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FINAL DELIVERABLE

Regional Report - Enschede

VREPO

Final Report // November 2025

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ESPON EGTC
Sandra Di Biaggio - Research and Policy Manager
Caroline Clause - Financial and Budget Manager

Coordination:
Dr. Séverine Hermand – Sweco
Diego Luna Quintanilla – Sweco

Authors
Dr. Mario Balzan – Ecostack Innovations
Dr. Sara Camilleri – Ecostack Innovations
Benjamin Mifsud Scicluna - Ecostack Innovations
Bram Wolters – Sweco
Natan Vandeginste – Sweco
Donatas Baltrusaitis - Bauland

Advisory group
Enrico Moens - Sweco

Acknowledgements
Dr. João Cortesão – Sweco
Denis Giannelli – Sweco

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Layout and graphic design by BGRAPHIC, Denmark

Contact: info@espon.eu

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1 Executive Summary

Enschede faces converging risks from **climate hazards, geopolitical disruptions, and public health crises**, with the same infrastructures and communities repeatedly exposed, hospitals, schools, utilities, transport corridors, and wetlands. Vulnerable districts such as **twekkelerveld and Pathmos** are especially at risk from floods, heat, and social vulnerability. To make resilience systemic and future-proof, three strategic shifts are needed:

1. **Build Back Better through multi-use and resilient infrastructure** – ensuring hospitals, schools, and corridors are retrofitted or rebuilt as **multi-purpose hubs** (shelters, cooling, vaccination) and critical assets in floodplains are relocated or elevated.
2. **Cross-dimensional no-regret measures** – prioritising wetlands and sponge streets for flood/heat/drought control, redundant routing of utilities to guard against floods and cyberattacks, smart sensor networks for early warning, and equity-first planning so underserved neighbourhoods receive priority investments.
3. **Smart, anticipatory monitoring** – leveraging Enschede's **university and IoT innovation ecosystem** to build a unified City Resilience Dashboard that integrates health, ecological, and infrastructure data, with automatic triggers for pre-deployment and response.

A unifying recommendation across risks is the adoption of **Build Back Better as a spatial planning framework for recovery.** Unlike building codes that focus only on technical standards, this framework guides *where and how* to (not) rebuild, ensuring equity, relocation clarity, and long-term resilience. The spatial planning framework ensures that:

- **low-risk areas** host resilient new developments,
- **moderate-risk areas** allow renovation only with mandatory adaptation measures, and
- **high-risk areas** trigger relocation supported by land reallocation and compensation instruments.

Together, the recommendations, strategic shifts, and Build Back Better framework provide a **comprehensive pathway** for Enschede to move from identifying risks to embedding resilience in law, planning, and investment, ensuring anticipatory, equitable and transformative resilience.

2 Introduction

The work presented in this document is part of an ESPON Targeted Analysis (TA) entitled "Vulnerability, Resilience and Recovery Policies of the Physical Living Environment (VREPO)" which aims to strengthen integrated territorial development by building local and regional capacity for resilience and recovery policymaking. It focuses on analysing current policies, governance practices, and implementation challenges across diverse European regions and climatic zones. Through policy research and continued stakeholder engagement, VREPO investigates pre- and post-crisis resilience strategies, identifies vulnerabilities in the physical living environment and develops targeted policy recommendations for the 5 regions forming part of this TA: Flanders Region (Belgium), Région SUD Provence-Alpes-Côte d'Azur (France), Lithuania, the municipality of Enschede (Netherlands), and the Southern Regional Council of Malta (Malta).

To achieve the aims of this TA we conducted four main tasks together with two hybrid workshops (in Vilnius and Brussels) where stakeholders participated in regional-specific exercises and provided input and/or feedback on the respective tasks.

- **Task 1** – Development of a conceptual framework and identification of priority risks composed of: hazards, exposures, and vulnerabilities, within each region.
- **Task 2** – Analysis of data availability, selection of Territorial Resilience Indicators, data collection and harmonization for indicator development.
- **Task 3** – Scrutiny of territorial resilience strategies and assessment of their application potential to each stakeholder region.
- **Task 4** – Development of practical, place-based recommendations on resilience strategies, instruments, governance, actions, and good practices for each region, as well as resilience strategies common to all regions forming part of this TA.

Within Task 1, a conceptual framework for territorial resilience was developed with resilience conceptualized as the capacity of coupled Social–Ecological–Technological-Systems (SETS) to mitigate risks, prepare for and respond to hazards, and recover from their impacts, while simultaneously adapting and transforming to confront future, unforeseen challenges.

- **Social**: Communities and populations exposed in rural and urban environments, including factors such as demographics, public health, economic conditions, and governance capacity.
- **Ecological**: The natural environment, ecosystems, and biodiversity, which provide critical services for human and planetary health but are increasingly under stress from climate impacts.
- **Technological**: Public amenities (e.g., hospitals, schools, care facilities) and critical infrastructure (e.g., energy, water, transport, telecommunications) that are located in hazard-prone areas and are essential for societal resilience.

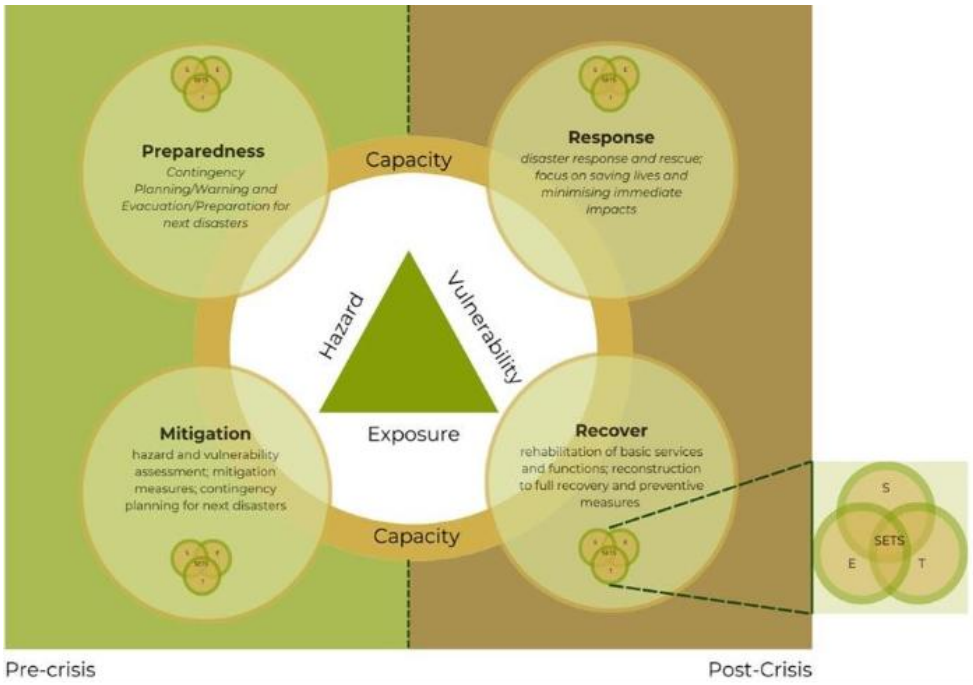


Figure 1 The conceptual framework

By integrating the principles of the SETS framework, this approach establishes explicit linkages between hazards, vulnerabilities, and exposures, and the capacity of regions to act across the four stages of the Disaster Management Cycle (DMC) - mitigation, preparedness, response, and recovery.

- **Mitigation**: Actions to reduce or minimize risks and adverse impacts of hazards. Examples include hazard assessments, early warning systems, strengthening infrastructure, restoring wetlands, promoting sustainable land use practices, improved environmental and social policies and retrofitting buildings.
- **Preparedness**: The planning and implementation of measures to ensure readiness for hazards. This includes activities such as community training, developing and testing real-time monitoring and early warning systems, creating and practising response plans, and ensuring resources are in place to respond effectively.
- **Response**: Immediate actions taken during and shortly after a hazard to save lives, protect property and minimize harm. Such activities include rescue operations, emergency medical care, evacuation, and the provision of critical information through effective communication systems.
- **Recovery**: Efforts to rebuild, restore and improve communities, infrastructure and systems after a hazard, focusing on stronger, more resilient and sustainable systems to better withstand future hazards. Examples of relevant systems applied to recovery include community-led housing reconstruction initiatives (social domain), wetland restoration to mitigate flooding risks (ecological domain), and smart grid technologies for energy infrastructure (technological domain).

The territorial resilience recommendations presented in this document are framed using the conceptual framework described above resulting in a set of SETS-based actions for each stage of the DMC for three main risk categories in line with Enschede 's specific needs and priorities as described in Section 3.

3 Territorial Risk Profile

This section provides an overview of the key priority risks identified for Enschede, where **Risk** is defined as:

> *The probability of a hazard causing harm to people, property, or the environment. It is determined by the interaction of three key components: the **hazard** itself (including its frequency, intensity or probability of occurring), the level of **exposure** to the hazard and the **vulnerability** of the affected system (capacity to cope vs susceptibility).*

This relationship is often expressed as:

Risk = Hazard x Exposure x Vulnerability

The risk landscape of Enschede (Figure 2) is characterised by three overarching categories: climate risks, geopolitical risks, and public health risks, each associated with distinct hazards, exposures, and vulnerabilities. We note that while the conceptual framework is needed to systematically assess SETS vulnerabilities and exposures across all three risk categories, overlaps are common. For example, a single hazard may simultaneously disrupt ecological systems, impact communities, and damage critical infrastructure.

Risks	Hazards	Exposure	Vulnerabilities
Climate risks	Floods	Communities living in flood-prone areas Densely built urban areas Farms and agricultural hubs Critical infrastructure Strategic targets	Social Infrastructure Public health
	Heat stress		
	Droughts		
	Storms		
Geopolitical risks	Terrorism & cyberattacks		
	Armed conflict		
Public health risks	CBRNe		
	Pandemics		

Figure 12 The priority areas of Enschede, including the main risk categories, alongside their hazards, exposures, and associated vulnerabilities.

Climate-related risks are considered the topmost priority for Enschede, reflecting both the region's geographical characteristics and its socio-economic dependencies. Hazards such as floods, heat stress, storms, and droughts pose recurring and intensifying threats to communities, densely built urban areas, farms, agricultural hubs, and critical infrastructure. The region's polycentric settlement pattern, the proximity of towns and villages to river systems, and the reliance on highly productive agricultural land mean that climate-related hazards carry disproportionate impacts across multiple domains of vulnerability, including infrastructure, social well-being, and public health

Geopolitical risks, while less frequent, carry high-impact potential, particularly in the context of armed conflict and terrorism and cyberattacks. Strategic targets and critical infrastructure are most exposed in this category, and their disruption could lead to cascading effects across governance, economic stability, and social cohesion. Though not as immediate as climate risks, their potential consequences position them as the second-most pressing category of concern.

Public health risks are represented in the framework by pandemics and Chemical, Biological, Radioactive, Nuclear, and Explosive (CBRNe) hazards, which, although low-probability events, are characterised by their potentially severe consequences for urban populations, healthcare systems, and economic activities. The COVID-19 pandemic demonstrated how quickly such crises can overwhelm health infrastructure and disrupt societal functioning. In Enschede, vulnerabilities in healthcare capacity, critical infrastructure, and social systems make preparedness for CBRNe scenarios a priority, even if these risks are ranked below climate and geopolitical concerns.

4 Risk Maps

This project collected a set of spatial indicators describing **priority hazards, critical infrastructures, and ecological and social vulnerabilities** relevant to the city of Enschede. Hazards that cannot be mapped spatially, such as cyber threats, were excluded. All indicators were harmonised on a **hexagonal grid** to analyse the spatial co-occurrence of hazards, exposure, and vulnerabilities across the **region surrounding Enschede**. The complete list of indicators is provided in Table 1, with details on data sources, processing, and data gaps available in the Data Report[1]. The maps in the following section illustrate examples of how these indicators can be combined to assess **regional risk patterns that include Enschede**. The aim is not to show every possible combination but to demonstrate how local authorities can use the dataset to produce risk maps tailored to their specific needs. An atlas of maps is provided in the annexes.

The dataset integrates indicators, grouped into four main categories:

- **Hazards** – including fluvial flood risk, heat wave exposure, drought potential, wildfire risk, and distance to nuclear power plants.
- **Critical Infrastructure** – including hospitals, energy facilities, industrial risk sites, military areas, banks, government and public service buildings, train stations, and road network classes. Building stock (number and construction year) is also included as part of infrastructure exposure.
- **Ecological / Environmental Indicators** – including land cover types, urban green areas, agricultural parcels, Natura2000 protected zones, and biodiversity intactness.
- **Social Vulnerabilities** – including population density, age structure (% elderly, % youth), foreign nationality, urbanisation degree, urban fabric, and social vulnerability indices (general and for elderly populations).

These indicators are organised around three key concepts that guide risk assessment and policy action: **Hazard-Prone Areas**, **Exposure**, and **Vulnerability**.

- **Hazard-Prone Areas** identify locations most likely to experience specific hazards, such as flood zones or wildfire-prone regions. This helps policymakers understand *where* risks originate.
- **Exposure** combines hazard data with territorial characteristics—such as land use, population, and infrastructure—to show which assets or communities lie within risk zones. This supports targeted urban planning and resource allocation.
- **Vulnerability** integrates exposure data with social and economic indicators—such as income distribution, building quality, or access to services—to highlight which groups are *most at risk* and where resilience measures should be prioritised.

Together, these indicators allow for **multi-dimensional analysis of exposure, hazards, and vulnerability patterns at a regional level including Enschede**. The dataset, available on the ESPON portal, includes accompanying metadata describing definitions, sources, and data processing steps.

[1] **Intermediate deliverable 2 (ID2), Data report, May 2025**: A set of spatial datasets focuses on territorial resilience indicators for each region, using a common data model, format, unit of measurement, and scale where possible. Each dataset is accompanied by a brief methodological note that explains its composition. Format : one Geodatabase and one Word file

Table 1 Overview of spatial indicators collected on priority hazards, critical infrastructures, and ecological and social vulnerabilities.

Category	Indicator	Expanded Description
Hazards	pluvial_flood_risk	Flooding from heavy rainfall and urban runoff; important for local stormwater management.
	heat_risk	Urban heat exposure; affects health and infrastructure during heatwaves.
Critical Infrastructure	transport_network	Roads, railways, and public transport; essential for emergency mobility.
	utilities	Electricity, water, and communication infrastructure; vital for maintaining basic services.
Social & Ecological Vulnerabilities	population_density	Concentration of residents; higher density increases potential impact.
	vulnerable_groups	Identifies low-income, elderly, or socially isolated populations; priority for targeted interventions.
	green_spaces	Urban parks and natural areas; provide cooling, infiltration, and recreation benefits.
	housing_quality	Measures building condition; lower-quality housing increases disaster vulnerability.

With these metrics, the following maps and graphs can be created. Other combinations between the metrics are possible after further data analysis. For example, each statistic can be broken down into the different NUTS regions to assess which sub-region is most at risk for a given hazard, exposure and/or vulnerability.

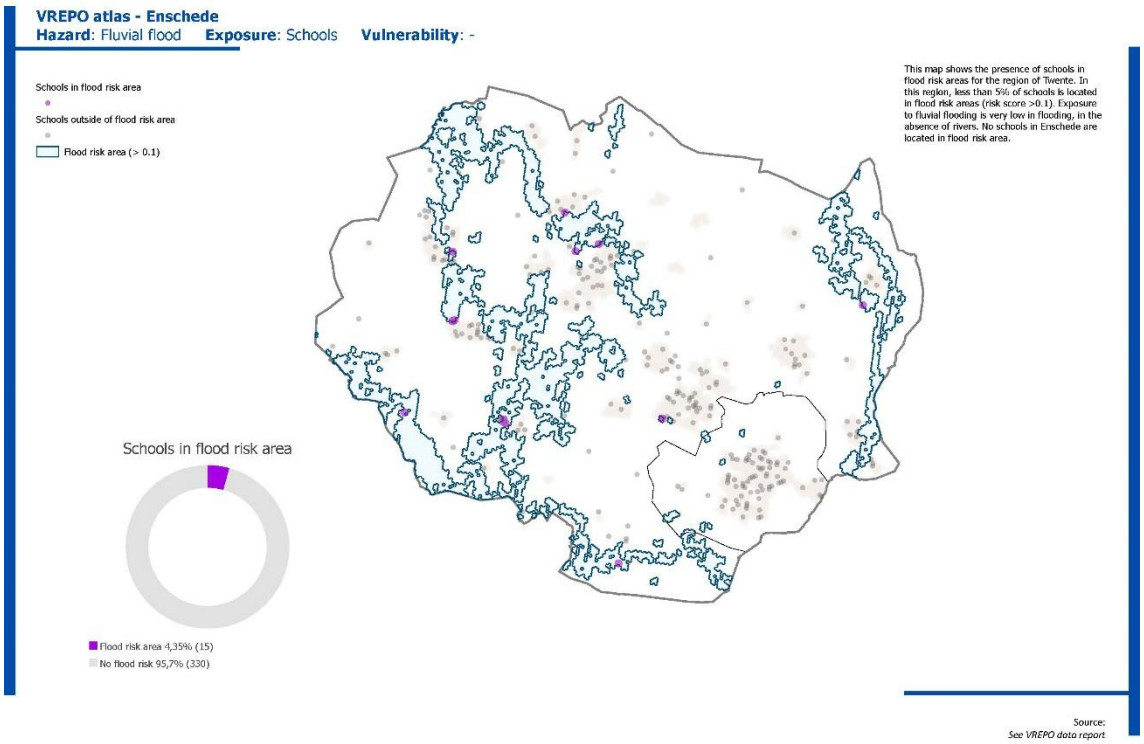


Figure 23 Map of Schools in Twente Located in Flood Risk Areas
Indicators: School locations; Fluvial flood risk; Pluvial flood risk; Regional distribution

Figure 3 provides a **spatial overview of schools in the Twente region with respect to flood risk**, highlighting areas of potential exposure to **fluvial and pluvial flooding**. The map combines school location data with **flood risk assessments** to evaluate **vulnerability of educational infrastructure**. This map should be regarded not as a single indicator, but as a **composite analytical product** derived from multiple spatial datasets to inform **risk management and planning for schools**.

The map shows that **less than 5% of schools in Twente are located in flood risk areas** (risk score >0.1), indicating a **low overall exposure**. **Fluvial flooding risk is minimal**, particularly due to the **absence of rivers** in much of the region. Specifically, **no schools in Enschede are located in fluvial flood-prone areas**, highlighting very low exposure in urban centers. However, for **pluvial flooding**, a **small number of schools in both Enschede and other parts of Twente are vulnerable**, indicating localized risk from heavy rainfall and surface water accumulation.

Policy Takeaways:

- **Monitor and prepare** for pluvial flood risks at schools in vulnerable areas.
- **Maintain low exposure of schools** in urban areas like Enschede by integrating flood resilience measures into urban planning.
- **Incorporate localized flood mitigation strategies** (e.g., drainage improvement, temporary flood barriers) for schools at risk.
- **Use composite spatial indicators** to evaluate risk across multiple flood types rather than relying on a single metric.

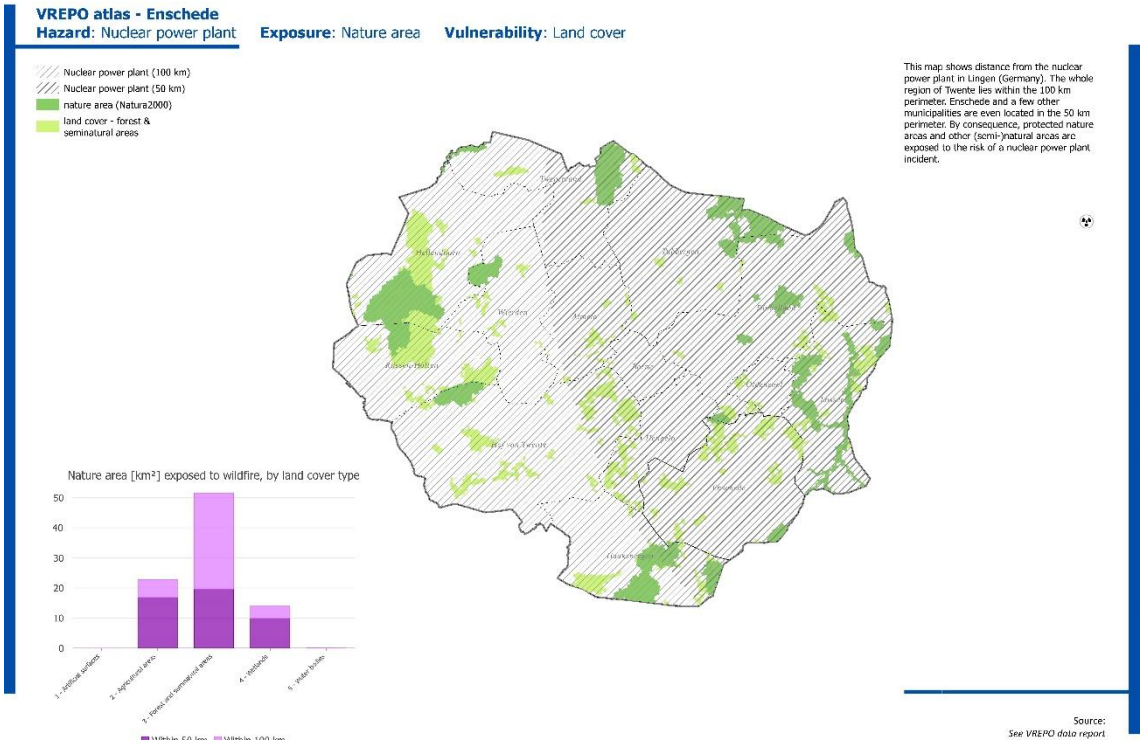


Figure 43 Map of Distances from the Lingen Nuclear Power Plant[2]

Indicators: Distance from Lingen nuclear power plant; Protected and semi-natural areas; Municipal boundaries

Figure 4 provides a **spatial overview of the Twente region in relation to the Lingen nuclear power plant in Germany**, illustrating distances to assess potential **nuclear risk exposure**. The map highlights areas within **50 km and 100 km perimeters** from the plant, including **municipalities such as Enschede**, and identifies **protected and semi-natural areas** that could be affected in the event of an incident. This map should be regarded not as a single indicator, but as a **composite analytical product** derived from multiple spatial datasets, to support **risk assessment and environmental planning**.

The map shows that the **entire Twente region lies within the 100 km perimeter** of the Lingen plant, with some municipalities, including **Enschede, falling within the 50 km perimeter**. These areas encompass **protected nature and semi-natural zones**, which could theoretically be exposed to a nuclear incident. While the plant was **shut**

[2] Since the **Lingen nuclear power plant has been shut down and is undergoing dismantling**, the **risk of a nuclear incident is now extremely low**, essentially eliminating active nuclear risk. However, **residual risks remain during the dismantling and decommissioning process**, such as **handling radioactive materials and waste**, so precautionary measures should still be observed until the site is fully decommissioned and decontaminated.

down in April 2023 and is currently being **dismantled**, these distances highlight the historical potential exposure and inform **long-term land use and emergency planning**.

Policy Takeaways:

- **Maintain monitoring and contingency plans** for areas historically within nuclear risk perimeters.
- **Incorporate historical nuclear risk into land use planning** for protected and semi-natural areas.
- **Communicate residual risk information** to local authorities and residents.
- **Use spatial analysis of distances and sensitive areas** to guide environmental protection and emergency preparedness.

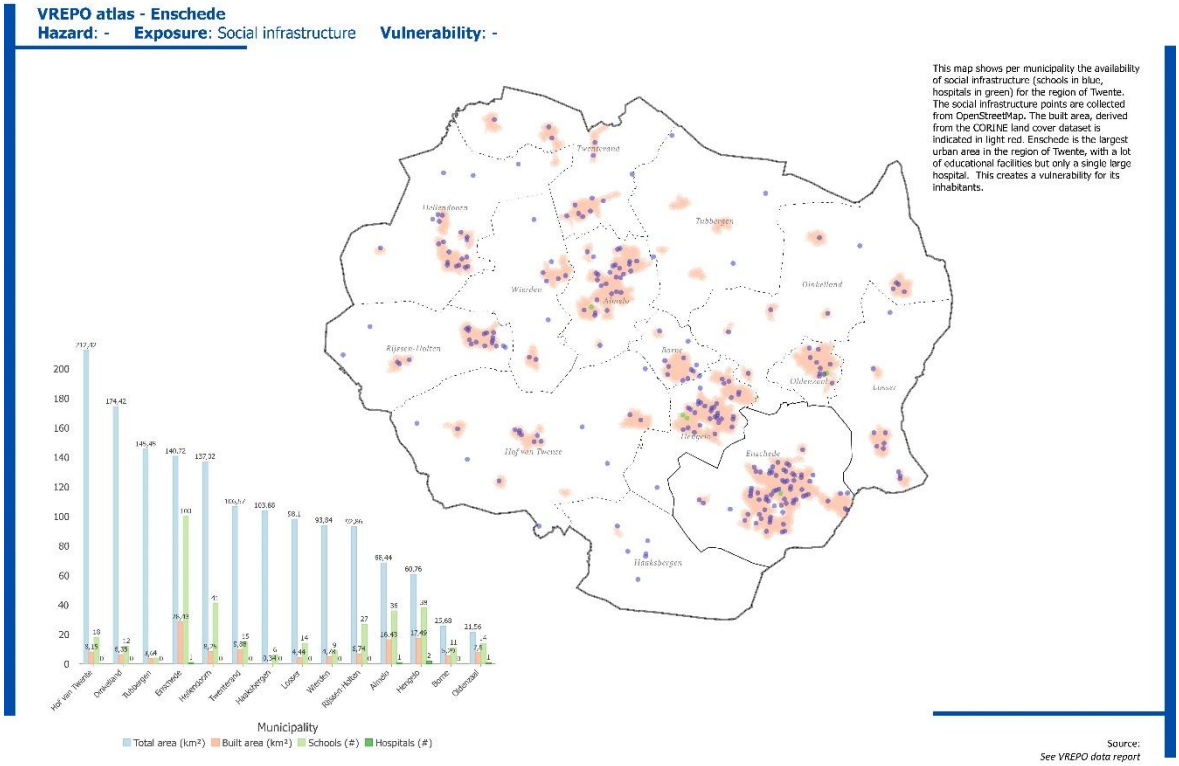


Figure 45 Map of Social Infrastructure Availability in Twente

Indicators: Built-up areas; Hospital and schools locations

Figure 5 provides a **spatial overview of social infrastructure in the Twente region**, highlighting the distribution of **schools (blue) and hospitals (green)** across municipalities, overlaid on **built-up areas (light red)**. The map combines **OpenStreetMap data on schools and hospitals** with **built area coverage from the CORINE land cover dataset**, offering a **composite view of service availability and potential vulnerabilities**. This map should be regarded not as a single indicator, but as a **synthesis of multiple spatial datasets** to support **policy planning and accessibility analysis**.

The map shows that **Enschede, the largest urban area in Twente, has many educational facilities** but only **one large hospital**, creating a **localized vulnerability** for residents in terms of healthcare access. While the number of hospitals is important, the **overall vulnerability of a hospital also depends on factors such as its capacity, emergency preparedness, specialization of services, and accessibility for the surrounding population**. Therefore, even a single hospital may pose a risk if demand exceeds capacity or if critical services are concentrated in one location. Other municipalities in Twente generally have a **lower density of both schools and hospitals**, highlighting differences in service availability across the region.

Policy Takeaways:

- **Consider expanding hospital capacity or decentralizing health services** in Enschede to reduce localized vulnerability.
- **Assess hospital vulnerability beyond numbers**, including capacity, emergency response readiness, and critical service coverage.
- **Ensure equitable access to schools and healthcare** across all municipalities in Twente.
- **Use composite spatial indicators** to capture multi-dimensional service accessibility and vulnerability, rather than relying solely on facility counts.

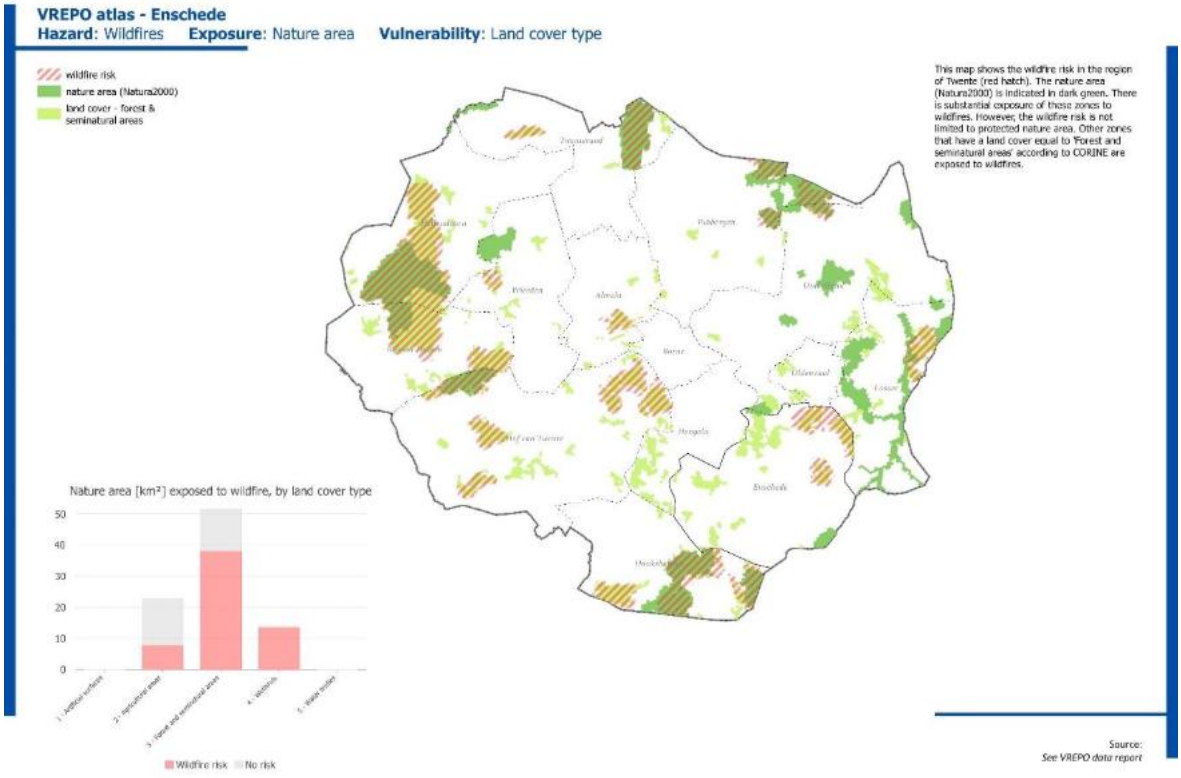


Figure 65 Map of Wildfire Risk in Twente

Indicators: Wildfire risk zones; Protected nature areas (Natura2000); Forest and semi-natural areas

Figure 6 provides a **spatial overview of wildfire risk in the Twente region**, highlighting areas of **forest and semi-natural land cover** that are exposed to potential wildfires. **Natura2000 protected areas** are shown in **dark green**, while **wildfire risk zones** are indicated with **red hatching**. The map combines **wildfire risk modeling** with **land cover data from CORINE** to identify **vulnerable ecosystems**, supporting **risk assessment, land management, and fire prevention planning**. This map should be regarded not as a single indicator, but as a **composite analytical product** derived from multiple spatial datasets.

The map shows **substantial exposure of both protected Natura2000 areas and other forest/semi-natural areas to wildfire risk**. While **some nature areas have high wildfire risk**, others do not. This variation depends on factors including:

- **Vegetation type and density** – Dense or highly flammable vegetation increases wildfire likelihood.

- **Land management and human activity** – Managed forests, areas with fire breaks, or less human interference tend to have lower risk.
- **Topography and microclimate** – Slopes, wind patterns, and dryness of the soil affect wildfire susceptibility.
- **Historical fire occurrence** – Areas with previous fire events may be more prone to recurrence.

Policy Takeaways:

- **Prioritize wildfire prevention and monitoring** in areas where high-risk zones overlap with Natura2000 and other sensitive forests.
- **Implement targeted land management strategies** (e.g., controlled burns, fire breaks, vegetation thinning) to reduce wildfire risk.
- **Enhance emergency preparedness** for communities and ecological areas near high-risk zones.
- **Use composite spatial indicators** combining land cover, protection status, and wildfire modeling to inform risk mitigation strategies.

5 Identified Gaps in Resilience

The identification of priority risks in Task 1 and indicator development in Task 2 were complemented in Task 3 by a systematic review of existing territorial resilience strategies, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. Relevant policy documents from European and regional sources from the five territories were collected, screened, and validated with stakeholders, resulting in 92 key documents. From these, 329 strategies were extracted, categorized by DMC stage, hazard domain, governance level, and spatial scale, then refined through deduplication and pre-assessment to 97 unique strategies. These were further evaluated through a multi-criteria assessment (MCA) based on spatiality, operationality, innovation, resilience potential, and stakeholder-defined priorities. The process, consolidated in Workshop 3.2, produced a final ranked set of 40 operational strategies, mapped to risks and DMC stages, which highlight strong coverage of pre-crisis preparedness and mitigation but reveal notable gaps in recovery-oriented policies.

The list of existing strategies (a total of 29 strategies) consists mostly of climate strategies with fewer geopolitical and public health strategies. Climate risks are the most represented category, with 18 strategies identified across three out of four stages of the DMC cycle. However, none of the identified 18 strategies address the recovery stage, a shortfall that is consistent across all three risk categories. By comparison, geopolitical and public health risks are less represented, with 5 and 6 strategies each, respectively. Geopolitical strategies tend to focus less on mitigation strategies altogether and lack recovery-stage strategies. Existing strategies consist of 1, 2 and 3 Public Health strategies for Mitigation, Preparedness and Response, respectively but, similarly to the other risk categories, have no recovery-stage strategies. Across all three risk categories, there are no existing recovery strategies, and no mitigation strategies for geopolitical risks.

From the 29 existing strategies identified across the five stakeholder regions, a subset was selected as particularly relevant for Enschede. This selection was guided by a combination of factors: the specific priority risks from Task 1 and stakeholder input on local needs, and the territorial context of Enschede.

Based on these criteria, 20 strategies were identified as relevant for Enschede (stemming from existing strategies), distributed across risk categories and DMC stages as follows:

- 13 strategies under Climate (7 Mitigation, 5 Preparedness, 1 Response and 0 Recovery)
- 2 strategies within Geopolitical (0 Mitigation, 1 Preparedness, 1 Response and 0 Recovery)
- 5 strategies falling under Public Health (1 Mitigation, 2 Preparedness, 2 Response and 0 Recovery)

Figure 7 illustrates the distribution of the **existing strategies** for Enschede across the four stages of the DMC and the primary risk categories. Grey cells indicate stages for which no existing strategies are present, highlighting gaps in the current proposal set. This visualization is intended to identify gaps rather than assess the performance of existing policy implementation. Based on these identified gaps, we developed targeted policy recommendations to strengthen the alignment of disaster management strategies in Enschede with the DMC and the associated SETS for each risk category (Section 6). These recommendations aim to foster a comprehensive and balanced disaster management approach, ensuring that all DMC stages are adequately addressed and that existing policy gaps are effectively filled.

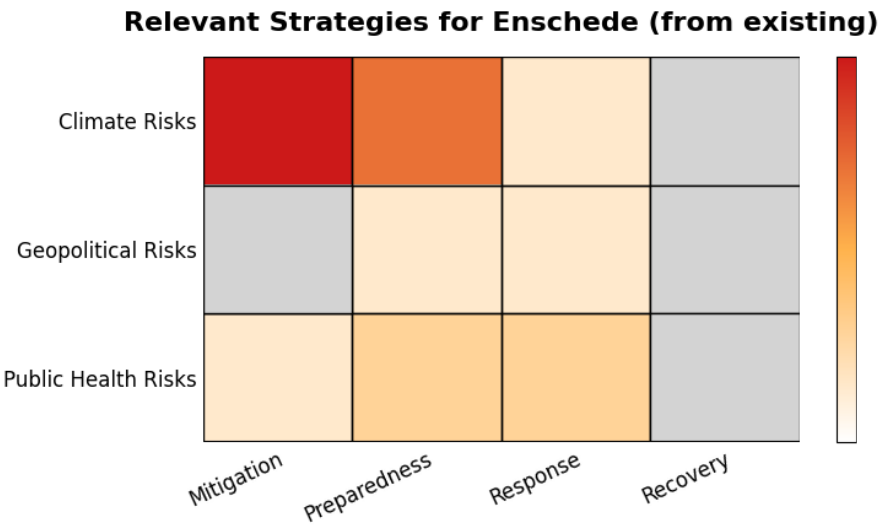


Figure 7 - Heatmap showing the distribution of existing strategies across DMC stages and risk categories in Enschede. The darker red gradient denotes a greater number of existing strategies. Grey cells indicate that no existing strategies are present.

6 Policy recommendations

The risk maps in Section 4 not only illustrate exposure to climate, geopolitical, and public health threats across Social-Ecological-Technological-Systems (SETS), but also highlight the main strategic spatial challenges, which are directly addressed in the recommendations. They provide examples of the geographies and sectors most at risk, from flood-prone urban areas to drought-sensitive ecosystems and critical infrastructure hubs. Additionally, gaps in territorial resilience policy strategies are identified across the DMC stages in Section 5. Building on this evidence, the following nine evidence tables (one for each risk category and SETS dimension combination) provide the analytical foundation for this report. They map risks across climate, geopolitical, and public health hazards, breaking them down by the social, ecological, an technological dimensions and across the four stages of the Disaster Management Cycle (DMC). Together, they provide targeted actions for each risk category while also laying the groundwork for cross-sectoral and public–private collaboration. The relevant existing strategies identified in Section 5, with the addition of recommendations to address the associated gaps across the DMC stages and SETS dimensions, all of which are within the recommendation tables below.

For each of the three risk categories and SETS dimensions (3x3) we present territorial policy recommendations across the DMC stages (Table 2). Each recommendation is structured around three components to make recommendation practical and actionable:

- **Content ("what")** - refers to what the policy recommendation aims to address.
- **Instruments ("how") -** are the tools and mechanisms used to implement and enforce the policy recommendation.
- **Key Actors ("who") -** covers the potential initiators, responsibilities, and coordination needed to guide implementation.

Table 2 – The table structure used to present the policy recommendations. For each risk category, 3 tables, one for each SETS dimension, is developed, resulting in a total of 9 tables.

DMC Phase	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*			
Preparedness *(ensure readiness before hazards occur)*			
Response *(immediate actions during/after hazards)*			
Recovery *(rebuild stronger & more resilient)*			

Each table provides targeted recommendations aligned with governance instruments such as legislation, plans, zoning policies, subsidies, and softer tools like guidelines and awareness campaigns, ensuring that the strategies are actionable and tailored to the municipality of Enschede. The tables were developed through a multi-step, evidence-based process to ensure their relevance and practicality for Enschede. Starting with Task 3 recommendations as a

foundation, the strategies were refined through feedback gathered from focus groups and workshops involving local stakeholders, experts, and policymakers. Additionally, further research into current instruments, governance frameworks, and policies in Enschede helped identify gaps and areas where implementation is lacking. Thus, the recommendations presented include both recommendations which stem from existing strategies, and which require improvements as well as recommendations addressing gaps in policy in-line with the risks identified in this TA.

By combining these insights, the analysis highlights critical opportunities to enhance resilience and provides actionable policy recommendations tailored to the social, ecological, and technological aspects of the region's risk management across the DMC stages. It consolidates critical information on specific instruments, governance roles, and implementation steps, enabling spatial planners and policymakers to quickly identify priority actions and responsible actors. This resource is intended to support policy development, coordinate across sectors, and design integrated responses tailored to local risks and capacities. However, it is important to recognize the limitations of this study: Stakeholders had limited opportunity to provide feedback on the final recommendations presented in the tables below, which are largely based on desk-based work by the consortium. Moreover, as this study was conducted externally and without sustained on-the-ground expertise across sectors, certain local nuances, socio-political dynamics, and emerging issues may not be fully captured. The guidance provided here should therefore be regarded as a preliminary framework that requires supplementation through local expertise, validation, and continuous stakeholder engagement to ensure its relevance, effectiveness, and sensitivity to the local context.

Climate Risks – Social Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Expand **safe, inclusive green spaces** (3-30-300 rule) in dense districts like Twekkelerveld/Pathmos, improving public health and raising nearby property values. (**MC**) • Integrate **multi-layered vegetation and cooling corridors** into the Omgevingsplan to lower UHI impacts and reduce health costs from heat stress. (**MC**) • Prioritize underserved neighborhoods for **green retrofits**, reducing inequities and avoiding productivity losses from health disparities. (**MC/SC**)	Enschede can apply **zoning and building regulations** that require canopy cover and permeable surfaces while coupling these rules with investments in **parks, shaded streets, green roofs, and permeable pavements** (MC). **Awareness campaigns** such as *"Tegel eruit, groen erin"* and **participatory co-design processes** mobilise residents (MC/SC). Financing comes from **Stimuleringsregeling Klimaatadaptatie** and **EU Urban Innovative Actions**, linking local interventions to national and EU programs (SC/HC).	The **Department of Urban Development and Sustainability** leads by embedding resilience into the **Omgevingsplan** (MC). **Waterschap Vechtstromen** aligns water retention with urban greening projects (SC). **Housing corporations** support retrofits (SC), while **NGOs such as GroenBlauw Enschede** mobilise residents (MC). At national level, **DPRA** ensures compliance and co-funding (HC).
Preparedness *(ensure readiness before hazards occur)*	• Integrate **heat stress into public health strategy**: cooling corridors, mandatory reflective/green roofs, also as a means of lowering healthcare expenditures. (**SC**) • Encourage **self-protection** (household retrofits, rainwater harvesting) to reduce future public aid costs. (**MC/SC**) • Develop **community-wide awareness** in vulnerable neighborhoods, lowering economic impacts of absenteeism and hospital admissions. (**MC**)	**Heat resilience clauses** can be added to the **Bouwbesluit** and municipal health strategies (HC/MC). Investments in **rainwater harvesting, cisterns, and bioswales** increase resilience (MC/SC). **Co-creation labs, citizen advisory boards, and multilingual subsidy guides** strengthen equity and participation (MC). **Urban heat island mapping** provides the technical basis for prioritising vulnerable districts (SC).	The **Department of Environment and Sustainability** and **GGD Twente** integrate climate–health preparedness into municipal planning (MC). **Schools, welfare organisations, and Groenbeheer** act as partners for outreach (MC/SC). At higher levels, **RIVM** and the **Ministry of Infrastructure and Water Management (IenW)** provide technical standards and national guidance (HC).
Response *(immediate actions during/after hazards)*	• Establish **public cooling shelters** in community centres, schools, and elderly care homes (Figure 5); reduces hospital admissions and productivity losses. (**MC**) • Develop a **flood crisis response system**: mobile logistics for food, water, medicine, protecting workforce continuity. (**SC**) • Create a **climate-specific emergency protocol** embedded in Gemeentelijk Rampenplan, avoiding costly coordination failures. (**MC**)	Municipal buildings can be **retrofitted as cooling shelters** with backup systems (MC). Preparedness is reinforced through **regular drills and simulation exercises** (MC/SC). **Hazard-specific emergency ordinances** are issued at municipal level but aligned with regional protocols (MC/SC). Funding comes from **municipal emergency budgets** and **regional crisis response grants** (SC/HC).	The **Department of Public Order and Safety** and **Veiligheidsregio Twente** lead command-and-control operations (SC). The **Social Policy Department** ensures vulnerable households are supported (MC). **NGOs and community volunteers** provide frontline logistics and communication (MC). At national level, the **Safety Regions Act** ensures consistency across Dutch crisis frameworks (HC).
Recovery *(rebuild stronger & more resilient)*	• Plan **phased relocation** of housing/infrastructure in high-risk zones; avoids repeat losses and stranded assets. (**HC**) • Require **inclusive CBAs** for all adaptation projects, accounting for long-term economic benefits (e.g., lower mortality, energy savings). (**MC/SC**) •	The municipality can **mandate CBAs** for urban development permits (MC). A **CBA toolkit with the University of Twente** quantifies health, energy, and resilience benefits (SC). **Adaptation co-funding** is tied to projects with positive long-term outcomes (SC/HC).	The **Finance Department** and **Climate Adaptation Office** oversee investment decisions (MC). The **University of Twente** supports modelling and evaluation (SC). The **Social Policy Department** ensures equity in delivery (MC).

	Adopt a **Municipal Climate Equity Strategy**, ensuring fair distribution of resilience investments. (**MC**)		At higher levels, **DPRA** and national equity frameworks provide funding and oversight (HC).

KEY: **MC** = Municipal competence (Enschede can act directly); **•SC** = Shared competence (municipality + regional/national partners); **•HC** = Higher-level competence (national/EU lead; municipality aligns or advocates)

Climate Risks – Ecological Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Capture and store **rainwater in cities** (wadis, bioswales, permeable pavements, cisterns), reducing potable water demand and lowering municipal utility costs (Figure 3). (**MC/SC**) • Develop a **Climate Buffer Network** (floodplains, blue-green corridors, peatland rewetting) to avoid costly flood damages and sustain agricultural productivity. (**SC/HC**)	Enschede can enforce **retention requirements in new developments** and mandates for permeable paving in zoning and building codes (MC/SC). Physical measures include **bioswales, infiltration trenches, and cisterns** supported by municipal works (MC). **Awareness campaigns and financial incentives** for SMEs and homeowners encourage uptake of rainwater harvesting (MC). Funding can be sourced from the **Stimuleringsregeling Klimaatadaptatie** and EU programs such as **LIFE or Interreg**, which link ecological resilience to regional and EU priorities (SC/HC).	The **Afdeling Waterbeheer and Stadsontwikkeling en Klimaat** lead by embedding water storage and buffer zones into spatial planning (MC). **Waterschap Vechtstromen** manages hydrological modelling and water flow integration at catchment scale (SC). **NGOs such as GroenBlauw Enschede and housing cooperatives** support local delivery (MC/SC). At higher level, the **DPRA** ensures national alignment and co-funding (HC).
Preparedness *(ensure readiness before hazards occur)*	• Optimize **water demand & groundwater use** via aquifer mapping, quality monitoring, and pollution remediation, reducing risks to drinking water supplies and agricultural losses. (**SC/HC**) • Introduce **real-time groundwater monitoring & digital twin models** to avoid over-abstraction and costly emergency supply measures. (**SC/HC**) • Protect **urban ecological assets** (corridors, buffer zones) to sustain property values and tourism potential. (**MC/SC**)	Preparedness relies on **monitoring stations and aquifer remediation infrastructure** supported by municipal and water board investments (SC/HC). The national government updates **abstraction permits and water balancing policies** to prevent overuse (HC). **Awareness campaigns** help communities understand groundwater risks and responsibilities (MC). **GIS-based stress tests and hydrological modelling** ensure that future demand and risk are projected in advance (SC).	The **Municipal Waterbeheer department** provides local oversight (MC), while **Waterschap Vechtstromen** co-leads by managing catchment-scale monitoring and licensing (SC). **Provincie Overijssel and the Omgevingsdienst Twente (ODT)** enforce water abstraction and quality rules (SC/HC). Knowledge partners such as the **University of Twente, KWR, and Deltares** supply modelling, scenario analysis, and innovation (SC/HC).
Response *(immediate actions during/after hazards)*	• Deploy **temporary retention and diversion systems** (pumps, modular basins) to limit economic losses from service disruption. (**MC/SC**) • Implement **emergency ecological safeguarding** to prevent polluted runoff entering waterways, reducing costly clean-up and fisheries impacts. (**SC**) • Activate **community water stewardship groups** for monitoring, lowering municipal surveillance costs. (**MC**)	Enschede and partners can deploy **mobile pumps and modular basins** in flood-prone areas (MC/SC). Trained **community water stewards** provide rapid ecological damage assessments and reporting (MC). The national government can impose **emergency restrictions on abstraction** to protect water supplies (HC). Funding comes from **municipal emergency reserves, regional crisis funds, and national emergency allocations** (SC/HC).	The **Crisis and Waterbeheer departments** coordinate the technical response (MC). **Veiligheidsregio Twente** integrates water measures into wider crisis management protocols (SC). **Landowners and NGOs** act as frontline monitors and provide ecological expertise (MC/SC).
Recovery *(rebuild stronger & more resilient)*	• Apply **Build Back Better**: relocate assets from high-risk ecological zones, restore wetlands, and rewet peatlands — reducing long-term repair and insurance costs. (**SC/HC**) • Integrate **future climate risks** into all restoration projects, preventing maladaptation. (**MC/SC**) • Conduct **resilience audits** of restored ecosystems to assess avoided costs and co-benefits (carbon storage, flood prevention). (**SC**)	Enschede can adopt **revised land-use rules** to prevent rebuilding in ecological risk zones (MC/SC). Investments include **post-flood wetland and peatland restoration** supported by water boards and provincial partners (SC/HC). **Multi-stakeholder recovery forums and citizen stewardship programs** ensure transparency and co-management (MC/SC). Funding can be drawn from the **EU Solidarity Fund** and **DPRA**	The **Department of Spatial Planning and Environment** leads by embedding ecological resilience into rebuilding permits (MC). **Veiligheidsregio Twente** ensures alignment with risk planning (SC). **Provincie Overijssel, Rijkswaterstaat, and ministries BZK/IenW** provide oversight, funding, and regulatory backing (HC). **Citizen groups and**

		Zoetwater, tying recovery to measurable ecological resilience (HC).	**NGOs** co-manage restored ecosystems, ensuring stewardship and legitimacy (MC/SC).

Climate Risks – Technological Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Upgrade **stormwater and drainage systems**: separate rainwater/wastewater, embed blue-green infrastructure in flood-prone districts. Reduced flooding of utilities lowers long-term repair costs and insurance claims. (**MC/SC**) • Integrate **climate risk assessments into all new transport planning**; use future scenarios to guide design/material standards, avoiding costly retrofits. (**SC/HC**) • Retrofit **public buildings and critical infrastructure** with passive cooling and energy efficiency upgrades, reducing operational costs and improving productivity. (**MC/SC**) • Institutionalize **regular climate stress tests for energy systems**, prioritizing decentralized, climate-proof networks to limit economic losses from outages. (**SC/HC**)	Enschede can embed **retention requirements and updated technical standards** into the **Omgevingsplan** (MC/HC), ensuring all new projects integrate flood and heat resilience. Investments include **blue–green roofs, retention ponds, and decentralized energy hubs** (MC/SC). **Subsidy schemes and awareness campaigns** encourage retrofitting for households and businesses (MC). Funding streams include the **municipal adaptation budget, the Stimuleringsregeling Klimaatadaptatie, and EU Green Deal programmes**, which tie local actions to EU climate goals (SC/HC).	The **Afdeling Waterbeheer and Duurzaamheid en Bouwen** oversee integration of stormwater and building upgrades into spatial planning (MC). **Waterschap Vechtstromen and Enexis** ensure catchment-level water management and energy network resilience (SC). **Housing corporations** support retrofits in social housing (SC). The **Omgevingsdienst Twente** enforces building and zoning compliance (SC). National frameworks such as the **DPRA and Nationale Adaptatiestrategie** guide alignment and provide higher-level funding (HC).
Preparedness *(ensure readiness before hazards occur)*	• Develop a **long-term relocation plan** for essential infrastructure in high-risk flood zones (phased, with triggers). Prevents stranded assets and costly emergency rebuilds. (**SC/HC**) • Establish a **municipal retrofit and cooling-shelter program** for schools (Figure 3), social housing, and elderly homes; improved indoor comfort reduces heat-related productivity loss and healthcare costs. (**MC**) • Pre-designate **public schools/sports fields as emergency relief nodes** with modular shelters, backup power, potable water — protecting education continuity and limiting business interruptions for families. (**MC/SC**) • Install **automated misting points** at hospitals, tram hubs, and care centres, avoiding spikes in medical admissions during heatwaves. (**MC/SC**)	Preparedness combines **GIS-based vulnerability mapping** and **digital twin models** to identify relocation needs (SC/HC). **Cooling capacity mandates** for public buildings and relocation triggers are embedded in zoning regulations (SC/HC). Practical measures include **retrofitted schools and modular shelters** with backup systems (MC/SC). **Technical toolkits for building managers** and **public communication campaigns** support awareness and readiness (MC). Funding comes from the **municipal climate fund, provincial adaptation grants, and EU RescEU programmes** (SC/HC).	The **Woonbeleid en Vastgoedbeheer department** leads retrofits in public buildings and housing (MC), supported by the **Afdeling Maatschappelijke Voorzieningen** for social facilities (MC). **GGD Twente** ensures compliance with health and safety standards, while **Consent (schools)** and **Enexis** provide operational capacity for backup power and continuity planning (SC). **Provincie Overijssel** and national ministries provide financial support and enforce relocation frameworks where municipal competence is insufficient (HC).
Response	• Use **schools and sports fields as temporary shelters** with grid-independent power, water taps, and medical support — reducing productivity and wage losses by enabling faster recovery of the workforce. (**MC/SC**) • Deploy **emergency**	Emergency response relies on **mobile modular shelters and backup solar/battery systems** (SC). **Crisis ordinances** can restrict risky activities during floods or extreme heat (MC/SC). **Response drills and public alert systems** build readiness	The **Dept. of Safety & Resilience (Veiligheid en Crisisbeheersing)** coordinates municipal-level crisis protocols (MC). **Veiligheidsregio Twente** manages multi-sector emergency coordination, while **GGD Twente** handles medical surge response (SC).

(immediate actions during/after hazards)	**cooling infrastructure** (misting points, shaded evacuation hubs) during heatwaves, lowering healthcare system costs. (**MC/SC**) • Establish **emergency logistics protocols** to protect lifeline services (electricity, water, telecoms) and minimize economic downtime. (**SC/HC**)	and trust (MC). Funding for rapid interventions comes from **municipal emergency reserves, regional crisis budgets, and national emergency grants** (SC/HC).	National operators such as **Rijkswaterstaat and telecom/energy grid managers** ensure infrastructure continuity and reinforcement (HC).
Recovery *(rebuild stronger & more resilient)*	• Implement **Build Back Better strategy**: relocate critical assets from floodplains, restore natural buffers, and apply adaptive reconstruction (elevated foundations, fire/flood-resistant materials). Reduces long-term costs of repeat disasters (Figure 6). (**SC/HC**) • Restrict rebuilding in high-risk areas; pre-define rebuild/no-build zones for clarity. (**MC/SC**) • Establish a **Post-Crisis Recovery Taskforce** to coordinate reconstruction, link with national recovery funds, and monitor economic losses. (**SC/HC**) • Pilot a **Disaster Recovery Dashboard** to track investments, integrate risk data, and improve cost-efficiency of rebuilding. (**MC/SC**)	Recovery requires **strict zoning rules and adaptive reconstruction codes** that define where rebuilding is permissible (MC/SC/HC). Investments include **relocated utilities and adaptive reconstruction materials** guided by resilience standards (SC/HC). **Community liaison teams and urban renewal programmes** ensure inclusive rebuilding (MC). Funding comes from the **EU Solidarity Fund, municipal recovery funds, and parametric insurance schemes** (SC/HC).	The **Post-Crisis Recovery Taskforce within the Safety Department** coordinates local recovery planning and financing (MC). **Waterschap Vechtstromen and Veiligheidsregio Twente** provide technical and operational support during reconstruction (SC). **Deltares, KNMI, Rijkswaterstaat, and national ministries (BZK/IenW)** ensure hazard data, modelling, and national co-financing (HC). **Housing corporations and citizen groups** co-design rebuilding plans to ensure legitimacy and social acceptance (MC/SC).

Geopolitical Risks – Social Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Launch **digital literacy & social cohesion programs** in schools, libraries, and community centers to prevent radicalization and reduce vulnerability to cyber misinformation. (**MC**) • Require **continuity planning from local service providers** (utilities, IT, telecoms) to ensure social services remain functional during hybrid attacks. (**MC/SC**) • Foster **public–private partnerships** with businesses and NGOs for secure information exchange and resilience. (**SC**) Reduced risk of social unrest and cyber fraud lowers municipal enforcement and healthcare costs.	Municipal awareness campaigns and youth programmes build trust and self-protection capacity (MC). Continuity planning is embedded in service-provider licensing, supported by **cyber risk modelling, redundancy audits, and GIS vulnerability mapping** to identify weak points (MC/SC). Funding from the **Dutch Resilience Programme and EU Internal Security Fund** supports both technical upgrades and social initiatives (SC/HC).	The **Afdeling Samenleving en Veiligheid** leads community-facing programmes (MC). **GGD Twente, schools, and youth workers** deliver outreach locally (MC/SC). The **NCTV (National Coordinator for Security & Counterterrorism)** provides national guidance, while **ANSSI** and other partners support continuity planning and cyber compliance (SC/HC).
Preparedness *(ensure readiness before hazards occur)*	• Develop a **comprehensive map of critical infrastructure** (digital, health, transport, utilities) and carry out regular risk assessments. (**SC**) • Build a **multi-hazard shelter strategy**: upgrade basements, schools, and heritage buildings for long-term operability (ventilation, water, backup power). (**MC/SC**) • Establish **joint drills and exercises** for hybrid events (cyber + physical disruption). (**SC**) Investing in preparedness reduces business downtime and protects regional competitiveness.	Infrastructure maps are produced using **GIS tools and critical asset audits** funded by regional civil protection programmes (SC). Shelters are upgraded through municipal investment and co-financed by EU funds, with standards aligned to **RIVM health and safety protocols** (MC/SC/HC). Drills involve both public agencies and private operators, ensuring continuity of health and utility services (SC).	The **Afdeling Informatievoorziening & IT** leads digital infrastructure mapping (MC). **Veiligheidsregio Twente and utility providers (Enexis, Vitens)** coordinate preparedness planning and exercises (SC). The **NCSC (National Cyber Security Centre)** ensures cyber standards and risk assessments are integrated into regional and local practices (HC).
Response *(immediate actions during/after hazards)*	• Activate **shelter network** quickly in case of air raid, cyber-attack, or hybrid crisis; ensure accessibility for elderly and vulnerable groups. (**MC/SC**) • Enable **real-time cross-sector communication platforms** for rapid coordination between municipality, utilities, and emergency services. (**SC/HC**) • Launch **emergency counter-misinformation campaigns** to maintain public trust and reduce panic. (**MC**) Faster recovery of public services prevents cascading financial losses in healthcare, retail, and logistics.	Emergency shelters are powered through **backup energy and water systems**, funded by municipal reserves (MC). **Crisis ordinances** allow rapid imposition of utility redundancy requirements and mobility restrictions (SC/HC). Multilingual communication campaigns use both digital and traditional channels, with funding from **regional crisis budgets** (SC).	The **Dept. of Public Order & Safety** coordinates municipal emergency response and shelter activation (MC). **Veiligheidsregio Twente** manages cross-sector crisis coordination (SC). **NCTV and NCSC** provide national guidance on hybrid threat response and misinformation control, ensuring coherent communication across agencies (HC).
Recovery	• Develop **community-based recovery programs** to address trauma, reduce stigmatization, and rebuild trust in both digital and physical spaces. (**MC**) • Launch	Community programmes use **peer networks, storytelling, and citizen juries** to rebuild trust (MC). **Digital monitoring tools** track the decline of misinformation and help target interventions (SC). **Microgrant**	The **Afdeling Maatschappelijke Ontwikkeling** leads community reintegration and trauma support (MC). **GGD Twente and local CBOs** provide psychosocial and health services (SC). The **Ministry of VWS** supplies national

(rebuild stronger & more resilient)	**reintegration and mental health initiatives**, including safe public dialogues, peer support, and digital re-engagement campaigns. (**MC**) • Create a **Post-Crisis Social Recovery Taskforce** to coordinate municipal, regional, and national support, embedding lessons learned into long-term resilience strategies. (**SC/HC**) Social recovery programs reduce long-term welfare costs and help workers return to economic participation faster.	**schemes** for grassroots groups ensure accountability and inclusion in recovery (MC/SC). Larger-scale funding is secured from the **Dutch Recovery & Resilience Facility (RRF)** and the **Ministry of VWS** (SC/HC).	oversight, funding, and integration into long-term health and welfare frameworks, aligning with EU RRF mechanisms (HC).

Geopolitical Risks – Ecological Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Identify and secure **ecological infrastructures** (e.g., Kristalbad, treatment wetlands, urban green corridors) vulnerable to sabotage or hybrid threats. (**MC/SC**) • Implement **physical + cyber defences** (controlled access, CCTV, intrusion detection, encrypted monitoring). (**SC**) Early protection lowers the enormous costs of post-sabotage remediation (e.g., water contamination cleanup).	Security upgrades include **perimeter fencing, CCTV, and biometric access** for sensitive sites (MC/SC). Mandatory **threat assessments** are integrated into the Omgevingsplan to ensure ecological assets are systematically reviewed for vulnerabilities (MC). **Community watch schemes** and NGO partnerships raise awareness and enable early reporting of unusual activity (MC). Funding from **DPRA security investments and EU resilience funds** ensures continuity (HC).	The **Afdeling Waterbeheer & Duurzaamheid** leads site-level security (MC). **Waterschap Vechtstromen** ensures hydrological/ecosystem management (SC), while the **University of Twente** pilots monitoring technologies (SC). Oversight and alignment with national security standards comes via the **Delta Programme (DPRA)** (HC).
Preparedness *(ensure readiness before hazards occur)*	• Deploy **integrated sensor networks** with cybersecurity protections to detect abnormal ecological activity (water quality, air pollution, biodiversity loss). (**MC/SC**) • Use **digital twin models** for ecosystems to anticipate cyber or physical disruption. (**SC**) • Train **citizen-scientists** to monitor ecological indicators reliably, building trust in local data. (**MC**) Automated detection prevents costly delays in identifying sabotage (e.g., polluted groundwater).	Install **IoT sensors with encrypted transmission** and anomaly-detection firmware to detect threats in real time (SC). Municipal IT guidelines embed **cyber-protection standards** into ecological monitoring (MC/SC). Citizen-scientist training builds community capacity to feed reliable data into official systems (MC). Funding through **NCSC security grants, Horizon Europe pilots, and EU Green Deal innovation funds** supports scaling (SC/HC).	The **Afdeling Informatievoorziening & IT** ensures cybersecurity and municipal IT integration (MC). **Waterschap Vechtstromen** manages hydrological monitoring networks (SC), supported by **NCSC** for cybersecurity compliance (HC). **University of Twente and Deltares** provide digital twin modelling and technical expertise (SC/HC).
Response *(immediate actions during/after hazards)*	• Develop **emergency protocols** for ecological sabotage (chemical release, bioterrorism in protected areas), integrated into the Crisisbeheersingsplan. (**MC/SC**) • Implement **early warning + rapid notification systems** for eco-terrorism events (water alerts, public advisories). (**MC/SC**) • Run **inter-agency drills** simulating	Real-time **dashboards and automated alerts** link municipal, regional, and national actors (SC). Municipal emergency planning formally includes ecological sabotage scenarios through **updated disaster response protocols** (MC). **Inter-agency exercises** simulate eco-terrorism, refining coordination between municipal responders, water boards, and health services (SC). Funding comes from **municipal**	The **Afdeling Veiligheid & Crisisbeheersing** leads municipal-level response planning (MC). **GGD Twente** and **Waterschap Vechtstromen** manage health-water intersections (SC). National expertise from **RIVM** (public health) and **NVWA** (food/environment safety) ensures compliance with national CBRNe and biosafety protocols (HC).

	CBRNe/ecological hybrid threats (Figure 4). (**SC**) Faster response reduces long-term ecosystem restoration costs and prevents economic losses in tourism and agriculture.	**emergency reserves and national civil protection budgets** (SC/HC).	
Recovery *(rebuild stronger & more resilient)*	• Establish an **Ecosystem Recovery & Resilience Fund** for rapid rehabilitation after sabotage (wetlands, soils, biodiversity). (**MC/SC**) • Launch **ecological restoration projects** with co-financing from provincial/EU sources. (**SC/HC**) • Include **citizen participation** in monitoring recovery, ensuring legitimacy and cost-sharing. (**MC**) A dedicated fund speeds up recovery, avoiding protracted economic damage (e.g., unusable farmland, lost tourism).	**Pre-approved budget lines and rapid restoration contracts** allow immediate deployment of cleanup and rehabilitation measures (MC/SC). **Fast-track permitting** supports urgent ecosystem restoration (MC). **Citizen oversight boards and participatory monitoring** ensure recovery reflects community priorities (MC). Funding via the **EU Green Deal Recovery Fund, Provincie Overijssel allocations, and the Dutch Postcode Loterij Fonds** secures long-term restoration (SC/HC).	The **Afdeling Duurzaamheid** manages fund distribution and restoration contracts (MC). **University of Twente experts and local NGOs** provide ecological monitoring and recovery expertise (SC). **Provincie Overijssel** aligns regional priorities with national adaptation goals (SC). National and EU funding channels (HC) guarantee resources for scaling restoration efforts.

Geopolitical Risks – Technological Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Mandate **utility providers** (Enexis, telecom operators) to design geographically diverse backup routes (redundant power/fiber-optic links, cross-provincial cabling, flood-resilient crossings). (**SC/HC**) • Embed **redundancy planning** into all new infrastructure projects to reduce dependency on single corridors. (**MC/SC**)Reduced downtime lowers losses to businesses and municipal services during disruptions.	Enforce **continuity mandates for utility providers** through ACM audits and municipal planning approvals (SC/HC). Utilities co-invest in **redundant cabling, backup substations, and flood-proofed crossings** (SC). **Public–private partnership agreements** secure shared data and investment commitments (SC). Funding combines **utility co-investment with national climate-security subsidies** (SC/HC).	The **Municipality (Urban Development & IT)** ensures local embedding in Omgevingsplan (MC). **Utility providers (Enexis, telecoms)** design and operate redundant networks (SC). **Waterschap Vechtstromen** secures flood-exposed corridors (SC). Oversight and compliance is managed by **ACM and national ministries** (HC).
Preparedness *(ensure readiness before hazards occur)*	• Conduct **comprehensive shelter audit** (schools, basements, public facilities) and prioritize retrofitting against floods, heat, and power outages. (**MC/SC**) • Establish **multi-hazard shelter standards** (ventilation, backup power, comms, water). (**SC**) • Run **cross-sector risk assessments** for banking, finance, and telecoms to test resilience to hybrid attacks. (**SC/HC**) Shelter retrofits protect lives and prevent costly service interruptions for education and healthcare.	Develop a **regional shelter database** and fund retrofits (ventilation, filtration, backup power) (MC/SC). **Hazard-proofing standards** incorporated into local building codes and MOUs with private/religious institutions for shared access (MC/SC). Awareness workshops in vulnerable districts prepare residents (MC). Funding from **municipal crisis budgets, Veiligheidsregio Twente, and Ministry of Justice & Security programmes** (SC/HC).	The **Afdeling Veiligheid & Crisisbeheersing** leads audits and municipal retrofits (MC). **Bouwen Woningtoezicht** ensures building standards (MC). **Veiligheidsregio Twente** provides crisis planning and retrofitting guidelines (SC). National ministries co-finance and enforce compliance with security standards (HC).
Response *(immediate actions during/after hazards)*	• Deploy a **real-time operations centre** linking cyber + physical infrastructure data (telecom, power, water, emergency services). (**SC/HC**) • Ensure **joint incident response protocols** between utilities, municipality, and national cybersecurity agencies. (**SC/HC**) • Run **regular hybrid attack**	Integrate **IoT sensors and SCADA-secure platforms** to monitor utilities in real time (SC). Establish **data-sharing protocols under NCSC guidelines** to ensure rapid cross-sector communication (HC). Run **joint scenario exercises** with utilities, crisis managers, and civil protection to refine	The **Enschede Crisis Management Office** oversees municipal coordination (MC). **Veiligheidsregio Twente** manages multi-agency emergency operations (SC). **NCSC** sets cybersecurity protocols and provides technical support (HC). Utility operators (Enexis, telecoms, Vitens) are

	simulations to test readiness of control systems. (**SC**) Joint control room reduces downtime costs from prolonged outages.	coordination (SC). Horizon Europe grants and municipal budgets fund platform development and exercises (SC/HC).	integrated into the control centre for live data sharing (SC).
Recovery *(rebuild stronger & more resilient)*	• Issue **Recovery Resilience Bonds** (municipal/provincial) to finance urgent rebuilding of networks (roads, telecom, power), tied to measurable targets (e.g., 72h restoration). (**SC/HC**) • Launch a **multi-sector Recovery Taskforce** (energy, transport, water, telecom, finance) applying Incident Command System (ICS) principles for resource allocation. (**SC**) • Use **digital recovery dashboards** for transparency, monitoring repair progress, and rebuilding trust. (**MC/SC**) Bonds leverage private capital for faster recovery, reducing reliance on municipal reserves.	Establish **performance-based restoration requirements** (e.g., 72h power grid restoration) linked to Recovery Bonds (SC/HC). Networks are repaired and upgraded with **resilient standards and adaptive materials** (SC/HC). Public dashboards monitor reconstruction progress, feeding back lessons into spatial planning (MC/SC). Financing blends **municipal bonds, RVO green finance, and insurer payouts** (SC/HC).	The **Municipal Finance Department** manages bond issuance and dashboard transparency (MC). The **Recovery Taskforce**, chaired by the Mayor or delegate, coordinates resource allocation across utilities and sectors (SC). **Provincie Overijssel and RVO** provide financing frameworks (SC/HC). National ministries supervise compliance with national resilience and financial accountability standards (HC).

Public Health Risks – Social Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Establish **syndromic & event-based surveillance** covering all neighbourhoods, ensuring vulnerable groups (elderly, migrants, low-income) are included in reporting. (**SC**) • Launch **equity-focused community resilience programs** in underserved districts to reduce disaster-health risks. (**MC**) • Safeguard **WASH continuity** in flood-prone, low-resource areas via pre-positioned supplies and monitoring. (**SC**)	Implementation relies on **digital health reporting systems**, **GIS-linked outbreak mapping**, and **IoT water sensors** in at-risk districts. **Standardised reporting under the Wet publieke gezondheid** (HC) ensures consistency, while **mHealth tools and community health workers** (MC/SC) provide last-mile inclusion. Funding is drawn from municipal resilience budgets and co-financed by EU cohesion health funds (SC/HC).	The **GGD Twente** leads local health surveillance (MC), integrating with national oversight from **RIVM** (HC). **Waterschap Vechtstromen** manages water-related health risks (SC). Local municipalities design and deliver resilience programmes in vulnerable districts, working with NGOs to maintain trust and access (MC).
Preparedness *(ensure readiness before hazards occur)*	• Roll out **multilingual, culturally adapted campaigns** on flood-health and pandemic risks, co-created with NGOs and migrant/disability groups. (**MC**) • Form **inclusive neighborhood volunteer teams** with members from elderly, migrant, and disability communities. (**MC**) • Prioritize **health facility upgrades & mobile units** in underserved areas identified by gap analyses. (**SC**)	Preparedness tools include **shelter audits** applying accessibility and surge-capacity standards, **training exercises for volunteers**, and **emergency capacity requirements** embedded in municipal health policies (MC/SC). Campaigns are delivered via schools, religious centres, and NGOs. Funding comes from municipal health budgets, supplemented by national preparedness funds and EU social inclusion grants (SC/HC).	The **Department of Social Affairs & Community Development** leads (MC), in partnership with NGOs, schools, and **GGD Twente** (SC). Oversight lies with the **Municipal Resilience Office** (MC), ensuring strategies align with regional and national health frameworks (HC).
Response *(immediate actions during/after hazards)*	• Activate **volunteer teams** to assist vulnerable residents (evacuation, first aid, translation, communication). (**MC**) • Provide **equitable WASH services**: mobile treatment units, hygiene kits, prioritized delivery in low-income flats and care homes. (**SC**) • Ensure **accessible emergency health services** with telemedicine, reserve staff, and mobility support. (**SC**)	Response requires **mobile water treatment units, hygiene stockpiles, and backup power for clinics** (MC/SC). **Multilingual public alerts** (SMS, radio, easy-read) ensure accessibility, while **emergency health standards** embedded in national protocols (HC) guarantee continuity. Funding is provided by municipal emergency reserves, regional crisis budgets, and national civil protection allocations (SC/HC).	The **Crisis Management Office** and **Veiligheidsregio Twente** coordinate deployment (SC). **Local hospitals and GGD Twente** provide medical capacity (MC/SC), supported by **RIVM** and the **Ministry of Health (VWS)**, which provide emergency protocols, surge staff, and national-level resources (HC).
Recovery *(rebuild stronger & more resilient)*	• Launch **community rebuilding programs** with mental health & social cohesion activities accessible to all groups. (**MC**) • Integrate **housing + health equity**: reconstruction prioritizes vulnerable districts' access to schools, clinics, and care. (**MC/SC**) • Monitor recovery with **social vulnerability & health indicators** (income, housing, digital access). (**SC**)	Recovery involves rebuilding **social infrastructure** (schools, clinics, housing) in underserved areas first (MC/SC). **Peer-support networks and citizen juries** with migrant and disability representation strengthen legitimacy. **Equity criteria** are embedded into a formal Social Recovery Framework (MC/SC). Funding is provided through municipal budgets, housing association co-investments, provincial recovery schemes, and EU Recovery & Resilience Facility grants (SC/HC).	The **Department of Social Affairs and Urban Planning** leads recovery locally (MC), coordinating with housing associations, NGOs, and **GGD Twente** (SC). Oversight is provided by the **Province of Overijssel** and national recovery funds (HC), ensuring compliance with equity standards and alignment with Dutch resilience policies.

Public Health Risks – Ecological Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Develop **ecological surveillance systems** to monitor wildlife, water, and soil for zoonotic pathogens and chemical pollutants. (**SC**) • Establish **biosecurity buffer zones** around water sources, wetlands, and urban green spaces to minimize pathogen spillover and chemical exposure. (**MC/SC**) • Integrate **One Health principles** into land-use planning, linking human, animal, and environmental health. (**SC/HC**)	Mitigation relies on **sensor networks and eDNA sampling** in wetlands and parks to detect emerging threats, supported by **urban planning rules requiring ecological buffer zones** and hazard assessments for new developments (MC/SC). **Awareness campaigns** on zoonotic risks and safe land use help residents and landowners reduce exposure (MC). Funding is mobilised through municipal environmental budgets, provincial subsidies, and **EU Horizon/One Health programmes** (SC/HC).	The **Municipal Environmental and Public Health Departments** lead implementation locally (MC), working with **Waterschap Vechtstromen** to manage water-related health risks (SC). Universities such as **Twente and Wageningen** provide research and technical expertise (SC). National alignment is ensured through the **Ministry of Health (VWS)** and **Ministry of Agriculture (LNV)**, which set biosecurity standards and fund national surveillance (HC).
Preparedness *(ensure readiness before hazards occur)*	• Deploy **integrated environmental sensor networks** with cybersecurity protections to detect pathogens, toxins, or radiological anomalies. (**SC**) • Conduct **GIS-based ecological risk mapping** (linking floodplains, farms, green spaces) to identify hotspots. (**MC/SC**) • Train **citizen-scientists and local NGOs** to support surveillance and early warning. (**MC**)	Preparedness combines **IoT sensors, remote sensing, and GIS mapping tools** for early detection, with **standard operating procedures for data sharing** between ecological and health authorities (SC/HC). **Citizen training and school-based ecology programmes** make preparedness visible and inclusive at the community level (MC). Provincial environmental funds and EU resilience grants support equipment and training, ensuring continuity across borders (SC/HC).	The **Urban Planning and Environment Departments** coordinate municipal deployment (MC). **Waterschap Vechtstromen** and regional biodiversity agencies provide operational and technical expertise (SC). NGOs are engaged to run training and citizen-science pilots (MC/SC). At the higher level, the **Ministry of Agriculture (LNV)** enforces biosecurity standards and the **RIVM** provides epidemiological modelling and national data integration (HC).
Response *(immediate actions during/after hazards)*	• Deploy **multidisciplinary rapid response teams** (ecologists, hazmat, water authorities) for CBRNe/ecological incidents. (**SC**) • Establish **early warning + public alert systems** for water/soil contamination and air quality risks. (**MC/SC**) • Conduct **regular interagency drills** simulating chemical spills, zoonotic outbreaks, or radiological contamination in ecological zones. (**SC**)	Response involves **portable detection devices** (chemical sensors, radiation monitors), **containment barriers**, and **real-time dashboards** for tracking events (SC). Emergency response is codified by integrating **ecological CBRNe protocols into the Crisisbeheersingsplan** (MC). Public communication is strengthened through **multilingual alerts and simulation exercises** that prepare residents for ecological incidents (MC/SC). Funding comes from municipal emergency budgets, regional crisis allocations, and national disaster response funds (SC/HC).	The **Crisis Management Office** leads incident coordination (MC), supported by **GGD Twente** for public health and **Waterschap Vechtstromen** for water-related contamination (SC). Local fire brigades provide hazmat capacity (SC). National agencies such as the **NCTV** and the **Ministry of Justice & Security** offer guidance, additional personnel, and cross-regional support in hybrid or CBRNe contexts (HC).
Recovery *(rebuild stronger & more resilient)*	• Implement **ecosystem restoration programs** for contaminated soils, wetlands, and water systems after CBRNe or pandemics. (**SC**) • Use **nature-based remediation techniques** (bioremediation, phytoremediation, soil washing) to reduce long-term health risks.	Recovery uses **remediation technologies** such as phytoremediation and bioremediation, supported by **fast-track permits for ecological restoration** to avoid bureaucratic delays (MC/SC). Community involvement is institutionalised through **participatory monitoring and advisory boards**, ensuring	The **Environmental and Urban Planning Departments** oversee local implementation (MC), working with **Waterschap Vechtstromen** and the **Provincial Environmental Agency** for technical execution (SC). Universities provide research on ecosystem resilience and long-term monitoring (SC). National environmental authorities align

	(**SC/HC**) • Establish a **transparent community advisory board** to oversee restoration priorities and rebuild public trust. (**MC/SC**)	legitimacy and cost-sharing (MC/SC). Funding is provided via the **EU Green Deal Recovery Facility**, Dutch remediation grants, provincial co-financing, and insurance payouts (SC/HC).	standards with EU frameworks and ensure recovery funding flows (HC).

Public Health Risks – Technological Dimension

DMC Stage	Content (What)	Instruments (How)	Key Actors (Who)
Mitigation *(reduce risks before hazards happen)*	• Install **IoT-based sensors** in schools, hospitals, and transit hubs to monitor air quality, CO_2, and airborne pathogens/chemicals. (**MC/SC**) • Map and design **vaccination infrastructure** that can serve ≥70% of the population, with equity prioritization for vulnerable and hard-to-reach groups. (**MC/SC**)	Mitigation uses **biosensors, CO_2 monitors, and VOC detectors** to capture real-time health data, integrated into **data-sharing protocols with schools, hospitals, and transport authorities** (MC/SC). Awareness campaigns promote **ventilation and infection control** among the public (MC). Funding comes from **municipal innovation budgets and EU digital health grants**, ensuring scalability (SC/HC).	The **Public Health and Smart City Units** of Enschede lead (MC), in cooperation with **GGD Twente** and municipal education/transport authorities (SC). The **University of Twente** supports with technical expertise and piloting (SC), while higher-level alignment with national health frameworks is maintained via the Ministry of Health (HC).
Preparedness *(ensure readiness before hazards occur)*	• Establish a **GIS-based vaccination registry** with accessibility audits, ensuring equitable coverage of underserved districts. (**MC**) • Develop **mobile vaccination and health service units** for isolated populations. (**MC/SC**) • Build **shelter-convertible public buildings** (schools, community centers) with modular layouts for emergency medical use. (**SC**)	Preparedness is supported by **GIS registries and modular facility designs**, making vaccination and emergency medical service delivery more equitable (MC/SC). **Urban planning guidelines** require adaptability in public buildings (SC). Outreach campaigns are co-created with **NGOs and community groups** to improve trust in vaccination, particularly in migrant and low-income communities (MC). Funding is secured through **municipal health budgets, national pandemic response funds, and EU resilience programmes** (SC/HC).	**GGD Twente** leads vaccination registry development and health preparedness (MC). Municipal health and social services coordinate with NGOs for community outreach and engagement (SC). The **Ministry of Health (VWS)** provides policy guidance, ensuring national standards for vaccination and preparedness are aligned with local implementation (HC).
Response *(immediate actions during/after hazards)*	• Deploy a **coordinated early warning network** for radiological/CBRNe threats with ≥72h autonomous power supply. (**SC/HC**) • Activate **multidisciplinary modular isolation & decontamination units** in outbreak/contamination hotspots. (**SC**) • Integrate **real-time situational awareness** through a secure digital platform combining health, CBRNe, and emergency data. (**MC/SC**)	Response measures include **gamma sensors, solar or UPS backups**, and modular decontamination units (SC). Clear **standard operating procedures for CBRNe alerts** are embedded into the Crisisbeheersingsplan (MC). Regular **simulation drills for pathogen release or chemical incidents** are conducted to maintain readiness (MC/SC). Funding comes from **national security grants and EU Civil Protection funds** (SC/HC).	The **Crisis Management Office** of Enschede coordinates local response (MC), working with **Veiligheidsregio Twente, hospitals, and local fire brigades** to deploy containment and response measures (SC). National-level support from the **RIVM** and **national emergency services** provides technical capacity and crisis surge assistance (HC).
Recovery *(rebuild stronger & more resilient)*	• Deploy a **digital resilience dashboard** to track restoration of healthcare, water, sanitation, and essential services after pandemics/CBRNe incidents. (**MC/SC**) • Establish a **multi-sector Recovery Taskforce** to coordinate repair timelines, resource	Recovery relies on **GIS-enabled dashboards and mobile reporting tools** to monitor progress (MC/SC). **Post-crisis infrastructure audits** are standardised to ensure resilience is integrated into rebuilding (SC/HC). **Recovery liaison teams** connect health, utilities, and citizens to improve coordination and trust (MC/SC). Funding	The **Crisis Management and IT Departments** co-lead dashboard deployment and recovery monitoring (MC). Partnerships with **healthcare providers, utilities, and sanitation services** ensure service restoration (SC). Oversight and funding compliance are provided by the

	allocation, and public communication. (**SC**) • Conduct **after-action reviews** feeding lessons into municipal resilience planning. (**MC**)	comes from **municipal IT/emergency budgets, provincial contributions, and EU resilience funds** (SC/HC).	**Province of Overijssel and national bodies**, ensuring that local actions align with higher-level resilience frameworks (HC).

The evidence tables for Enschede highlight sectoral risks and cross-cutting needs across climate, geopolitical, and public health threats. To operationalise these findings, we set out how municipal, regional, and national actors, together with utilities, housing associations, businesses, and the University of Twente, can work across the disaster management cycle.

Enschede's strengths lie in its **innovation ecosystem (IoT pilots, design labs, university research)**, its **regional collaboration through Regio Twente and Waterschap Vechtstromen**, and its **community networks**. These should be leveraged not only for risk management but also for long-term investment in resilience. The public sector sets frameworks (zoning codes, subsidy schemes, shelter standards, equity criteria in Omgevingsplan), while private and civic partners bring capital, technical expertise, and community trust. Public–private partnerships (PPPs) are essential to deliver scale and accountability, such as redundant utility corridors co-funded by utilities and municipalities, or One Health surveillance systems co-developed with the University of Twente.

Table 3 – Table presenting key cross-risk priorities across the four DMC phases in Enschede, highlighting the complementary roles of public and private actors in coordinating mitigation, preparedness, response, and recovery efforts, which is essential for effective risk management and successful policy implementation.

DMC Stage	Cross-Risk Priorities	Municipal / Public Role	Private / Civic Role
Mitigation	Risk-sensitive spatial planning (flood zoning, no-build zones); nature-based buffers (wetlands, sponge streets, peatland); redundancy in lifelines (separated drainage, diverse routing for power/fibre/transport); resilient retrofitting of hospitals, schools, utilities.	Integrate overlays and resilience clauses into **Omgevingsplan**; fund subsidies for green infrastructure/retrofits; update building codes.	Utilities invest in redundant routing and upgrades; housing associations retrofit social assets; NGOs/citizen groups co-manage green corridors.
Preparedness	Multi-risk monitoring platforms (IoT, eDNA, gamma sensors, health data); dual-use shelters and vaccination hubs; critical infrastructure audits; inclusive community preparedness (volunteers, multilingual drills).	Develop monitoring platforms with University of Twente; mandate continuity planning for utilities/health; fund shelter retrofits and ensure equity.	Utilities/telecoms share data and run stress tests; community groups lead drills and campaigns; volunteers support elderly/disabled readiness.
Response	Rapid deployment of modular assets (cooling, decon, water units); continuity of WASH, power, telecoms, transport; real-time operations centre for cyber/physical threats; multilingual crisis alerts.	Activate **Veiligheidsregio Twente**; mobilise municipal assets and funds; ensure equitable access to shelters/services.	Utilities maintain services and deploy crews; NGOs/schools open facilities as hubs; citizen networks support outreach/communication.

DMC Stage	Cross-Risk Priorities	Municipal / Public Role	Private / Civic Role
Recovery	Build Back Better (multi-use hubs, relocation of assets); ecosystem restoration/remediation; recovery dashboards and resilience bonds; equity-focused recovery (housing, mental health, cohesion).	Allocate funds with transparency; apply equity impact assessments; lead participatory planning via recovery taskforce.	Developers co-finance resilient housing/infrastructure; universities/consultancies support dashboards; community groups deliver social recovery.

6.1 Strategic shifts

Across climate, geopolitical, and public health risks, the evidence tables point to the same recurring pressure points. **Hospitals, schools, and care homes** are strained by heatwaves, pandemics, and cyberattacks; **energy and telecom networks** face disruption from floods, hybrid threats, and radiological incidents; **transport corridors and drainage systems** are vulnerable to heavy rainfall and outages; and **wetlands and water bodies such as Kristalbad and peri-urban streams** are exposed both to flooding and to ecological sabotage. This convergence highlights how risks in Enschede are not isolated, but interlinked — placing simultaneous stress on critical lifelines and the most vulnerable communities.

To address this systemic exposure, Enschede must move beyond ad-hoc measures and adopt **strategic shifts that cut across risk categories, deliver co-benefits, and lock resilience into future planning**. We suggest three strategic shifts: **building back better through multi-use and resilient infrastructure, scaling no-regret measures, and moving from fragmented monitoring to smart, anticipatory systems.**

1. **Build Back Better Through Multi-Use and Resilient Infrastructure**
   The first is to **build back better through multi-use and resilient infrastructure**. Floods are consistently identified as Enschede's most urgent threat, particularly where critical corridors and facilities intersect with vulnerable basins such as the Glanerbeek. Recovery must therefore reduce, not reproduce, existing vulnerabilities. Hospitals, schools, and care homes should be retrofitted as multi-use hubs able to function as care facilities, vaccination centres, cooling shelters, and emergency accommodation. Critical energy, telecom, and transport corridors must be elevated, relocated, or flood-proofed where they intersect with high-risk zones, guided by a flood zoning overlay in the *Omgevingsplan*. This Rebuild–Adapt–Relocate logic ensures that future spatial planning does not lock in new risks, but systematically reduces exposure.
2. **Cross-Dimensional No-Regret Measures**
   Prioritise **cross-dimensional no-regret measures** that cut across climate, geopolitical, and public health risks. The evidence tables show that the same infrastructures—utilities, hospitals, wetlands—are repeatedly under pressure. Enschede should therefore focus on interventions that deliver multiple benefits at once: restoring wetlands, expanding sponge streets, and rewetting peatlands to manage both flooding and drought; diversifying power and fibre routing to safeguard against both floods and cyberattacks; and deploying smart monitoring networks that provide early warnings for climate, health, and security threats. Crucially, these measures must be phased in an equity-first way: underserved districts such as Twekkelerveld and Pathmos should be the first to receive investments in cooling corridors, dual-use shelters, drainage upgrades, and canopy cover. No-regret measures are not just technically sound—they also ensure that resilience begins where vulnerabilities are greatest.

3. **From Ad-Hoc Monitoring to Smart, Anticipatory Systems**
   Enschede's strength as a university city and innovation hub provides a unique opportunity to build a unified City Resilience Dashboard. This platform would integrate environmental monitoring, public health surveillance, CBRNe sensors, and utility data, underpinned by predictive analytics. To be operationally effective, it must include formal agreements for data sharing between the municipality, GGD Twente, utilities, schools, and Waterschap Vechtstromen; baseline cybersecurity protections aligned with national NCSC standards; and clear activation thresholds. For example, rainfall exceeding the 95th percentile would automatically trigger the pre-deployment of pumps, a gamma breach would activate decontamination teams, and a spike in syndromic health data would deploy mobile clinics. With such a system, Enschede can move from reactive crisis management to anticipatory governance that acts before shocks escalate.

These shifts provide the foundations for a **Build Back Better spatial planning framework**, ensuring that recovery after crises does not reproduce old vulnerabilities. In operational terms, this framework requires spatial planners to apply a **Rebuild–Adapt–Relocate** logic

Spatial Planning Framework

Rebuild only in low-risk areas, as defined by watertoets and forward-looking climate projections (2050/2100).

Renovate/adapt in moderate-risk areas, with mandatory adaptation measures included in renovation permits (e.g. green roofs, flood-proofing, shading).

Relocate from high-risk zones using land reallocation and compensation instruments.

By aligning zoning, investment, and monitoring, these strategic shifts ensure that Enschede's recovery after crises does not reproduce old vulnerabilities but creates a resilient, equitable, and future-proof city.

Enschede's resilience depends on rebuilding critical assets as multi-use hubs, prioritising no-regret measures in its most vulnerable districts, and harnessing smart anticipatory systems to move from reactive crisis response to future-proof governance

7 Transferability of Best Practices

The nine evidence tables for Enschede identify critical gaps and opportunities across climate, geopolitical, and public health risks. They highlight repeated vulnerabilities in **critical infrastructure, community resilience, and anticipatory monitoring systems**, as well as the need for **equity-focused planning** in vulnerable districts like Twekkelerveld and Pathmos. Best practices from Flanders, Région SUD, Malta, the UK, and Ireland illustrate how other regions have already tackled similar challenges. These practices were selected because they **directly mirror gaps highlighted in Enschede's evidence tables**:

- Where the tables stress **dual-use infrastructure and community-based preparedness**, Malta's shelters and resilience hubs show how municipal buildings can serve every day and emergency roles.
- Where the tables emphasise **flood risks to utilities and critical facilities**, Ireland's zoning framework and Flanders' cross-border water agreements show how to lock risk thresholds into planning and operations.
- Where the tables point to **fragmented governance**, Région SUD's inter-agency climate structures provide a model for Enschede's cross-sectoral coordination.
- Where the tables call for **anticipatory monitoring**, Aix-Marseille's data-driven risk planning illustrates the power of spatial intelligence and predictive analytics.
- And where the tables highlight **geopolitical and hybrid risks**, the UK's counter-terrorism planning framework demonstrates how to embed protective design into urban development.

Together, these examples offer Enschede a **menu of tested approaches** that can be adapted to local governance structures, building blocks for resilience, and equity priorities.

In the following pages, we outline these best practices in detail, with an emphasis on **how they could be implemented in Enschede**.

7.1 Best Practices

Below we first list best practices relevant to Enschede, indicating the type of risk each one addresses, the nature of the practice, its region of origin, the associated system (social, ecological or technological), and the relevant phase of the DMC (Table 4). These best practices are based on stakeholder feedback from the five regions, contributions from the European Council of Spatial Planners (ECTP) at the European level and the Executive Committee members (UK, Italy, Ireland, France, Norway, Slovakia, Belgium-Walloon, Austria), project consortium expertise, and additional research. Each best practice is then explored further using a 3-step logic: **Context, Relevance for Enschede, Implementation in Enschede.**

Table 4 - Overview of Selected Best Practices Relevant to Enschede.

Relevant Risk	Best Practice	Region of Origin	System (SETS)	DMC Phase
Climate	Cross-Border Flood Agreement	Flanders	Social Technological	Preparedness Response Recovery
Climate	Emergency Decrees	Flanders	Social Technological	Response Recovery

Relevant Risk	Best Practice	Region of Origin	System (SETS)	DMC Phase
Climate	Blue Deal 2.0	Flanders	Social Ecological Technological	Mitigation Preparedness
Climate Geopolitical Public health	Data-Driven Spatial & Risk Planning (Aix-Marseille)	Région SUD	Social Ecological Technological	Mitigation Preparedness
Climate Geopolitical Public Health	Cross-Sectoral Climate Governance (Inter-agency collaboration)	Région SUD	Social	Preparedness Response Recovery
Climate Geopolitical Public Health	Community and Emergency response (emphasis on dual-use infrastructure)	Malta	Social Technological	Preparedness Response
Geopolitical	Counter-terrorism through spatial planning	United Kingdom, Edinburgh	Social Technological	Mitigation Preparedness
Climate	Adapting Land Use to Flood Risk levels	Ireland	Social Ecological Technological	Mitigation Preparedness

7.1.1 Example 1: Cross-Border Flood Agreement – Flanders

Context

In the Moeren region, Flanders and France have established a **joint flood management agreement**[3]. The arrangement allows water to be diverted across borders through shared infrastructure, with **clear responsibilities for maintenance**, **joint early warning protocols**, and **automatic emergency measures** during high water events. This cooperation is critical in an area where low-lying farmland straddles the border and unilateral interventions could worsen flooding on the other side. By embedding collaboration in legal agreements and technical protocols, both sides improved flood safety and avoided disputes.

Relevance for Enschede

The agreement is seen as a model for **cross-border water diplomacy**, ensuring resilience is managed at the scale of hydrological systems rather than administrative boundaries.

Implementation in Enschede

Enschede could establish similar agreements with neighbouring German municipalities and Dutch water authorities (Waterschap Vechtstromen, Provincie Overijssel). This would cover **shared retention and diversion measures**, **joint monitoring**, and **automatic crisis triggers**, ensuring timely and coordinated responses during floods. Such frameworks would prevent fragmented action, optimise use of assets like Kristalbad, and strengthen trust across borders.

7.1.2 Example 2: Emergency Decrees – Flanders

[3] An important step towards connecting Flanders and France

Context

Flanders has repeatedly used **emergency decrees** to bypass lengthy legislative procedures during crises. In 2018, an energy supply crisis was addressed by fast-tracking procurement and supply diversification. During the COVID-19 pandemic, decrees enabled rapid expansion of hospital capacity. More recently, in 2022, emergency legal powers provided flexible housing for Ukrainian refugees. These cases show how temporary, **targeted legal flexibility** enables fast adaptation while preserving longer-term checks and balances.

Relevance for Enschede

Emergency decrees have become a core part of Flanders' resilience toolkit, allowing authorities to act quickly in crises where time is critical.

Implementation in Enschede

Enschede could design a **local emergency decree mechanism** embedded in the Municipal Disaster Plan (Rampenplan), covering floods, industrial accidents, cyber disruptions, or pandemics. This would allow temporary authorisation of **evacuations, shelter conversions, rapid infrastructure reinforcement**, or **public health surges**, giving the city legal flexibility to act without delay.

7.1.3 Example 3: Blue Deal 2.0 – Flanders

Context

The Blue Deal 2.0[4] is a Flemish flagship programme addressing water scarcity and drought. It combines more than 70 measures: restoring wetlands, promoting rainwater reuse, investing in sustainable drainage and sponge infrastructure, and incentivising water-efficient practices across agriculture, industry, and households. Crucially, it integrates **ecological restoration with governance reforms** and long-term funding, creating a comprehensive water resilience roadmap.

Relevance for Enschede

The Blue Deal represents a **multi-pronged, systemic approach** that addresses both immediate risks and long-term climate resilience.

Implementation in Enschede

Enschede could replicate this model with a **"Blue Deal Enschede"**. Actions would include sponge streets, depaving, rainwater harvesting, urban wetlands, and incentives for industrial water reuse. By integrating these under one programme with clear targets and funding sources (municipal + provincial + EU), Enschede could move from fragmented projects to a structured water resilience framework.

7.1.4 Example 4: Data-Driven Spatial & Risk Planning – Région SUD

Context

The Aix-Marseille Metropolis is pioneering **data-informed risk management**, using high-resolution mapping and AI to monitor soil permeability, land artificialisation, and water resources. Satellite and sensor data are integrated into dashboards for both **real-time alerts** and **long-term scenario planning**, supporting adaptive decisions on stormwater, coastal retreat, and ecosystem management.

Relevance for Enschede

[4] Blue Deal | Vlaamse Landmaatschappij

It demonstrates how combining **spatial intelligence with predictive analytics** strengthens both short-term crisis readiness and long-term adaptation.

Implementation in Enschede

Enschede could develop a **spatial risk dashboard** with University of Twente, linking IoT flood sensors, GIS mapping of permeability, and predictive models of rainfall and drainage stress. The dashboard could guide zoning, prioritise depaving and green roofs, and support anticipatory decision-making for flood and drought resilience.

7.1.5 Example 5: Cross-Sectoral Climate Governance – Région SUD

Context

Région SUD uses structured inter-agency frameworks (e.g., Regional Climate Plan) to align land use, water management, forestry, and biodiversity under a **single governance umbrella**. Agencies like ADEME and DREAL PACA coordinate policy, finance, and technical expertise. EU programmes (Horizon, CARDIMED) further link science, policy, and practical interventions.

Relevance for Enschede

It shows how cross-sectoral coordination ensures that adaptation measures are **not fragmented but** aligned across departments and funding streams.

Implementation in Enschede

Enschede could establish a **cross-sectoral climate board** linking municipal departments (Urban Planning, Waterbeheer, Safety, GGD Twente), utilities, and University of Twente. This board would coordinate heat, flood, and drought measures under the **Omgevingsplan**, and use EU pilot funding to integrate science-driven solutions like green corridors and wetlands.

7.1.6 Example 6: Community & Emergency Response (Dual-Use Infrastructure) – Malta

Context

Malta's civil protection system relies on **dual-use infrastructure**. Historic shelters and modern community centres are designed or retrofitted to serve both everyday roles and emergency functions. This is combined with **education campaigns, and real-time SMS alert systems** for heatwaves and floods. A strong emphasis is placed on inclusion of schools and vulnerable populations.

Relevance for Enschede

It highlights how **infrastructure and education together** strengthen resilience, with buildings serving as both hubs of daily life and crisis nodes.

Implementation in Enschede

Schools, sports fields, and community centres could be **upgraded as dual-use facilities** for floods, heatwaves, and pandemics. A **multilingual SMS alert system** could warn residents in real time.

7.1.7 Example 7: Counter-Terrorism through Spatial Planning – United Kingdom (Edinburgh)

Context

Following terror incidents, the UK embedded **counter-terrorism measures into planning guidance**. The

"Crowded Places[5]" framework requires new developments to consider hostile vehicle mitigation, natural surveillance, and protective design features from the outset. Edinburgh provides examples where barriers and layouts are integrated into historic streetscapes without harming accessibility or aesthetics.

Relevance for Enschede

It demonstrates how **planning policy can reduce vulnerabilities** at low cost by embedding security into design, avoiding retrofits.

Implementation in Enschede

Protective design principles could be integrated into **Enschede's urban development codes**. High-traffic sites like the city centre, transport hubs, and event venues could be pilot areas. Guidelines would cover hostile vehicle mitigation, surveillance-friendly layouts, and blast-resistant design. This reduces exposure to hybrid risks while maintaining open, attractive public spaces.

7.1.8 Example 8: Adapting Land Use to Flood Risk – Ireland

Context

Ireland has adopted a **risk-based zoning framework**[6] with three flood zones (A–C). Development in high-risk areas (Zone A) is largely prohibited, with exceptions only for essential infrastructure subject to strict justification tests. Moderate-risk zones (B) restrict sensitive uses like hospitals, while Zone C is considered low risk for development. This approach integrates climate projections and ensures urban growth aligns with long-term safety.

Relevance for Enschede

It illustrates how **land-use planning can systematically reduce exposure** to flood risks without halting development altogether.

Implementation in Enschede

Enschede could introduce a **flood zoning overlay** in its Omgevingsplan, guiding land use by probability and consequence of flooding. Zone A (high risk) would be reserved for water-compatible functions (parks, flood storage), while hospitals, schools, and residential care would be steered away. This structured approach supports long-term adaptation and aligns spatial planning with resilience priorities.

[5] Crowded Places: The Planning System and Counter-Terrorism

[6] the-planning-system-and-flood-risk-management-guidelines-for-planning-authorities-nov-.pdf

8 Implementation and Monitoring Strategy

The evidence tables and recommendations highlight how Enschede's risks, flooding, droughts, heatwaves, cyber-attacks, and pandemics, converge on the same infrastructures and neighbourhoods. Vulnerable districts such as **Twekkelerveld** and **Pathmos** are repeatedly exposed to floods, heat, and social vulnerability. While strong local innovation ecosystems and university-led research provide unique opportunities, resilience will only be achieved if Enschede moves beyond planning into **systematic implementation, continuous monitoring, and adaptive learning**. This section sets out how the city can operationalise its resilience strategy through **coordinated mechanisms, smart monitoring, capacity-building, and community innovation**, ensuring that recommendations translate into visible outcomes.

Implementation Mechanisms

Enschede's resilience efforts should be coordinated through a **City Resilience Council**, chaired by the municipality but bringing together the **Civil Protection Region Twente, Water Boards (Waterschappen), universities (University of Twente), housing corporations, and local neighbourhood associations**. This ensures that urban design, flood risk management, and social equity are addressed in one integrated framework.
Critical to Enschede's strategy is embedding **dual-use infrastructure**. Schools, hospitals, and municipal halls should serve both everyday needs and crisis functions (cooling centres, vaccination hubs, shelters). Implementation should also ensure **no-regret measures** like sponge streets, urban green areas, and redundant utilities are scaled across vulnerable districts. Toolkits on **nature-based solutions, equity-first planning, and dual-use retrofits** can provide practical guidance to local planners, builders, and neighbourhood initiatives.

Monitoring & Evaluation Frameworks

Enschede can build on its innovation ecosystem (University of Twente, Saxion, local startups) to create a **City Resilience Dashboard** that integrates environmental, social, and technological datasets into a single platform with automatic triggers for early action. Further details on these indicators can be found in Section 4, Table 1, which provides a comprehensive overview of the metrics, their definitions, and associated data source. The following examples illustrate this approach; the aim is not to present every possible combination, but rather to demonstrate how local authorities can apply these indicators to assess and strengthen their resilience.
Social indicators

- **Dual-use facility upgrades** – mapped via *social_infra_hospital* and *social_infra_education*.
- **Population and building exposure** – *population*, *buildings_count*, *built_area*.
- **Equity in adaptation investments** – *vulnerable_areas*, *elderly_pct*, *young_pct*, *foreigners_pct*, *rural_urban_class*.
- **Hospital accessibility during crises** – *dist_1*, *dist_2*, *delta_dist.*

Environmental indicators

- **Wetland, green buffer, and urban NbS expansion** – *urban_green_area*, *area_nature_zone*, *biodiversity_intact_index*, *land_cover_lvl2/3*.
- **Agricultural drought resilience** – *area_agri_parcel*, *drought_score*.
- **Wildfire-sensitive ecosystems** – *wildfire_risk*, *area_nature_zone*.

Technological indicators

- **Resilience of lifeline corridors** – *road_class*, *infra_station*, *critical_energy_infra*.
- **Protection of critical facilities in hazard zones** – *industrial_risk_site*, *social_infra_hospital*, *wastewater treatment (if available)*.
- **Retrofit rates in older buildings** – *constr_year* as a proxy for building vulnerability.
- **Continuity of financial & governance services** – *infra_bank*, *infra_government_building*.

Hazard / cross-cutting indicators

- **Flood hazard evolution** – *fluvial_flood_score*.
- **Heat stress evolution** – *heat_waves_4_5*.
- **Multi-hazard exposure** – *climate_risk* (collection of hazards) and *dist_nuclear_pp* (as a specific geopolitical/technological risk).

Governance indicators

- **Number of multi-hazard simulation exercises per year** – tracked at *nuts3* or *lau1* scale.
- **% of neighbourhoods with resilience action plans** – linked to *lau2 (wijk/buurt)* units.

Public accountability requires annual **Resilience Progress Reports**, disaggregated by neighbourhood (*lau2*) and municipality (*lau1*), so residents can see tangible progress and disparities addressed.

Capacity-Building and Training

Resilience data must translate into usable skills. Enschede should expand **training for municipal planners, housing associations, and utilities** on topics such as dual-use design, NbS maintenance, and crisis communication. Special emphasis should be placed on **equity training** so that vulnerable districts receive priority interventions.
Annual **cross-risk simulation exercises** involving floods, cyberattacks, and health emergencies would test preparedness across agencies. Smaller-scale **neighbourhood workshops** could empower residents to use dashboards, report vulnerabilities, and co-manage adaptation measures like green roofs and sponge streets.

Social Innovation and Collaboration

Enschede's strength lies in its **university-driven innovation ecosystem**. Partnerships between the municipality, University of Twente, and local tech startups could deliver **IoT-enabled flood monitoring, AI-based heat mapping, and real-time health–climate surveillance**.
A **Resilience Learning Platform** at the city-region level could allow **neighbourhood councils, water boards, and NGOs** to share practices and learn from European peers via Horizon Europe and Interreg North-West Europe. Embedding resilience in local law—through **mandatory resilience clauses in zoning plans** and **dual-use requirements in building permits**—would institutionalise practices and guarantee continuity.

Next Steps

For Enschede, resilience must move from **isolated neighbourhood pilots to a city-wide, data-driven framework**. A City Resilience Council, backed by harmonised monitoring using the provided metrics, would provide the

governance backbone. Annual reporting, simulation exercises, and equity-focused planning would build public trust and ensure that investments reach the most vulnerable.

By aligning its monitoring system to **exposure, vulnerability, and hazard indicators already available**, Enschede can deliver anticipatory, equitable, and systemic resilience. This ensures that sponge streets, wetlands, shelters, and smart dashboards are not stand-alone projects but integrated into a broader **Build Back Better framework** that protects citizens, ecosystems, and critical services for the long term.

9 Conclusion

The analysis of Enschede's risks across climate, geopolitical, and public health categories reveals a common pattern: the city's resilience hinges on the same infrastructures, the same vulnerable neighbourhoods, and the same need for anticipatory governance. Floods, cyber threats, and health emergencies all converge on critical lifelines, hospitals, schools, energy and telecom networks, water systems, and transport corridors, while social and ecological vulnerabilities concentrate in districts such as Twekkelerveld and Pathmos.

The nine evidence tables have provided detailed, actionable recommendations across the disaster management cycle, supported by clear instruments and governance structures. The synthesis shows that to move from fragmented initiatives to systemic resilience, Enschede must embrace three strategic shifts:

- **Build Back Better** by ensuring hospitals, schools, and infrastructure are reconstructed or retrofitted as multi-use, resilient hubs, and by relocating or elevating assets in high-risk flood zones.
- **Scale No-Regret Measures** such as wetlands, sponge streets, redundant utility routing, and equity-first planning, which simultaneously protect against multiple risks while delivering social and ecological benefits.
- **Leverage Smart, Anticipatory Systems**, using Enschede's innovation ecosystem to unify IoT, eDNA, syndromic health, and utility monitoring into a City Resilience Dashboard that can trigger pre-emptive action.

The review of international best practices demonstrates that these shifts are feasible and already in motion elsewhere. From **Ireland's flood zoning** to **Flanders' Blue Deal** to **Région SUD's data-driven risk mapping**, the transferable lessons are clear: resilience is strongest where governance, technical tools, and community engagement are aligned.

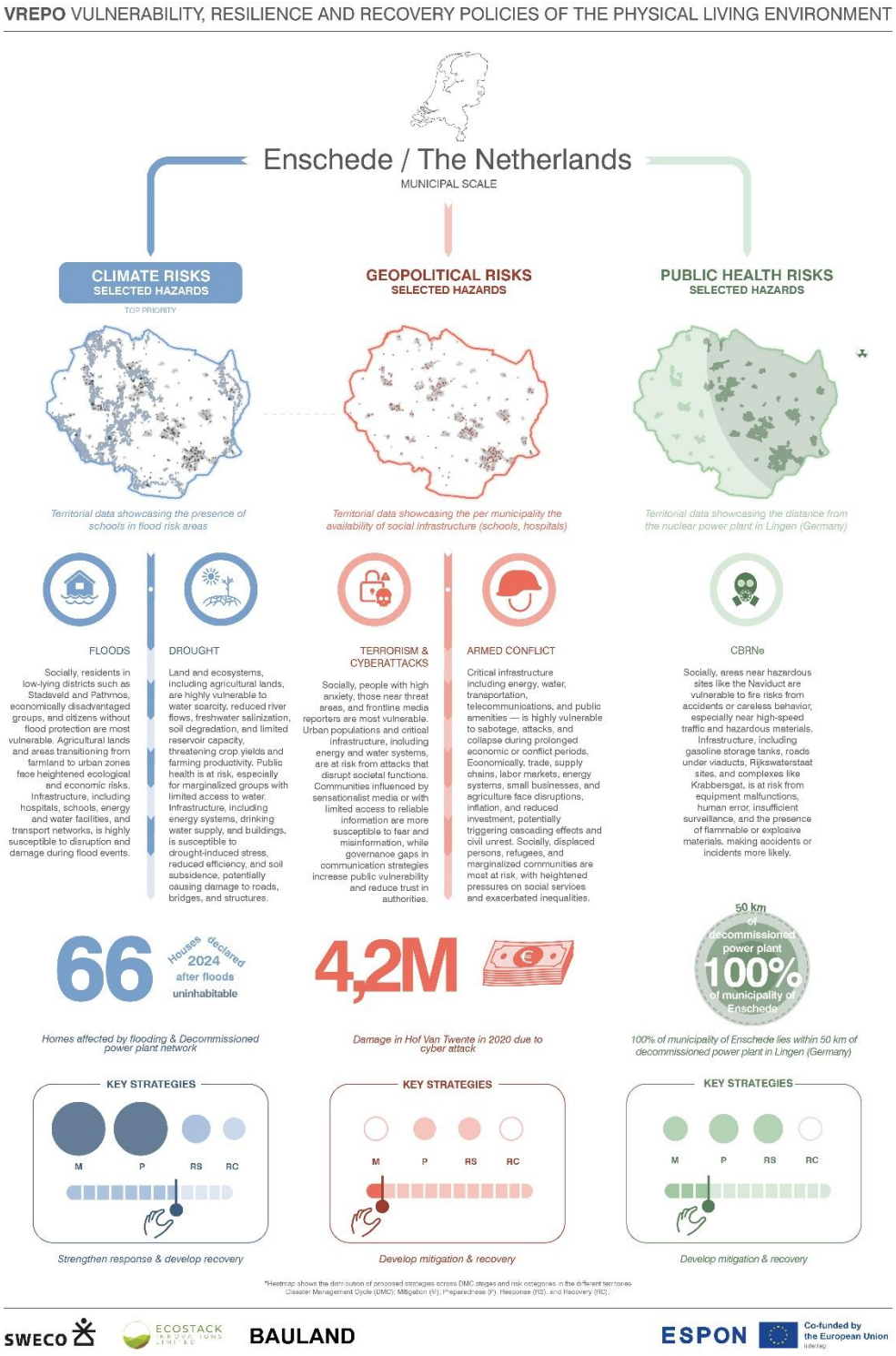
By embedding these measures, Enschede has the opportunity to become a **regional leader in anticipatory, equity-driven resilience**, one that not only protects its most vulnerable communities and infrastructures but also uses innovation and collaboration to transform crises into opportunities for long-term sustainability.

Key Policy Takeaways

- **Strengthen Critical Infrastructure:** Retrofit, relocate, or elevate hospitals, schools, and essential services as multi-use resilient hubs.
- **Implement Multi-Benefit Measures:** Expand wetlands, sponge streets, and redundant utility networks to protect against multiple risks while supporting social and ecological goals.
- **Adopt Smart, Anticipatory Systems:** Use IoT, health, and utility monitoring via a City Resilience Dashboard for proactive risk management.
- **Focus on Vulnerable Neighborhoods:** Prioritize districts like Twekkelerveld and Pathmos for targeted interventions.
- **Align Governance and Community Engagement:** Integrate government, technical tools, and citizen participation for effective, equitable resilience.

10 Annexes

The Enschede poster presents a clear synthesis of the project's findings for the region, highlighting local vulnerabilities, hazard exposure, and resilience strategies across climate, geopolitical, and public health risks. By connecting these insights to the Policy Recommendations chapter, it provides a visually engaging tool to support discussion, prioritization, and context-specific policymaking.



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ESPON 2030

ESPON EGTC
11 Avenue John F. Kennedy
L-1855 Luxembourg
Grand Duchy of Luxembourg
Phone: +352 20 600 280
Email: info@espon.eu
www.espon.eu

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