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The adaptation pillar

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1 Introduction

This report presents the analysis of the available climate risk and vulnerability assessments and adaptation action plans implemented by 40 European local authorities in the framework of the Covenant of Mayors. The results are presented aggregating the signatories' submissions by European regions as defined in JRC PESETA III project (Fig. 1) ([1]).

Figure 1. Regions considered in the analysis

Source: ([2]). Note: Iceland has been included in Northern Europe region.

The report is organised as follows: section 2 presents the main hazards reported by the signatories, as well as their future expectations; section 3 highlights the sectors exposed to the main climatic hazards; in section 4 the actions proposed by the Covenant signatories to tackle climatic risks are summarised, including information on selected investment costs per type of action; section 5 is devoted to present the main gaps and challenges detected so far in the submissions; lastly, section 6 concludes.

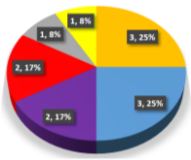
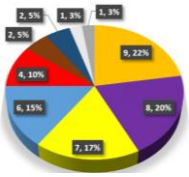
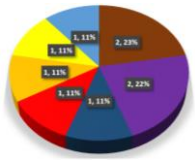
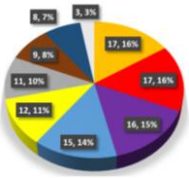
([1]) Number of signatories in each region: Northern Europe (2); UK and Ireland (1); Central Europe North (11); Central Europe South (3); and Sothern Europe (23). This analysis covers around 12 million inhabitants.

([2]) JRC, Climate impacts in Europe: Final report of the JRC PESETA III project, EUR 29427 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-97218-8.

2 Main hazards reported

Data reported by regions (Table 1) highlight two key results regarding climate hazards: 1) Northern Europe and Central North Europe report extreme precipitation as the main current high-level climatic hazard. However, these two regions will face in the future a rather multi-hazard scenario, where current hazards are expected to become more frequent whereas new hazards will come into play; 2) Central Europe South and Southern Europe are already facing multi-hazard events according to the data reported. For these two regions, the multi-hazard events are expected to intensify in the future.

Table 1. Hazards reported

Timeframe	Northern Europe	Central Europe North	Central Europe South	Southern Europe	Legend
Present					Extreme Precipitation Floods Storms Extreme Heat Droughts Sea level rise Forest fires Extreme cold Landslides
Future					

Source: own elaboration. *Note*: charts represent the number of times a hazard is considered as high level (using a classification of low, moderate, and high) has been reported by a signatory. No relevant information was reporter for UK and Ireland.

3 Future climate risks

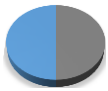
According to Table 2, climate hazards are likely affect municipal sectors. Overall, "land use planning" (orange in Table 2) has been reported as the most potentially exposed sector to climatic hazards. Floods, extreme heat, landslides, extreme precipitation, and sea level rise are expected to influence land use planning in most regions.

The "water" sector equally appears to be heavily at risk. Droughts, extreme precipitation and floods appear as dangerous hazards that might affect the water sector. The "building" sector appears at risk of floods, extreme heat, extreme precipitation and storms.

Cities across all regions are concerned about the expected impact of extreme heat on the "health" sector. Analysing the most exposed sectors to climate change by region, UK and Ireland indicates "environment and biodiversity", and "civil protection and emergencies". Northern Europe reports "buildings", "land use planning", "health", "agriculture and forestry", "water", "energy", and "civil protection and emergency".

Central Europe North expects that "buildings", "water", "land use planning" and "health" will be increasingly exposed to climate hazards. "Buildings", "water", "transport", "energy", and "environment and biodiversity" are the sectors more exposed to climate hazards in Central Europe South. Lastly, Southern Europe appears as a truly multi-risk prone region potentially impacting "land use planning", "water", "health", "energy", "agriculture and forestry", "civil protection and emergency", and "buildings".

Table 2. Sectors reported to be at risk

Hazards	UK and Ireland	Northern Europe	Central Europe North	Central Europe South	Southern Europe
Droughts					
Floods					
Extreme heat					
Landslides					
Extreme precipitation					
Storms					
Forest fires					
Sea level rise					

- Buildings
- Transport
- Energy
- Water
- Land use planning
- Agriculture & Forestry
- Environment & Biodiversity
- Health
- Civil protection & Emergency

Source: own elaboration. *Note*: high and moderate levels of hazard expected impact were considered.

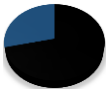
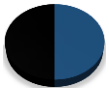
4 Adaptation actions

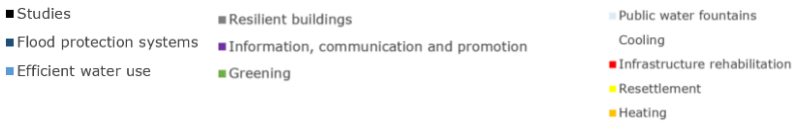
4.1 Actions tackling climate risks

According to Table 3, adaptation actions differ depending on the hazard tackled and the climate region considered. However, there is a type of action that dominates over all hazards and regions: "studies" ([3]). This type of action is common to all regions for floods, pointing to the need for further assessment for example for the effective planning of flood control zones. The same is true for droughts, since "studies" are the most important action along with "efficient water use".

([3]) Examples of studies are: "risk and vulnerability maps", "urban heat island monitoring", "climate change adaptation communication Plan", and "Metropolitan Plans for climate change adaptation" among others.

Table 3. Main action types proposed to cope with climatic hazards

Hazards	UK and Ireland	Northern Europe	Central Europe North	Central Europe South	Southern Europe
Floods					
Droughts					
Extreme heat					
Extreme cold					
Extreme precipitation					
Landslides					
Sea level rise					
Storms					
Forest fires					



Source: own elaboration.

Extreme heat is, on the other hand, tackled by a diverse range of actions in all regions, especially by means of "resilient buildings", "information, communication and promotion", and "greening" actions. Extreme precipitation is tackled by different actions across the regions as well, such as "resilient buildings", "studies", and "infrastructure rehabilitation".

Landslides affect Northern Europe and Central Europe North especially. In the former region, landslides require further "studies" and in the latter landslides are tackled through "information, communication and promotion". Sea level rise, storms and forest fires are also dominated by actions referring to "studies", although "flood protection systems" are also found relevant for sea level rise actions in Central Europe North and Southern Europe.

Water, land-use planning, buildings and health were the municipal sectors that triggered most actions in cities' adaptation plans. Table 4 below provides an overview of the kind of measures cities are planning to undertake to increase resilience in these four sectors.

Table 4. Adaptation measures included in the analysed plans per highly exposed sectors

BUILDINGS	LAND-USE PLANNING
- Green/white roofs, facades, bioclimatic architecture and other building elements for increased cooling and shading - Increase of green areas - Generators for most significant municipal facilities - Thermal protection of the building envelope - Passive cooling systems - Water saving/reuse measures, incl. rainwater collection and storage - Inclusion of all of the above in respective building codes, regulations, incentive schemes	- Review of the main planning instruments/regulations to integrate climate resilience requirements/incentives - Increase of green spaces - Increase of permeable territory - Green/bioclimatic infrastructure - Planning for cooling/shading infrastructure - Assessment of the degree of vulnerability of critical infrastructure
HEALTH	WATER
- Improved coordination of public health related institutions - Development of health action plans for extreme weather events - Development of early warning systems to alert citizens in the case of extreme weather events - Measures to fight vector-borne diseases (e.g. aerial inspection of growth centers of the tiger mosquito) - Regular cleaning and maintenance of sewage and drainage systems - Cleaning and maintenance of municipal refrigeration installations and systems susceptible to problems of legionella - Public awareness campaigns, educational measures on health-related effects of extreme events - Shading/solar protection of open spaces and shading of building facades - Establishment of suitable microclimate for pedestrians and cyclists - Increase number of drinking fountains and other water-based cooling elements (like vaporing)	- Improved water distribution systems to prevent potential water shortages - Increase the capacity of sewerage systems (adapted to extraordinary run-off) - Water treatment facilities for drinking water - Increase of urban green areas - Water saving/reduced consumption/reduction of losses and recovery/reuse measures - Modernization and expansion of Wastewater treatment plants - Development of drought, water resources management plans - Permeable materials in transport and infrastructure, increase of permeable territory - Improved flood warning systems

Source: own elaboration from reported plans.

4.2 Investment costs per type of action

Only six local authorities from two European regions reported an estimation of the investment costs related to the planned adaptation actions. Table 5 shows harmonized investment cost in Purchasing Power Parities (PPPs) ([4]) per action type tackling specific hazards. Not surprisingly, measures with a large infrastructure component like flood protection systems appear as the most costly action type.

([4]) PPPs are indicators of price level differences across countries. PPPs tell us how many currency units a given quantity of goods and services costs in different countries. PPPs are obtained by comparing price levels for a basket of comparable goods and services that are selected to be representative of consumption patterns in the various countries.

Table 5. Actions investment

Climate region	Action	Hazard tackled	Investment costs (PPP 2017)
Central Europe North	Flood protection systems	Sea level rise	EUR 46,000,000
Southern Europe	Greening	Storms	EUR 308,000
		Extreme heat	EUR 3,560,000
			EUR 154,000
			EUR 120,000
		Droughts	EUR 113,000
			EUR 3,560,000
		Extreme precipitation	EUR 142,000
		Sea level rise	EUR 1,571,000
	Information, communication and promotion	Forest fires	EUR 121,000
		Extreme heat	EUR 21,000
			EUR 10,000
	Efficient water use	Extreme heat	EUR 230,000
			EUR 132,000
		Extreme precipitation	EUR 26,000
	Studies	Droughts	EUR 5,046,000
		Extreme precipitation	EUR 1,533,000
		Extreme heat	EUR 145,000
		Extreme cold	EUR 92,000
	Regulations	Extreme precipitation	EUR 15,383,000
	Urban vegetable garden	Extreme heat	EUR 103,000
	Infrastructure rehabilitation	Extreme precipitation	EUR 1,538,000
	Flood protection systems	Floods	EUR 192,474,000
	Heating	Extreme heat	EUR 149,000

Source: own elaboration.

5 Gaps identified and challenges

According to the information reported by the signatory cities analysed in this report, a range of remaining gaps have been identified so far, and need careful attention. These include:

- Stakeholder and citizen participation is generally an undervalued step of the adaptation process that is taken superficially: e.g. only 5% of the signatory cities have engaged citizens in their participatory processes, adopting a medium level of participation.
- Cities report:
    - In some cases, a current high-level hazards that are no longer identified in the future; although in some cases this might be justified, it would be important to understand why this happens.
    - In some cases, high-level hazards miss to identify which sectors will be impacted.
    - High-level hazards that might imply a serious threat to Municipality sectors, but, adaptation actions are not proposed.
    - Actions to protect sectors that are not threatened by any hazard. This probably indicates that cities report adaptation actions that have already been decided without having a direct connection with the risk and vulnerability analysis performed and reported.

- Mitigation actions are proposed as adaptation actions; although in some cases mitigation actions can have indirect benefits on adaptation this is not always the case.
- Maladaptation actions. This kind of actions might be a risk to climate action since they can promote the increase of green-house gases or have other negative impacts on vulnerable people or assets (such as heating or cooling). Maladaptation represents those «actions taken ostensibly to avoid or reduce vulnerability to climate change that impact adversely on, or increase the vulnerability of other systems, sectors or social groups» ([5]).

6 Conclusions

In this report we have analysed the submission of vulnerability risk assessments and adaptation actions of 40 European local authorities in the framework of the Covenant of Mayors. According to the information received from the signatories, Northern Europe and Central North Europe will face a multi-hazard scenario in the future, whereas Central Europe South and Southern Europe are already facing multi-hazard events. Hazardous events are expected to intensify in all regions.

Climate hazards are likely to impact several municipal sectors, especially "land use planning". Floods, extreme heat, landslides, extreme precipitation, and sea level rise are expected to influence land uses in most regions. Adaptation actions differ depending on the hazard tackled and the climate region considered. However, further "studies" is a common adaptation action proposed across all regions, pointing to the need for additional assessments. Not surprisingly, actions with a large infrastructure component like flood protection systems appear as the most costly action type.

Lastly, a range of remaining gaps have been identified in the analysis, and need careful attention, such as improvement of stakeholder and citizen engagement, improvement of planning actions (which includes reducing the inconsistencies between the risk and vulnerability assessment and the actions proposed), and better address the risk of implementing maladaptation actions.

([5]) Barnett, J., & O'Neill, S. (2010). Maladaptation. Global Environmental Change (20), 211-213.

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