplay between sediment transport through rivers, tides, and wind can be used to shape structures along the coast, but direct intervention through beach nourishment is a common measure			Local
3	Early warning systems and operational response	Extreme heat	Urban resilience	Institutional measures				
4	Mitigating health risks during extreme heat	Extreme heat	Health & Welbeing	Institutional measures	Creating checklists for homes and schools during heatwaves, enhancing warning systems, distributing targeted information, and establishing 'cool spots' for public use, effectively mitigating health risks during extreme heat		functional regional system with regards to DRM (committee etc.) - how can they react in cases of extreme heat?	
5	Training in climate change and health for the public health and wider health workforce	Extreme heat	Health & Welbeing	Behavioural change measures	The climate-health crisis calls for immediate and robust action to increase resilience of the health systems. One strategy is strengthening the education and training programs for health professionals. Public health and the wider health workforce require core training and continuous professional development to improve their understanding of the impact of climate change on health and the health co-benefits of climate mitigation and adaptation measures. As trusted voices on population health and wellbeing, public health and healthcare professionals have a responsibility to protect individuals and communities against the negative health effects of climate change. Enhancing climate-health literacy among public health professionals and the broader health community requires a new approach to healthcare education to prepare the workforce for current and future impacts. Beyond public health schools, the call for updated curricula also extends to continuing professional education.	health sector		

6	Early warning systems and operational response	Flooding	Urban resilience	Institutional measures		
7	Mental health support	Flooding	Health & Welbeing	Institutional measures	Climate change impacts not only physical but also mental health. As extreme precipitation, flooding and other climate hazards and impacts increase in intensity and frequency, there is a need to identify climate change adaptation measures to protect psychological wellbeing and to respond to growing mental health needs.	
8	Riverbed and floodplain management	Fluvial flooding	Water resources & Flood risk	Nature-based measures	Widening rivers, lowering floodplains, and removing obstacles in and around the river are strategies to reduce flood hazard by creating space for rivers to safely discharge their flow.	Regional
9	Legal mainstreaming	non-specific	Urban resilience	Institutional measures	Embed adaptation objectives into regional spatial plans, environmental assessment, and public investment decisions	
10	Multi-level collaboration	non-specific	Urban resilience	Institutional measures	Coordinate adaptation planning between the local Municipality, Regional Administration, and relevant Directorates.	
11	Establish regional adaptation authority	non-specific	Regional resilience	Institutional measures		
12	Climate governance hub	non-specific		Institutional measures	mainstream climate adaptation and resilience across decision-making	
13	Strengthening the dialogue between insurers, policymakers and other stakeholders	non-specific	Awareness raising	Institutional measures	Example: the Climate Resilience Dialogue is a temporary group of stakeholders set up at the initiative of the European Commission (EC) to discuss ways to narrow the climate protection gap and increase the resilience of the economies and societies to the effects of climate change.	
14	Sustainable finance	non-specific		Institutional measures	identify and promote best practices in financial instruments for risk management	
15	Sharing expertise and data on cat risks	non-specific	Regional resilience	Institutional measures	Provide relevant stakeholders such as insurers with expertise, studies, tools and data to enable them to effectively assess, monitor and supervise risks	
16	Permeable areas for infiltration	Pluvial flooding	Water resources & Flood risk	Nature-based measures	Several measures have been developed and applied to reduce flooding in urban areas during intense precipitation that overwhelms the sewer system, particularly focusing on increasing infiltration and reducing or slowing down run-off generation. Some examples are the creation of green roofs and walls, rainwater capture systems, infiltration strips and swales, and pervious pavemens.	Local
17	Formalize inter-municipal flood governance	Pluvial flooding	Urban resilience	Nature-based measures		

18	Ignition reduction (human-induced)	Wildfires	Structural Forests & wildfire measures	A strategy to tackle human-lit wildfires involves education and well-distributed information aimed at generating awareness and wildfire hazard understanding, helping prevent wildfire ignition	National
19	Prescribed burning	Wildfires	Structural Forests & wildfire measures	Wildfire spread and intensity reduction	Local
20	Fire breaks	Wildfires	Structural Forests & wildfire measures	Creating areas that function as fire breaks, such as agricultural field located at specific locations	Local
21	Fire-resistant trees	Wildfires	Structural Forests & wildfire measures		Local
22	Evacuation	Wildfires	Structural Forests & wildfire measures	Sufficient detection and first response capacity to manage emerging wildfires. Firefighting and access route inventories, planning, and training all contribute to effective wildfire management, and to preventing wildfires from reaching critical infrastructure	Local

Table 10: Overview of measure scope characteristics. Please note that the ID matches with Tables 9-11.

ID	Measure Characteristics					
	Feasibility & Local Applicability	**Effectiveness**	**Co-Benefits**	**Equity & Vulnerability Considerations**	**Costs**	**Time span**
1	Restoration and expansion of coastal vegetation including salt marshes and mangroves has been modelled at a global scale, as an individual measure or as a complementary measure to reduce the height needed for dikes and seawalls; while it is often insufficient in fully meeting risk reduction targets, it can be valuable in combination with other strategies (Mortensen et al., 2023; van Zelst et al., 2021).	Medium	Long-term carbon storage, increased water retention and infiltration capacity (sponge function), heat abatement and habitat creation to foster biodiversity	Societies can be impacted through forced displacement and vector- and water-borne diseases	Medium	Medium-term
2	Must consider hydrodynamic conditions, sediment regimes, and erosion profiles	Medium			Medium	Medium-term
3						
4	yes, could be fitting, old (vulnerable) population in the region, no heat measures in place.					
5	could be useful given the circumstances of the health sector in Burgas Region ("Compared to the national level, Burgas District has fewer capacities regarding available hospital beds and general practitioners (per population), and one of the lowest health insurance coverages nationwide (90% vs. 95% nationally)".			potentially include targeting of vulnerable groups in the design of the measure: "These are often elderly people - the population aged 65 and over increased by 22% from 2014 to 2024 and currently accounts for 22.53% of the population (2024). Moreover, disadvantaged socio-economic groups were mentioned, more specifically poor population, migrants (notable from Ukraine and Russia), as well as the Sinti and Roma community. This is especially relevant because the percentage of people living below the national poverty line (which is currently at 390,63€) is still high with 23%."; people without health insurance		
6						
7						
8		High	Example: Room for the River project in the Netherlands, where existing flood		High	Long-term

		protection measures were combined with new adaptation options, while achieving healthier natural areas			
9					
10			Procedural and Recognitional justice considerations; who gets to participate, what powers does the group have, mandate, legitimacy etc.		
11	Useful, currently a lack of an institutional forum on CCA at the district level: Although a disaster risk management committee exists at the regional level, there is no official platform for exchange on climate change adaptation. Experts who manage, for example, wildfire emergencies can advise on prevention, but they lack a formal forum or mandate to coordinate integrated action across municipalities, indicating that DRM and CCA are largely treated as separate domains.		Procedural and Recognitional justice considerations; who gets to participate, what powers does the group have, mandate, legitimacy etc.		
12			Procedural and Recognitional justice considerations; who gets to participate, what powers does the group have, mandate, legitimacy etc.		
13			Procedural and Recognitional justice considerations; who gets to participate, what powers does the group have, mandate, legitimacy etc.		
14			Distributive justice risks of focusing only on CCA measures capable of producing return on investment, potentially overlooking needs of people in un-investable areas.		
15	From some interviewees, we've heard that they'd wish for a methodology available for non-experts to deal with risk assessments etc.; maybe that is something that could be addressed here		Often procedural and recognitional justice questions come into the social production of "expertise", who's knowledge is respected and sought in these conversations influences the kinds of "solutions" and adaptation options which are proposed. Byskov, M., Hyams, K. Epistemic injustice in Climate Adaptation. *Ethic Theory Moral Prac* **25**, 613–634 (2022). https://doi.org/10.1007/s10677-022-10301-z who gets to partipate, what powers does the group have, mandate, legitimacy etc S.O Hansson 2013 Ethics of risk remains the central text on ethics and risk management		
16		The elements used to improve infiltration come with benefits usually associated with green spaces, including increased water retention, reduced		Medium	Short-term

		heat stress, and creation of habitats for biodiversity (Choi et al., 2021).			
17			Procedural and Recognitional justice considerations, who gets to participate, what powers does the group have, mandate, legitimacy etc.		
18	Burgas District has a well-functioning DRM committee involving Fire Department, Police Department, district and municipality officials. They already undertake some measures with regard to behavioral changes to prevent wildfires (education of farmers in dry summers, warning systems...). This should be taken into account when considering additional measures.		Carrot vs Stick behavioral change incentives - government administrations can use different methods for incentivizing behavioral change and these have different justice implications. Perception of the fairness of incentives will depend on how you see the legitimacy of coercive actions (fines, bans, censures), the distributive outcomes/cost sharing for carrot incentives	Low	Short-term
19			General wildfire justice framework https://doi.org/10.1038/s41558-023-01726-0		
20			General wildfire justice framework https://doi.org/10.1038/s41558-023-01726-0		
21			General wildfire justice framework https://doi.org/10.1038/s41558-023-01726-0		
22			Vulnerability factors for rural isolation, hard to reach communities, elderly and mobility impaired etc. Communications needs for different communities.		

Table 11: Overview of remaining measure characteristics and relevant sources. Please note that the ID matches with Tables 9-11.

ID		Relevant sources	
	Maladaptation and Implementation Vulnerabilities	**Links to Case-Studies/Examples**	**Links to Literature**
1	While these ecosystems can be naturally present without human intervention, they have often been degraded and must be recovered to conserve and increase the protection they provide; this is especially true since coastal vegetation itself is among the first exposed to extreme coastal hazards. Coastal vegetation can be used in combination with other defenses, such as dikes and levees, to reduce the design requirements of grey infrastructure and abate cost and resource use (Mortensen et al., 2023; van Zelst et al., 2021). Another potential risk of maladaptation is the potential increase of vector- and water-borne diseases		D4.1 MIRACA; Mortensen et al., 2023; van Zelst et al., 2021
2	Concerns focus on the direct habitat destruction that can take place at both sides, but also around the cumulative and long-term effects of such practices, such as changes in turbidity and water chemistry (Greene et al., 2002; Saengsupavanich et al., 2023).		D4.1 MIRACA; Greene et al., 2002; Saengsupavanich et al., 2023
3			
4		https://climate-adapt.eea.europa.eu/en/metadata/case-studies/adapting-to-the-impacts-of-heatwaves-in-a-changing-climate-in-botkyrka-sweden	https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/heat-health-action-plans
5		https://climate-adapt.eea.europa.eu/en/metadata/case-studies/online-training-in-climate-change-and-health-for-the-public-health-and-wider-health-workforce-in-europe https://eu-mayors.ec.europa.eu/en/Preparing-Maribo-for-hotter-days-ahead-through-heat-action-planning	
6			
7		https://climate-adapt.eea.europa.eu/en/metadata/case-studies/mental-health-support-for-people-affected-by-floods-in-emilia-romagna https://climate-adapt.eea.europa.eu/en/metadata/case-studies/intercommunal-trauma-centre-for-psychosocial-assistance-in-response-to-floods-in-schleiden-germany	
8			D4.1 MIRACA; Rijke et al., 2012

9			
10			
11			
12			
13		https://climate.ec.europa.eu/document/download/4df5c2fe-80f9-4ddc-8199-37eee83e04e4_en?filename=policy_adaptation_climate_resilience_dialogue_report_en.pdf	
14		https://www.eiopa.europa.eu/browse/sustainable-finance_en	
15		https://www.eiopa.europa.eu/tools-and-data/centre-excellence-catastrophe-modelling-and-data_en	
16	Some studies point to technology-specific trade-offs which can materialize in applications of urban drainage systems, for example, a potential increase of nocturnal warming and mosquito proliferation due to vegetation, an increase of fertiliser use for green roofs affecting water quality, and increased heat stress due to higher surface temperatures of some permeable pavement (Choi et al., 2021).		D4.1 MIRACA; Choi et al., 2021
17			
18			
19	Air quality risks for downwind communities.		D4.1 MIRACA
20			
21			
22			

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