SGA-NZC

Foresight, anticipation and horizon scanning

Deliverable D4.16 Strategic insights for urban climate transition through horizon scanning, deep dives, and scenario generation

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Table of contents

List of figures

List of tables

Abbreviations and acronyms

Acronym	Description
AI	Artificial Intelligence
BC3	Basque Centre for Climate Change
CCC	Climate City Contract
CNAP	Climate Neutrality Action Plan
COE	Community-Owned Enterprise
CTM	Climate Transition Map
DML	Dark Matter Labs
EC	European Commission
EU	European Union
GHG	Greenhouse Gas
IfM	Institute for Manufacturing (University of Cambridge)
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
NZC	NetZeroCities
PESTLE	Political, Economic, Social, Technological, Legal, Environmental
POLIMI	Politecnico di Milano
SGA	Specific Grant Agreement
SGA-NZC	Specific Grant Agreement NetZeroCities
UCL	University College London
UN	United Nations
UPC	Universitat Politècnica de Catalunya
UTAK	Finnish Transport Infrastructure Agency
WP	Work Package

Summary

This report contextualizes the learnings from Task 4.8 (WP4): horizon scanning, anticipation, and foresight. It summarizes work undertaken throughout the task and incorporates learnings and reflections that can inform future work.

NetZeroCities supports cities aiming for climate neutrality by 2030—a very short timeframe for profound systemic change. Foresight tools enable cities to stretch thinking beyond short-term incremental measures and consider transformative trajectories. Urban systems are complex and subject to multiple interacting drivers (technological, social, economic, and governance-related). Foresight helps unpack this complexity, anticipate disruptive shifts, and create robust strategies. By exploring multiple futures and pathways, cities can prevent being locked into sub-optimal trajectories or investing in solutions that become obsolete. Futures work creates shared visions that help align diverse actors, unlock investments, and guide coherent portfolios of actions rather than isolated projects.

The purpose of Task 4.8 was to implement an anticipatory process by triangulating emerging signals from cities alongside scanning the horizon of risks and opportunities in the external environment of the Mission, including global trends and events (and potential crises). This approach enables capacity for agile responses and innovation through future programme and service (re)design.

The task integrated knowledge from various research activities and coordinated with Work Packages 2, 3, and 6 to enable agile responses and innovation in future programme and service design.

This task was structured around three core activities: **Horizon Scanning Interviews**—consultations with domain experts across Europe and internationally to identify trends, opportunities, and risks that may impact cities and the NetZeroCities mission; **Foresight Deep Dives**—intensive 30-day research sprints distributed across three-month intervals, examining critical areas of risk or opportunity for cities, with focus on near-term developments likely to impact urban systems within a 12-36 month timeframe; and **Scenario Generation**—drawing upon insights from horizon scanning interviews and foresight deep dives to develop scenario narratives exploring potential trajectories of identified trends, drivers, risks, and opportunities over the coming years. This process involved engaging external experts and delivering scenarios to help the consortium, cities, and the Mission anticipate barriers, bottlenecks, and opportunities.

T4.8 involved external experts as well as leveraging expertise and insights from consortium partners. Delivering both Deep Dives and Scenarios for the consortium, cities and the Mission to aid the anticipation of barriers, bottlenecks and opportunities facing the Cities Mission.

T4.8.1 Horizon Scanning, Weak Signal Recognition, and Pattern-Finding: This component involved conducting desk-based research and expert interviews to identify near-term and future trends, focusing on both risks and opportunities. Quarterly horizon scanning briefings were produced, providing insights into emerging trends and their implications for the Mission.

T4.8.2 Expert Engagement and Co-Creation: Aligning with T4.8.1, Deep Dives consisted of short intensive research sprints into pertinent topics that could present future risks or opportunities for cities. Alongside literature reviews establishing the state of knowledge in each topical area, external experts were engaged where appropriate to provide insights on social, economic, demographic, technological, and other trends affecting urban climate transitions. The insights gathered from these activities fed into the horizon scanning briefings and ensured that scenarios developed were informed by diverse perspectives and expertise.

T4.8.3 Scenario Development: Four visual syntheses of possible future scenarios were produced to support Mission development, SGA review, and external communications. These scenarios were designed to help cities anticipate barriers, bottlenecks, and opportunities, providing a strategic framework for planning and executing their transition to carbon neutrality. The scenarios leveraged

insights from deep dives in areas such as energy consumption, systemic impacts of emerging technologies, and socio-economic challenges.

Implications for Cities: The work presented provides cities with calibrated understanding of diverse risks, ranging from climate change as a security risk multiplier to the risk of maladaptation through misalignment of adaptation and mitigation efforts, and material supply chain vulnerabilities.

Finance remains a significant barrier to long-term sustainability efforts. Alternative governance structures such as community-owned enterprises (COEs) can address these challenges. The importance of alternative approaches to structuring projects and pilots in municipalities emerged through interviews and deep dive investigations. The outcomes of Task 4.8 scaffold city understanding of possibilities in this domain.

The complexities of decarbonizing urban infrastructure while maintaining environmental justice and equity are amplified by geopolitical shifts, particularly dependence on external supply chains and workforce shortages for energy transitions.

The implications of this activity for Work Package 4 include demonstrating that the Learning vision and framework must encompass future-focused storytelling assets with broader applicability. The standalone structure of the task revealed that foresight and anticipation capabilities need to be embedded within cities themselves for effective capacity and capability building. Knowledge production implications emerged through experiences with communication strategies.

The mission aims to deliver concrete solutions to critical challenges by 2030. The work in Task 4.8 illustrates the scale of this challenge, particularly through scenarios that reveal the enormous acceleration of activity required on pathways toward desirable futures within a compressed timeframe. This heightens the Mission's understanding of the necessary pace of change. Fundamentally, the cross-cutting nature of the deep dives demonstrates how siloed working can obscure key issues and knowledge essential for cities, underscoring the importance of integrated approaches in future project design.

Keywords

Foresight, anticipation, scenarios, horizon scanning, risks, vision, deep dive, city transitions, climate adaptation,

Introduction

1. Overview

Task 4.8 provided an anticipation and foresight function for NetZeroCities, enabling capacity for agile responses and innovation through future programme and service (re)design, in coordination with Work Packages 2, 3, and 6. The task engaged external experts and delivered scenarios to support the consortium, cities, and the Mission in anticipating barriers, bottlenecks, and opportunities.

This deliverable report is structured around three main components: horizon scanning, deep dives, and scenario generation, supported by several annexes that collate the outputs of the task.

In summary, the report describes the integration of various research activities and analyses that help European cities navigate the complexities of the green transition. The work completed establishes a foundation for agile and informed responses to the dynamic challenges of achieving climate neutrality by 2030.

1.1. Purpose

The purpose of this deliverable report is to summarize work undertaken in Task 4.8 and consolidate outputs in a single repository.

By presenting collated outputs, this deliverable serves as a resource to support European cities in their transition to climate neutrality by 2030 through futures-focused research. The anticipation and foresight process was designed to enable agile responses and innovation through the future design and redesign of programmes and services.

By providing access to materials that identify and address potential challenges early, this document aims to empower cities to navigate the complexities of the green transition with greater strategic foresight.

1.2. Activity Framework

The anticipation and foresight work package partners convened fortnightly to align on task execution and synthesis of findings for deliverable preparation. The work was structured around three principal activities:

- **Horizon Scanning Interviews** - Consultations were conducted with domain experts across Europe and internationally to identify emerging trends, opportunities, and risks with potential implications for cities and the net-zero cities mission.
- **Foresight Deep Dives** - Intensive 30-day research cycles, distributed across three-month intervals, examined critical areas of risk or opportunity for cities. These investigations focused on near-term developments likely to impact urban systems within a 12-36 month timeframe.
- **Scenario Generation** - Drawing upon insights from horizon scanning interviews and foresight deep dives, scenario narratives were developed to explore potential trajectories of identified trends, drivers, risks, and opportunities over the coming years.

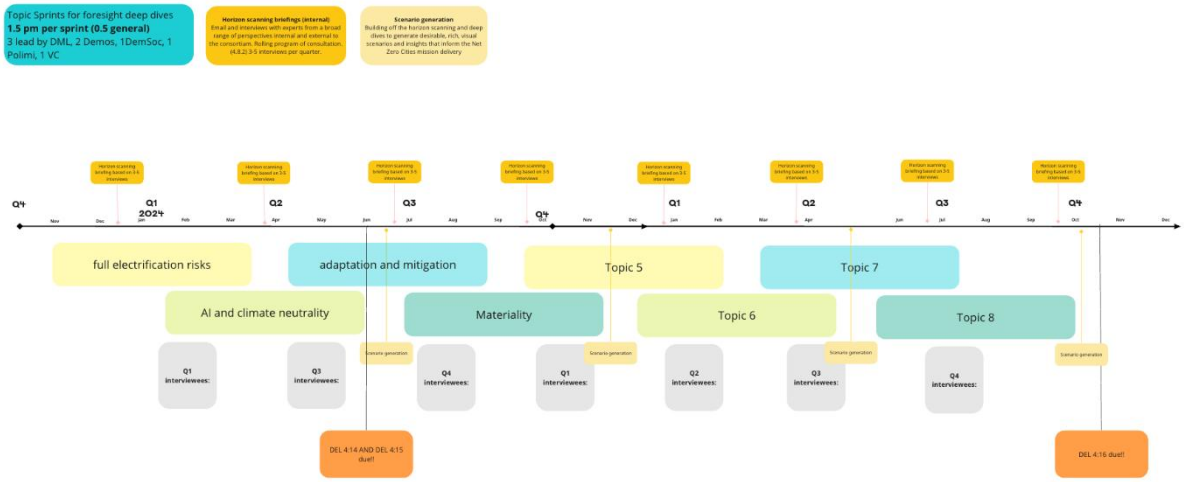

Figure 1: Timeline of WP4.8 activities

2. Horizon Scanning Interviews

The horizon scanning activity it sought to inform the wider NZC program through weak signal recognition and pattern-finding.

2.1. Approach

Horizon scanning constitutes a systematic methodology for identifying emerging trends, opportunities, and potential challenges that may influence the trajectory of urban systems and net-zero transitions. This approach entails the systematic collection and analysis of information from diverse sources to detect early signals of change within urban contexts. Within the scope of this work package, horizon scanning has served as a foundational tool for identifying key phenomena that inform the development of scenario narratives for net-zero cities (Amanatidou, Butter, Carabias, Könnölä, & Leis, 2012).

The horizon scanning exercise was designed through a collaborative workshop process, establishing its primary objective: to generate insights into trends, challenges, risks, and opportunities for cities pursuing climate neutrality. Particular emphasis was placed on disruptive developments and transformative changes that extended beyond incremental progress. The exercise was structured as a 20-month programme of expert consultations, responding to themes that emerged from continuous signal detection across academic literature, news media, City Support Group activities, and relevant events. The temporal focus encompassed an 18-36 month horizon, with thematic areas organized according to risk domains including technology, environment, and economy.Interview protocols were developed based on the '7 questions' foresight methodology (Hines & Bishop, 2006), designed as semi-structured conversations with flexibility for topic-specific inquiry. Interviewee selection prioritized both technical expertise and contextual knowledge, acknowledging a predominantly European focus while actively seeking perspectives from other regions. The initial target of 25-30 interviews (approximately four per quarter) proved challenging to achieve due to limited participant incentives.

Thematic analysis identified recurring themes, trends, drivers, risks, and opportunities to inform parallel work streams. Analysis distinguished between weak signals (emergent indicators of change) and strong signals (established trends), though the rigor of this assessment varied across interviewers.Findings were categorized into thematic clusters based on identified patterns and common topics. These analyses were synthesized into quarterly horizon scanning briefings, which assessed signal relevance, potential impact, and likelihood of influence on the net-zero cities mission. This reporting cadence proved difficult to sustain consistently throughout the work package duration.This analysis considered the following aspects:

- **Emergence:** How new is the trend? Is it just starting to appear or is it well-established?
- **Impact:** What is the potential impact of the trend on your organization or area of interest?
- **Uncertainty:** How certain are you about the trend's development? Are there conflicting signals or high levels of uncertainty?

2.2. Questions

A core set of interview questions was developed based on the '7 questions' foresight methodology (Hines & Bishop, 2006). The interview protocol is presented below. Interviewers supplemented these foundational questions with deepening inquiries and topic-specific probes, prepared in advance of each consultation.

1. Can you tell us a little about your area of focus? We're interested particularly in how it overlaps with the NZC mission ambition of supporting cities to climate neutrality by 2030.
2. What is the most interesting thing at the moment in your area of focus? What excites you?
3. What are the current trends, drivers, and risks that impact on [your area of focus]?
4. Optimistic but realistic: If things went well, how do you expect [your area] will develop over the next 5-10 years? What would be the signs of success? Can you tell us an ideal scenario?
5. What is the worst-case scenario you can imagine, what are the factors or challenges that would enable this?
6. The internal situation: From your knowledge of the organization, culture, knowledge systems, and resources (including people) that impact on [your area], how would these have to be changed to support the NetZeroCities mission or reach the optimistic state?
7. What are the key barriers and threats to [your area]? What events or environmental conditions could deteriorate the situation and impact the NetZeroCities mission?
8. Looking back 10-20 years, what has shaped [your area]?
9. Looking forward: What decisions or investments need to be made in the short term to enable a successful long-term state for [your area]?

2.3. Interviewees

Interviewee biographies are presented below. This list excludes individuals who requested anonymity and those who contributed directly to foresight deep dive investigations.

Sobia Kapadia
Sobia Kapadia is Senior Project Manager on the UKRI GCRF Gender, Justice and Security Hub at Middlesex University. She graduated as an architect in 2004 and joined the United Nations in 2010. She has worked in South Asia and the Middle East with a focus on gender, social justice, and human rights. Her work has primarily concentrated on urban resilience and community development to improve living conditions for the most vulnerable in disaster-affected and conflict regions. She has delivered and managed projects for the UN and international NGOs. Within the Hub, Sobia manages projects across the Migration and Displacement and Transformation and Empowerment streams.

Pooja Agrawal
Pooja Agrawal is an architect and planner who served as a public sector professional at Homes England and the Greater London Authority (GLA). During her tenure at the GLA in the Regeneration and Economic Development team, she developed the concept for and co-founded Public Practice in 2017. Previously, she worked at private architecture and urban design practices, including Publica, We Made That, and G-Tects (New York), taught at Central Saint Martins, and served as a Trustee for the Museum of Architecture. She was nominated for the Planner's Women of Influence award in 2018, 2019, 2021, and 2022. Public Practice is a social enterprise founded by Pooja Agrawal and Finn Williams to improve the quality of everyday places by building the public sector's capacity for proactive planning. The organization addresses how built environment experts can better serve society by embedding talented architects and urbanists within local authorities to tackle complex challenges, including the shortage of affordable housing.

Professor Tim Minshall
Professor Tim Minshall is the Head of the Institute for Manufacturing (IfM) and of the IfM's Centre for Technology Management. He is the inaugural Dr John C. Taylor Professor of Innovation, a member of the board of directors for St John's Innovation Centre Ltd and IfM-ECS Ltd, a Visiting Research Fellow

at the Institute of Technology, Enterprise and Competitiveness (ITEC) at Doshisha University, and a member of the IET's Innovation and Emerging Technologies Policy Panel. He is a member of advisory / steering committees for groups including ideaSpace, Cambridge i-Teams and 100% Open.He is a member of the board of directors for IfM Engage Ltd, St John's Innovation Centre Ltd, and the Møller Institute Ltd. Tim is a Fellow of Churchill College Cambridge and is Chair of Trustees for the William Templeton Foundation for Young People's Mental Health (YPMH).

Anders Wijkman
Anders Wijkman is a Swedish thought leader and author. Since 2012, he has served as Co-President of the Club of Rome, the global think tank, alongside Professor Ernst Ulrich von Weizsäcker. In 2017, he was appointed Chair of the Governing Board of Climate-KIC, a major public-private partnership at EU level promoting innovation for a low-carbon society. Since 2015, he has been a member of the International Resource Panel (IRP), a UN-appointed expert body established to build and share knowledge needed to improve global resource use. The Panel's goal is to steer away from overconsumption, waste, and ecological harm toward a more prosperous and sustainable future. Anders Wijkman also serves as Chair of the Association of Recycling Industries in Sweden and holds membership on the board of Sida (the Swedish International Development Cooperation Agency), the Royal Swedish Academy of Sciences, the Royal Swedish Academy of Agriculture and Forestry, and the World Future Council.

Marta Olazabal
Marta Olazabal is an interdisciplinary scientist exploring pathways of progress on climate action in cities worldwide. She is an Ikerbasque Research Associate and Head of the Adaptation Research Group at the Basque Centre for Climate Change (BC3), where she facilitates conversations around urban sustainability and serves as a member of the Management Committee. She holds a background in Environmental Engineering and a PhD in Land Economy, with almost 20 years of experience in urban sustainability and climate governance. Her research interests revolve around environmental governance, local climate planning, and transdisciplinary sciences, including knowledge production. Her current work focuses on assessing climate adaptation progress at the local scale. She maintains an extensive publication record in top international peer-reviewed journals, actively advises national and international bodies, and mentors MSc and PhD students. Since 2020, she has served on the Steering Committee of the International Platform on Adaptation Metrics (IPAM). She is currently Principal Investigator of the European Research Council project IMAGINE Adaptation.

José Chong
José Chong is an urban development and international cooperation specialist with over 20 years of professional experience. He has an established track record in managing global programmes for urban planning strategies, urban regeneration, and public space policies within international organizations. He leads the Global Public Space Programme at the Planning, Finance and Economy Section of the United Nations Human Settlements Programme (UN-Habitat). He has served as technical coordinator on urban planning and design initiatives in Latin America and the Arab States, and has advised numerous national and local governments on urban policies and sustainability strategies. He holds a degree in International Cooperation, with specializations in Urban Development, Post-Disaster Architecture, Renewable Energies, and Sustainable Architecture and Urbanism.

Dr Pablo Sendra
Dr Pablo Sendra is an architect and urban designer. He is an Associate Professor at The Bartlett School of Planning, University College London (UCL). He combines his academic career with professional practice through his urban design consultancy, LUGADERO LTD, which specializes in facilitating co-design processes with communities. At UCL, he serves as Director of the MSc Urban Design and City Planning Programme and Coordinator of the Civic Design CPD and the Cultural Infrastructure short course. He has undertaken action-research projects in collaboration with activists and communities. He is co-author of *Designing Disorder* (with Richard Sennett, 2020), which has been translated into seven languages, co-author of *Community-Led Regeneration* (with Daniel Fitzpatrick, 2020), and co-editor of

Civic Practices (with Maria João Pita and CivicWise, 2017). He is a member of the City Collective for the journal *City*.

Zaida Muxi
Dr Zaida Muxí is Associate Professor in the Department of Urbanism and Spatial Planning at the Universitat Politècnica de Catalunya (UPC), where she teaches urbanism and gender studies. She is a member of the research group QURBIS (Quality of Urban Life: Innovation, Sustainability and Social Engagement). Her research at UPC focuses on three main areas: gender studies in planning and architecture; dwellings and neighborhoods; and the impact of globalization on the urban fabric, encompassing both social and built dimensions. She is an architect and researcher with over 30 years of experience and extensive expertise in gender equality principles and their application in urban contexts, including the development and application of gender quality indicators.

Dr Lauri Holappa
Dr Lauri Holappa has worked as a post-doctoral researcher at the University of Helsinki, university teacher at the University of Turku, senior researcher at Demos Helsinki, and as a special economic policy adviser to former Minister of Education Li Andersson. As Executive Director of The Finnish Centre for New Economic Analysis (UTAK), he aims to challenge prevailing economic orthodoxy. The societal goals of UTAK include advancing democracy, equality, full employment, sustainable development, and reducing inequalities in income and wealth.

2.4. Themes and trends identified through interviews

- **Industrial Transformation and Urban Emissions** — Within the manufacturing domain, 'Regenerative Manufacturing' emerged as a significant trend, representing a fundamental reimagining of factory function and purpose. Professor Tim Minshall referenced the conceptual work of Professor Steve Evans (Director of Research in Industrial Sustainability, University of Cambridge Institute for Manufacturing), who envisions "the factory you want at the end of your street"—an industrial facility that produces clean energy, water, and purified air as beneficial outputs rather than pollutants.

  Interventions within manufacturing and production systems demonstrate substantial mitigation potential at scales directly relevant to urban emission reduction targets. Concrete production, for instance, accounts for approximately 8% of global emissions—substantially exceeding aviation's 2% contribution. Source-level interventions in such high-impact sectors therefore present opportunities for emission reductions of significant magnitude for net-zero city transitions.

- **Supply Chain Resilience and Maritime Transport —** Within this context, sustainable and resilient shipping has emerged as a critical concern, with recent geopolitical tensions in the Red Sea amplifying the vulnerability of established shipping routes and protocols. These disruptions have already impacted global supply chain timeliness, while growing recognition within the maritime sector suggests that shifting consumer expectations away from immediate delivery may prove essential.

  Research indicates that reducing vessel speeds by 10% across the global fleet could achieve a 13% reduction in greenhouse gas emissions from the shipping industry (Faber et al., 2017; Leaper, 2019)—a greater impact than transitioning to alternative fuels in the near term. Such speed reductions additionally reduce whale-ship collision risk by approximately 50% and underwater noise pollution by 40% (Leaper, 2019), thereby contributing to marine biodiversity conservation.

- **Public Sector Capacity and Skills —** Public sector staffing and skilling was highlighted by Pooja Agrawal with a recognition that the last 10-20 years has seen a trend of skills loss in the

public sector. The cause and experience of this varies across Europe ranging from austerity measures to an aging population and changing population needs. In this context, Public Practice as an organization specializes in attracting professionals from the private sector into public service roles and stresses the need for new roles and job descriptions that meet the city transition needs and the new cultures of work and capabilities that are required.

- **Climate-Induced Migration and Governance —** Sobia Kapadia emphasized that contemporary discourse must extend beyond climate change to encompass climate chaos and crisis, particularly in relation to livelihoods and governance structures affected by climate-induced population displacement. As a specialist in migration and displacement, she underscored the necessity for micro-level governance frameworks capable of responding dynamically to the evolving needs of migrant communities. Such frameworks must address housing provision, temporary employment arrangements, and social integration mechanisms. The majority of associated challenges are human-induced, reflecting inadequate or incapable governance structures that systematically marginalize vulnerable populations and constrain their adaptive capacity**.**

- **Urban Climate Adaptation and Evaluation — Marta Olazabal** emphasized the critical need for cohesive strategies in both mitigation and adaptation to climate change at the city level, pointing out a common pitfall of addressing these strategies in silos - within the same municipal departments. Contrasting with the more established evaluation and funding mechanisms available in the field of mitigation, She identified a significant challenge in the field of adaptation—primarily, the lack of evaluation methods, which affects the cities' ability to assess the effectiveness of interventions and how these really enhance resilience or lead toward maladaptation. This gap not only hinders understanding and measuring progress but also impacts the accessibility of financing options, particularly affecting cities that are already vulnerable and less equipped to confront these barriers. Moreover, Marta O. advocated for a change of narrative in how adaptation strategies are evaluated, calling for an approach that extends beyond technical measures to embrace a more inclusive, socially oriented framework. This includes integrating notions of justice, equity and amplifying diverse perspectives from the bottom-up, particularly those of more vulnerable cities, while at the same time addressing potential maladaptive outcomes. Redefining success in adaptation should be better connected with local realities and include notions of health, well-being and consumer behaviors (e.g., food choices) alongside the traditional metrics.

- **Gender Perspectives in Urban Planning — Zaida Muxi** emphasized the importance of incorporating a gender perspective in urban planning, highlighting the need to recognize and integrate care roles traditionally assigned to women. She pointed out that current urban mobility plans often overlook these roles, which involve complex, multifaceted trajectories. Muxi identified a significant challenge in overcoming the reductionist economic view of city planning, advocating instead for the feminist economy that values unpaid care work. This shift is crucial for creating mixed-use, walkable, and safe neighbourhoods, contributing to sustainable cities. Additionally, Muxi called for addressing suburban sprawl and promoting neighbourhoods that integrate diverse societal and age groups. She also stressed the importance of involving men in care work and building narratives that normalize and value collective care responsibilities. By recognizing and valuing care work, cities can enhance resilience and move towards climate neutrality, aligning with the goals of the Net Zero Cities project.

- **Political Dynamics and Climate Governance — Lauri Holappa** articulated that the rise of the extreme right makes it difficult to predict the future. Critically, extreme right-wing parties in national governments actively impede climate action, demonstrating limited commitment to advancing climate policy. This dynamic increasingly constrains municipal climate initiatives. While cities maintain considerable autonomy, carbon neutrality targets cannot be pursued in isolation from broader policy frameworks. The capacity of even major cities to invest in climate

> change mitigation becomes severely limited when higher levels of government reverse direction on climate commitments. The rise of extreme right-wing politics also generates indirect effects, notably influencing center-right parties toward more conservative positions and diminished engagement with climate policy. Climate action becomes then increasingly challenging when oppositional forces gain electoral legitimacy and institutional power. As these forces become embedded within governance structures, advancing climate initiatives grows more difficult. Moreover, as climate-skeptical actors deepen their institutional presence, articulating the imperative for systemic change becomes progressively more complex, given that the governance system itself becomes implicated in perpetuating the problem.

The remaining interviews fed directly into Foresight Deep Dives and were anonymised.

The horizon scanning interviews revealed that urban climate action is shaped by intersecting challenges including geopolitical instability, political dynamics, and financial constraints. Community-driven initiatives, particularly in housing and mobility, demonstrate vital potential for scaling climate solutions, yet face substantial funding barriers. Gender inclusivity and the recognition of care work emerge as essential components for equitable and sustainable urban futures, directly linking social justice imperatives with environmental objectives. While technological innovation presents significant opportunities for climate mitigation, effective deployment requires robust policy support and appropriate financial mechanisms at national and international levels to ensure solutions are both scalable and inclusive.

These insights from the horizon scanning interviews informed the subsequent deep dive investigations and scenario development activities. The themes identified—from regenerative manufacturing to political dynamics—highlighted the need for cities to integrate climate action with social equity, economic resilience, and technological innovation. These findings provided critical focal points for more intensive research and formed the foundation for exploring potential future trajectories, examining how local interventions might align with broader policy frameworks through systemic approaches to achieving climate neutrality.

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3. Foresight Deep Dives

Research activities were structured as deep dives, which sought to conduct an anticipatory process by exploring risks and opportunities within trends in the external environment of the Mission, including global trends and events (and potential crises). By collating the current state of knowledge on selected topics and analyzing the implied constraints and opportunities for cities, these investigations provided a knowledge base to enable agile responses and innovation through future programme and service (re)design.

3.1. Approach

A Deep Dive is a qualitative research technique involving detailed investigation into a particular subject. It explores underlying causes, implications, and intricacies beyond surface-level information to develop nuanced understanding that can inform decision-making, strategy, and further research.

Within Task 4.8, Deep Dives were structured as intensive three-month research sprints led by relevant partner organizations. Over the lifetime of the task, five deep dives were undertaken, with allocation dependent on available person-months per partner.

Deep Dives were framed through a lens of systemic transformation. Topics were selected based on their direct impact on cities' mandates to create quality of life and protect citizen health, alignment with the Cities Mission, and expected impact prior to 2030. Priority was given to emerging issues likely absent from current municipal action plans or strategies.

3.2. Methodology

Each deep dive began with initial scoping through collaborative workshopping to surface existing collective knowledge and insights. This was followed by systematic literature review to establish the current state of knowledge, accompanied by targeted expert interviews. Analysis articulated trends, drivers, risks, and opportunities impacting cities, employing collaborative and interdisciplinary methods emphasizing sustainability, resilience, and social equity. Each Deep Dive concluded with synthesis of key findings, analysis of current patterns and misconceptions, and comparison of relative advancements against absolute requirements for transition. Research was distilled into actionable takeaways for cities, informing descriptions of constraints and opportunities in scenarios where these topics' impacts are widely felt.

Selected topics for deep dives included:

#	Title	Authors	Organization	Full Version
1	**Integrating Mitigation and Adaptation** *Pathways for urban climate resilience and justice*	Mariela Urra Schiaffino, Reviewers: Otto-Wille Koste, Anna Kurth	Demos Helsinki	Annex 1
2	**AI Towards Climate Neutrality** *Exploring the Role of Artificial Intelligence in Achieving Sustainable, Carbon-Neutral Urban Futures*	Eden Grace Sicat, Lucía Nogales, Marzia Mortati.	Politecnico di Milano. Design Department	Annex 2
3	**Navigating Electrification Risks in European Cities** *Strategies for Sustainable Transition Amid Rising Demand and Geopolitical Challenges*	Ivana Stancic, Contributions: Alexandra Hansten Review: Aleksander Nowak (Dark Matter Labs)	Dark Matter Labs	Annex 3
4	**Reducing Resource Demand in Climate-Neutral and Just European Cities** *Sufficiency as a Policy Tool for Fair and Sustainable Urban Transitions*	Liisa Perjo & Aline Bolis Contributors: Jussi Asikainen & Seona Candy, Demos Helsinki Reviewers: Erkki Perälä & Theo Cox	Demos Helsinki	Annex 4
5	**From Neighbours to Networks** *How Communities Fund Their Own Future*	Daniela Amann, Arild Ohren, Marzia Mortati. Adriana Colquechambi zea O'Phelan	Democratic Society	Annex 5
6	**Climate, Security and Preparedness** *Pathways for Urban Climate Neutrality, Resilience and Preparedness in a New Geopolitical Landscape*	Åsa Minoz (Viable Cities), Anette Olovborn (Dark Matter Labs), Rebecka Engström, (KTH Royal Institute of Technology / Viable Cities)	Viable Cities	Annex 6

Table 1: List of deep dive reports produced by T4.8. partners

3.3. Key Insights

The Deep Dives generated several cross-cutting insights. Urban resilience to climate change and security requires multi-dimensional approaches integrating both mitigation and adaptation through collaborative governance across sectors and scales. Artificial intelligence presents transformative potential for climate action, but requires careful balancing with energy consumption concerns, social equity considerations, and green technology integration. Community-owned enterprises demonstrate alternative finance models for local climate action, though they face legal barriers, competition, and funding dependencies requiring enabling policy environments.

3.4. Application to Scenario Development

These insights informed scenario generation through workshop activities with task partners. Completed deep dives were refined and supplemented with additional research to articulate:

- **Constraints** - factors that will constrain the available actions or decisions available to cities

- **Opportunities** - factors that will augment the available actions, resources or decisions available to cities.
- **Tactics and action points** - any responses to the deep dive constraints and opportunities already formulated

In undertaking this reframing, we utilised the deep dives to create together systemic scenarios.

This reframing enabled the development of systemic scenarios that support cities in anticipating barriers, bottlenecks, and opportunities facing the Cities Mission, challenging established thinking on carbon neutrality transitions. For example, the Full Electrification Risks deep dive surfaced critical challenges around material scarcity and rare earth element strategies. Other deep dives identified near-term and future trends, such as the increased need for synergistic approaches to mitigation and adaptation within municipalities. The research also highlighted how geopolitical shifts—including political instability and conflicts—exacerbate transition challenges by influencing resource allocation and city priorities. Case study examples from the AI Towards Climate Neutrality deep dive demonstrate how cities can anticipate specific barriers, bottlenecks, and opportunities presented by AI adoption.

3.5. Deep Dive Summaries

3.5.1. Deep Dive 1: Integrating Mitigation and Adaption Strategies - *Pathways for urban climate resilience and justice*

The Deep dive on Adaption and mitigation was produced by Demos Helsinki and is available on the NZC Portal. Below is a summary of the key learnings.

3.5.1.1. Summary

This report ***Integrating Mitigation and Adaptation Strategies in Urban Contexts*** explores the integration of climate change mitigation and adaptation strategies in urban settings, highlighting pathways for building resilience and achieving climate justice in European cities. It is part of the NetZeroCities (NZC) initiative, which aims to accelerate the transition to climate-neutral, sustainable, and inclusive urban futures by 2050. This deep dive reflects the urgency of integrating mitigation and adaptation to tackle the multifaceted challenges cities face due to climate change.

3.5.1.2. Background and Context

Climate change continues to have profound impacts on urban areas, with increasing temperatures, flooding, and other extreme events becoming more frequent and severe. Cities, responsible for more than 70% of global CO2 emissions, are particularly vulnerable to these effects. Mitigation efforts, such as reducing emissions and enhancing carbon sinks, are essential for curbing future risks. However, adaptation strategies—adjustments to cope with the unavoidable effects of climate change—are equally crucial. While traditionally treated as separate domains, the report emphasizes the need for these strategies to be integrated for more effective and holistic climate action.

3.5.1.3. Key Issues and Challenges

Several key issues hinder the effective integration of mitigation and adaptation strategies:

10. **Lag in Adaptation Efforts:** Although adaptation actions are increasingly recognized, their implementation remains slow and uneven across cities. This delay is partly due to the lack of standardized metrics to evaluate adaptation efforts and limited financing for long-term adaptation initiatives.

11. **Justice and Equity**: Addressing climate change requires a focus on social justice, ensuring that vulnerable populations are not left behind in both adaptation and mitigation efforts. Climate policies must incorporate justice frameworks that consider the diverse impacts of climate change on different communities.
12. **Financial Gaps**: Funding for integrated climate actions remains insufficient. While the finance for mitigation actions has grown, adaptation finance remains limited, making it difficult for cities to implement comprehensive strategies that address both mitigation and adaptation goals.
13. **Nature-Based Solutions (NbS)**: NbS, such as urban green spaces and improved water management, offer synergies between mitigation and adaptation. They help cities reduce emissions while simultaneously building resilience to climate impacts, but their integration into policy and urban planning remains inconsistent.

3.5.1.4. Risks and Opportunities

The integration of mitigation and adaptation strategies presents both significant opportunities and risks:

- **Opportunities:** Integration can lead to co-benefits such as improved public health, enhanced biodiversity, and more resilient urban infrastructure. Effective governance, local participation, and the inclusion of diverse stakeholders are key to unlocking these benefits.
- **Risks:** Isolated actions may lead to maladaptation, exacerbating vulnerabilities. Without adequate funding and governance, fragmented approaches could undermine efforts to achieve comprehensive, synergistic climate action.

3.5.1.5. Key Takeaways for Cities

The report offers several recommendations for cities looking to integrate mitigation and adaptation efforts:

1. **Innovative Governance**: Cities should foster governance structures that support collaboration across sectors and levels of government. Expanding the involvement of local communities and vulnerable groups is crucial to ensuring the relevance and effectiveness of climate actions.
2. **Define Local Objectives**: Cities should establish clear, locally tailored climate goals that address specific vulnerabilities and opportunities. These goals should align with broader climate commitments, such as those under the NZC programme.
3. **Expand Engaged Sectors**: Integrating climate action across various sectors—such as energy, transportation, and urban planning—can create synergies that enhance both mitigation and adaptation outcomes.
4. **Funding Integration**: Aligning climate finance with integrated goals can help bridge the gap between mitigation and adaptation, ensuring that both areas receive the necessary resources.
5. **Enhance Local Participation**: Strengthening local participation in climate planning, especially from marginalized and vulnerable communities, will ensure that climate actions are inclusive and address real-world impacts.

3.5.2. Deep Dive 2: AI towards Climate Neutrality - Exploring the Role of Artificial Intelligence in Achieving Sustainable, Carbon-Neutral Urban Futures

The Deep dive on AI towards Climate Neutrality was produced by Polimi and is available on the NZC Portal. Below is a summary of the key learnings.

3.5.2.1. Summary

The report, *AI Towards Climate Neutrality: Exploring the Role of Artificial Intelligence in Achieving Sustainable, Carbon-Neutral Urban Futures*, examines how Artificial Intelligence (AI) can support the transition of cities towards climate neutrality, particularly within the NetZeroCities (NZC) framework. The study highlights the transformative potential of AI in various emission sectors such as energy management, mobility, agriculture, water, and waste, while also addressing the significant risks and challenges associated with its adoption.

3.5.2.2. Key Trends and Drivers

Urban areas are responsible for over 70% of global carbon emissions, with urban populations expected to grow substantially in the coming decades. This rapid urbanization places immense pressure on cities to reduce their environmental impact, making AI a potentially powerful tool for achieving sustainability goals. AI technologies, such as machine learning (ML) and generative AI (GenAI), hold the promise of revolutionizing how cities manage energy, transportation, food systems, and waste, thereby contributing to climate neutrality.

However, AI development is not without its challenges. AI itself requires significant energy, and its deployment could inadvertently lead to increased resource consumption and environmental degradation. As cities integrate AI into climate strategies, they must balance the potential benefits with the inherent risks of over-reliance on technology and ensure that its application does not create new sustainability issues.

3.5.2.3. Opportunities and Risks

1. **AI for Energy Management:**

- *Opportunities*: AI can optimize energy consumption, integrate renewable energy sources, and improve energy storage. Cities like Copenhagen are already using AI to reduce energy use in municipal buildings through predictive management systems.
- *Risks*: AI's own energy consumption, especially with large-scale models like GPT-3, is a significant concern. Greener AI solutions are necessary to ensure the technology remains sustainable.

2. **AI in Urban Mobility:**

- *Opportunities*: AI can improve public transportation efficiency through intelligent systems that reduce congestion and emissions. Cities like Reykjavik and Copenhagen are exploring AI-driven public transport and smart mobility systems.
- *Risks*: Significant investment is required to modify infrastructure for AI readiness, and regulatory and public acceptance hurdles remain. The integration of autonomous vehicles, for instance, requires substantial policy development and testing.

3. **AI for Agriculture:**

- *Opportunities*: AI can make agriculture more sustainable by optimizing water use, reducing pesticide application, and increasing crop yields. Urban farming and smart irrigation systems are emerging as AI-powered solutions to address food security and urban sustainability.
- *Risks*: High costs and limited accessibility to AI tools for small-scale farmers hinder widespread adoption. Additionally, capacity-building efforts are needed to ensure that farmers can effectively use AI technology.

4. **AI in Water Management:**

- *Opportunities*: AI can optimize water distribution, detect leaks, and predict water demand, helping cities manage this critical resource efficiently. Initiatives in Finland and the Netherlands demonstrate AI's potential in smart water systems.
- *Risks*: AI models, especially large ones, consume significant water resources, raising concerns about the sustainability of AI's water footprint. Transparency in AI's environmental impacts is crucial for effective management.

5. **AI in Waste Management:**

- *Opportunities*: AI can optimize waste sorting, improve recycling rates, and reduce emissions from waste collection. Amsterdam is a leading example, using AI to manage waste streams and enhance resource recovery within its circular economy framework.
- *Risks*: The high initial cost of AI systems and the need for collaboration across various stakeholders can complicate AI deployment in waste management. Additionally, ensuring accuracy and reliability in dynamic urban environments remains a challenge.

3.5.2.4. Systemic Levers for Change

Beyond sector-specific applications, AI also has the potential to strengthen systemic levers for climate action, particularly in urban governance and public participation:

6. **AI for Public Participation:** AI-driven platforms can facilitate citizen engagement in sustainability initiatives, democratizing urban planning and encouraging collective intelligence. Cities like Madrid are already using AI to improve citizen participation in policymaking.
7. **AI for City Governance:** AI can streamline decision-making processes, improve policy insights, and enhance transparency in governance. Initiatives like the European Commission's Destination Earth project demonstrate the use of AI in environmental forecasting and urban planning.

3.5.2.5. Key Takeaways for Cities

AI holds immense potential to accelerate climate neutrality efforts in cities, but it should not be viewed as a standalone solution. A multifaceted approach, integrating AI with policy development, behavior change, and international cooperation, is essential. Cities must invest in greener AI technologies, address the risks of technological lock-in and maladaptation, and ensure that AI systems are inclusive, transparent, and equitable. Collaboration between governments, tech companies, and communities will be critical to ensuring that AI contributes positively to the transition to climate-neutral cities.
Cities should focus on:

1. Integrating AI into broader sustainability strategies.
2. Ensuring that AI deployment is equitable and inclusive.
3. Fostering cross-sector collaboration to address systemic challenges.
4. Developing robust regulatory frameworks to manage AI's environmental and social impacts.

3.5.3. Deep Dive 3: Navigating Electrification Risks in European Cities - Strategies for Sustainable Transition Amid Rising Demand and Geopolitical Challenges

The Deep dive on Full Electrification Risks in Achieving Net Zero Cities was produced by Dark Matter Labs and is available on the NZC Portal. Below is a summary of the key learnings.

3.5.3.1. Summary

This report, *Navigating Electrification Risks in European Cities*, provides an in-depth analysis of the multifaceted risks associated with the electrification efforts in European cities, as part of the broader transition to low-carbon energy systems. It emphasizes the challenges cities face in balancing rising energy demand with the urgency to decarbonize, while ensuring social and environmental equity.

3.5.3.2. Key Trends and Drivers

European cities are at the forefront of the green transition, driven by ambitious targets for achieving net-zero emissions by 2050. This shift towards electrification, especially in heating, mobility, and industrial sectors, is considered crucial for reducing carbon emissions. However, the report identifies several overarching trends and drivers influencing this transition:

- **Rising Energy Demand:** As comfort expectations, technological advancements, and extreme weather events push up energy demand, cities must find ways to meet these needs while reducing their carbon footprint.
- **Geopolitical and Economic Pressure:** Geopolitical tensions, such as the aftermath of the Russia-Ukraine conflict, have exposed vulnerabilities in Europe's energy supply chains. These disruptions highlight the need for greater energy diversification and secure access to critical materials for green technologies.
- **Technological and Infrastructure Transformation:** Key technologies, including electric vehicles (EVs), solar panels, wind turbines, and heat pumps, are central to decarbonization. However, they are also heavily reliant on critical raw materials, which raises concerns about resource supply chains, environmental impacts, and recycling capacity.

3.5.3.3. Risks

The report categorizes the risks associated with electrification into four major areas:

- **Sourcing and Production Risks**: The rapid increase in demand for critical materials like lithium, cobalt, and rare earth elements is outpacing the ability to source and refine these materials sustainably. This leads to concerns about supply chain vulnerabilities and the environmental damage linked to mineral extraction.
- **Environmental Impact Risks**: While the green transition reduces operational emissions, the production and disposal of clean energy technologies pose environmental challenges. These include embodied carbon in manufacturing and waste management issues associated with renewable technologies like wind turbines and solar panels.
- **Social Impact Risks**: The geographic concentration of mineral extraction in politically unstable regions raises concerns about human rights abuses and social unrest. Additionally, the energy transition is exacerbated by a workforce shortage, especially in skilled trades, which threatens to delay the deployment of green technologies.

- **Economic Risks**: The high costs of electrification technologies, coupled with limited fiscal capacities at the municipal level, create financial barriers for cities. Cities with lower budgets may struggle to implement large-scale energy retrofits or build new infrastructure required for decarbonization.

3.5.3.4. Key Takeaways for Cities

Despite these risks, the report highlights several key opportunities for cities to mitigate challenges and accelerate the energy transition:

1. **Urban Mining and Circularity:** Cities can reduce their dependence on virgin materials through urban mining practices, recovering materials from existing infrastructure and promoting circular economy models. Initiatives like Amsterdam's urban mining projects exemplify this approach, showing how cities can act as material reservoirs.
2. **Innovative Financing Models:** To overcome funding barriers, cities should explore new financing models, such as revolving funds, local climate bonds, and public-private partnerships. These mechanisms can support green projects, ensuring financial returns while engaging citizens in climate action.
3. **Workforce Development:** Addressing the skills gap through coordinated training programs is crucial for meeting the demand for a green workforce. EU-wide initiatives like the BUILD UP Skills program aim to upscale the workforce, providing specialized training in renewable energy and energy efficiency technologies.
4. **Regional Cooperation:** Regional collaboration can help mitigate supply chain risks by diversifying sources for critical materials and optimizing procurement strategies. Programs like the NetZeroCities Twinning Learning Programme demonstrate how cities can collaborate to share knowledge and reduce vulnerabilities.

3.5.4. Deep Dive 4: Reducing Resource Demand in Climate-Neutral and Just European Cities: Sufficiency as a Policy Tool for Fair and Sustainable Urban Transitions

The Deep dive on ***Sufficiency as a Policy Tool*** was produced by Demos Helsinki and is available on the Portal, below is a summary of the key points.

3.5.4.1. Summary

This report explores the role of sufficiency in advancing the climate-neutral transition in European cities, emphasizing the need to reduce resource demand as part of a fair and sustainable urban future. As traditional strategies focusing solely on efficiency and technological innovation fail to meet climate goals, sufficiency complements these efforts by addressing the scale of consumption and its fair distribution. Sufficiency principles seek to meet societal needs while staying within planetary boundaries, calling for a re-evaluation of resource use in key sectors such as housing, mobility, and food systems.

Efficiency improvements alone are insufficient to achieve climate neutrality targets, as studies show that resource demand continues to rise in urban areas, outpacing the benefits of technological innovations. To meet global climate targets, particularly the 1.5°C target outlined in the Paris Agreement, cities must focus not only on improving efficiency but also on reducing demand for energy, materials, land, and water. The sufficiency approach is therefore critical, especially as research indicates that the wealthiest 30% of the population contribute disproportionately to environmental impacts, while simultaneously, a large portion of the population faces unmet basic needs.

3.5.4.2. Key Sectors for Demand Reduction

The report identifies three primary sectors for sufficiency-focused policies: **housing**, **mobility**, and **food**.

- **Housing**: The increasing size of homes and their energy demands present a challenge for achieving climate goals. Despite energy efficiency improvements, larger homes result in higher energy consumption for heating, cooling, and other services. The report advocates for sufficiency measures such as smaller living spaces, retrofitting existing buildings, and reducing the per capita housing footprint.
- **Mobility**: Transport is a major source of emissions, particularly from private car use. The report suggests sufficiency-oriented policies that prioritize public transportation, cycling, and walking. Reducing car dependency through initiatives like congestion charging, car-free zones, and investment in shared mobility systems are vital steps towards reducing transport-related emissions.
- **Food**: The food system is responsible for significant greenhouse gas emissions. The report promotes sufficiency through dietary shifts towards plant-based foods, reducing food waste, and supporting local food systems. Local governments can encourage sustainable diets by introducing plant-based meals in public canteens and schools, alongside policies to reduce meat consumption and promote sustainable agricultural practices.

3.5.4.3. Applying Sufficiency in Policy

The report outlines how sufficiency principles can be applied across various policy instruments. It categorizes sufficiency measures into **pull** and **push** strategies. Pull measures, such as subsidies for sustainable transport and energy-efficient housing, encourage sustainable behavior. Push measures, like taxes on excessive consumption (e.g., flight taxes, road tolls), discourage unsustainable practices.

Local governments play a crucial role in implementing sufficiency, particularly through regulatory and economic instruments. Effective sufficiency policies should integrate cross-cutting strategies, combining demand reduction with policies that enhance social equity and well-being. For instance, cities can use public procurement to support durable, repairable products and prioritize sustainability in new developments.

3.5.4.4. Challenges and Opportunities

The successful implementation of sufficiency policies faces several challenges:

- **Integration of Policy Areas:** Moving from isolated policies to a comprehensive, integrated strategy is a key challenge. Cities must develop coherent policy mixes that align housing, mobility, and food policies with broader sustainability goals.
- **Political and Public Acceptance:** Sufficiency measures often challenge deeply ingrained social norms around consumption, such as the need for large homes, private car ownership, and meat-heavy diets. Overcoming resistance requires broad citizen participation and engagement through deliberative processes.
- **Multi-Level Governance:** Cities often lack the authority to implement sufficiency measures on their own and must work with national and regional governments to secure necessary regulatory changes. Collaboration across levels of government is essential for the successful implementation of sufficiency-oriented policies.

3.5.4.5. Key Takeaways for Cities

Cities have substantial potential to lead the transition to climate neutrality by embedding sufficiency principles into urban strategies. The report highlights several opportunities:

1. **Citizen Engagement:** Deliberative forums, where citizens collaboratively discuss sufficiency principles and their application, are crucial for building public support. These forums can help redefine social norms and expectations about consumption.
2. **Collaboration with Civil Society:** Partnerships with NGOs, community organizations, and the private sector are essential for developing sufficiency strategies that are both effective and inclusive. Civil society can also help identify local needs and ensure that policies are fair and equitable.
3. **Pilot Projects:** Testing small-scale sufficiency measures, such as car-free zones or communal housing projects, provides valuable insights into what works and how policies can be scaled up. These experiments can also generate public and political support for more comprehensive sufficiency strategies.

3.5.5. Deep Dive 5: From Neighbours to Networks - How Communities Fund Their Own Future

The Deep dive on Community-owned Enterprises was produced by Democratic Society (DemSoc) and is available on the NZC Portal. Below is a summary of the key learnings.

3.5.5.1. Summary

This report explores the role of community-owned enterprises (COEs) in advancing a just, sustainable, and resilient climate transition, emphasizing the challenges and opportunities these initiatives face in securing funding and resources. It highlights how communities mobilize for shared goals in sectors such as housing, mobility, energy, and food systems, offering insight into how these initiatives can be scaled and supported in a wider context. Through a case study approach, the report examines four successful community-led projects: Mietshäuser Syndikat (Germany), SomMobilitat (Spain), Energy Island Samsø (Denmark), and the Community Grocery Shop (UK). Each case demonstrates different methods of mobilizing early-stage finance and achieving long-term sustainability.

3.5.5.2. Context and Purpose

The report underscores the urgent need for alternative financing models to complement conventional market-driven systems, which prioritize growth over sustainability. COEs, driven by community ownership and democratic governance, are increasingly seen as key mechanisms for achieving local and ecological sustainability goals. They offer viable alternatives to extractive economic systems, redistribute power and resources, and engage communities in decision-making processes. However, the financial stability and growth of COEs remain impeded by legal, political, and economic barriers.

3.5.5.3. Methodology

Using a case study approach, the report examines four diverse community-led enterprises that have achieved financial viability for at least three years. The cases were selected based on their successful mobilization of early-stage finance in distinct sectors (housing, mobility, energy, food systems) and geographies (Germany, Spain, Denmark, UK). Semi-structured interviews with project participants were conducted, and the data was analyzed using the PESTEL framework (Political, Economic, Social, Technological, Environmental, Legal) to identify key patterns and insights.

3.5.5.4. Key Findings: Opportunities and Risks

- **Early Financing Pathways**: The report identifies two primary financing pathways for community-owned enterprises: **solidarity-based models** (relying on direct community contributions) and **government-backed programs** (providing grants and subsidies). Both approaches were critical to the success of the featured cases. For example, Mietshäuser

Syndikat leveraged direct loans from the community and solidarity funds, while Samsø benefited from national government grants to kickstart its renewable energy transition.

- **Political and Institutional Support**: Successful community-led enterprises were heavily dependent on local political support. Projects such as SomMobilitat and Samsø were able to access funding and subsidies due to their deep-rooted relationships with local government entities. These political partnerships not only enabled financial access but also fostered a sense of legitimacy and trust in the initiatives.
- **Economic Models for Sustainability**: The four cases highlight diverse financing mechanisms, from the **internal solidarity fund** used by Mietshäuser Syndikat to **municipal loan guarantees** in Samsø, and **membership-based loans** in SomMobilitat. These models underscore the importance of blending grassroots funding with institutional support, enabling projects to scale while maintaining community ownership.
- **Social Justice and Inclusion**: The report emphasizes the role of COEs in promoting social equity. For instance, Samsø's model ensured broad participation by all residents in the renewable energy transition, regardless of income, through the municipal loan guarantee scheme. Similarly, the Community Grocery Shop in the UK not only addressed food insecurity but also offered wraparound services like financial advice and cooking classes, ensuring a holistic approach to community well-being.
- **Environmental Impact**: Many of the cases were driven by environmental goals, though the integration of ecological objectives into financial models varied. While Samsø and SomMobilitat had strong environmental drivers, the Community Grocery Shop focused more on social justice, with environmental impact being secondary.

3.5.5.5. Risks

The report identifies several risks that could hinder the growth and sustainability of COEs:

- **Legal and Regulatory Barriers:** Legal frameworks often constrain the ability of community-led projects to access funding and formalize ownership structures. In some countries, legal recognition of cooperative models is insufficient, creating barriers to financing.
- **Market Competition:** As community-led initiatives gain traction, they face increasing competition from larger, market-driven actors. For example, Samsø's energy transition model is now threatened by large-scale energy companies entering the market, which could undermine the local control of energy resources.
- **Dependence on External Funding:** Many COEs rely on grants and donations, making them vulnerable to shifts in political priorities and funding availability. This dependence on external resources limits long-term financial stability.

3.5.5.6. Recommendations for Cities

The report offers several key recommendations for cities looking to foster community-led enterprises:

1. **Flexible and Accessible Funding:** Municipalities should create funding programs that are flexible, recognizing different organizational forms such as cooperatives and community enterprises.
2. **Legal and Regulatory Support:** Cities should work with local communities to design legal frameworks that facilitate community-owned models, ensuring access to funding and recognition within broader economic systems.

3. **Support Local Economies:** Cities can help shield COEs from market pressures by prioritizing local actors in procurement processes, providing municipal guarantees, and facilitating access to public spaces and infrastructure.
4. **Encourage Leadership:** Cities should support local changemakers who drive community initiatives, fostering leadership through training and public recognition.

3.5.6. Deep Dive 6: Climate, Security, and Preparedness - Pathways for Urban Climate Neutrality, Resilience and Preparedness in a New Geopolitical Landscape

The Deep dive on *Climate, Security, and Preparedness* was produced by Viable Cities and is available on the NZC Portal. Below is a summary of the key learnings.

3.5.6.1. Summary

This deepdive, *Climate, Security, and Preparedness: Pathways for Urban Climate Neutrality, Resilience, and Preparedness in a New Geopolitical Landscape*, explores the interlinked challenges cities face as they navigate the transition to climate neutrality in a rapidly changing global context. It highlights the crucial role of cities as hubs for climate action and resilience, given their dual role as both vulnerable to and capable of addressing climate change, security risks, and geopolitical shifts. The deepdive is framed within the NetZeroCities (NZC) initiative, which supports cities in their efforts to become climate-neutral, resilient, and secure by 2030.

3.5.6.2. Background and Context

Cities are at the forefront of the climate crisis, experiencing the compounded effects of climate change, geopolitical instability, and security risks. The rapid onset of extreme weather events, rising sea levels, energy disruptions, and food insecurity present acute threats to urban environments. At the same time, political instability, hybrid warfare, resource scarcity, and social unrest are exacerbating vulnerabilities. Climate change, increasingly recognized as a "threat multiplier," amplifies these existing risks, making it essential for cities to adopt integrated approaches that blend climate mitigation, adaptation, and security preparedness.

The deepdive argues that, while climate mitigation has traditionally dominated the agenda, adaptation and security must now be prioritized equally, especially as climate impacts intensify and geopolitical tensions increase. Urban systems, critical infrastructure, and societal cohesion are all under significant pressure, necessitating coordinated responses at the local, national, and international levels.

3.5.6.3. Integrated Strategies for Urban Resilience

To address these interconnected challenges, the deepdive advocates for an integrated approach that harmonizes climate action and security efforts. Rather than treating climate change, security, and adaptation as separate domains, an integrated strategy enables cities to leverage synergies and co-benefits, maximizing the efficiency and effectiveness of public investments. Key strategies include:

- **Nature-based Solutions (NbS)**: NbS such as urban greening, green roofs, and restored wetlands offer multiple benefits, from reducing emissions and cooling urban environments to enhancing biodiversity, managing stormwater, and fostering social cohesion. These solutions provide a cost-effective, sustainable approach to building resilience against both climate and security risks.

- **Resilient Infrastructure:** Investing in resilient and energy-efficient infrastructure, including flood defenses, heat-resilient buildings, and decentralized energy systems, enhances both climate resilience and defense readiness. These investments ensure the continuity of critical services while reducing disaster recovery costs.
- **Local Food Systems:** Climate-resilient, localized food systems are vital for reducing reliance on global supply chains, enhancing food sovereignty, and mitigating emissions. Cities can foster more sustainable food systems by promoting urban agriculture, supporting regenerative farming, and creating local food cooperatives.
- **Collaborative Governance:** Strengthening governance structures that foster collaboration between local governments, civil society, and the private sector is crucial for effective climate and security responses. This approach encourages shared decision-making and collective action, ensuring that cities are well-prepared to handle crises.

3.5.6.4. Risks and Opportunities

The deepdive identifies several key risks that threaten the effectiveness of integrated strategies:

- **Geopolitical Risks:** The ongoing geopolitical tensions, including the war in Ukraine and instability in neighboring regions, heighten the risks of resource conflicts, energy shortages, and security threats. Cities are vulnerable to disruptions in supply chains, economic instability, and social unrest, which complicate their ability to address climate change.
- **Climate and Infrastructure Vulnerabilities:** Cities' infrastructure—roads, bridges, water systems—are highly vulnerable to extreme weather events, which are becoming more frequent and severe. Investing in climate-resilient infrastructure is critical, but the financial and political challenges remain significant.
- **Financial Barriers:** Securing funding for integrated climate and security strategies is a major challenge. Cities often face competing demands for limited resources, with defense spending rising amid economic pressures. Finding innovative financial models, such as blended finance and public-private partnerships, is key to unlocking the necessary investment in urban resilience.

Despite these challenges, the deepdive highlights several opportunities for cities to strengthen their resilience:

- **Building Resilient Communities:** Empowering local communities to play an active role in climate and security efforts can enhance social stability and trust in institutions. Collaborative governance models that involve citizens in decision-making can foster stronger, more cohesive communities, increasing the capacity to respond to crises.
- **Cross-Sector Collaboration:** Cities can build partnerships with national governments, international organizations, and the private sector to share resources, knowledge, and expertise. This collaboration can help cities implement scalable solutions that address both climate and security challenges.

3.5.6.5. Recommendations

To support cities in their transition to climate-neutral, resilient, and secure urban futures, the deepdive provides several recommendations:

1. **Adopt Integrated Climate-Security Strategies:** Cities should develop comprehensive strategies that combine climate mitigation, adaptation, and security preparedness, with a focus on co-benefits and long-term resilience.
2. **Strengthen Governance and Collaboration:** Multi-level governance structures that engage diverse stakeholders—local communities, businesses, and governments—should be established to facilitate collaborative action.
3. **Invest in Nature-Based Solutions**: Nature-based solutions should be prioritized for their ability to address multiple risks and provide long-term benefits for both the environment and society.
4. **Enhance Scenario Planning and Early Warning Systems:** Cities should invest in data-driven tools and scenario planning to anticipate and prepare for future climate and security risks.
5. **Innovate Financing Mechanisms:** Innovative financial models, such as green bonds, climate risk insurance, and blended finance, should be explored to unlock the necessary funding for resilience-building investments.

4. Desirable Scenarios for Sustainable Future

Scenario generation built upon the foresight deep dives and horizon scanning interviews, alongside work from across NetZeroCities, to create compelling narratives about systemic change.

4.1. Scenario Generation Process

4.1.1. Objective

Task 4.8 was initially tasked with producing six visual syntheses of possible future desirable scenarios to support Mission development, SGA review, and external communications. These scenarios were designed to help cities anticipate barriers, bottlenecks, and opportunities, providing a strategic framework for planning and executing their transition to carbon neutrality. By leveraging insights from deep dives, the task aimed to deploy knowledge in areas such as energy consumption, systemic impacts of emerging technologies, and socio-economic challenges.

The objective of this scenario generation aspect was to develop positive scenarios enabling the consortium, cities, and the Mission to anticipate barriers, bottlenecks, and opportunities in the journey towards achieving climate neutrality. By identifying these critical factors and proposing tactics to navigate future risks, Task 4.8 partners aimed to support cities by providing visual and narrative aids that inspire strategic planning and execution of the transition to carbon neutrality.

Ultimately, the scenarios produced serve as editorial assets that use storytelling to enable relatability to the pathways they highlight as possible. Their purpose is as conversation starters and stimuli for reflection.

4.1.2. Method

The approach to scenario generation followed a vision-oriented framework and was iterated collaboratively and individually several times. The selected catalysts emerged through horizon scanning activities and an early workshop with task partners. Initially, these catalysts were distributed across task partners to produce separately, following a communication template produced by Dark

Matter Labs and a methodology outlined by Demos Helsinki. Politecnico di Milano contributed ideas on methods and tools to include within the scenario generation approach.

This approach adopted a strong ethical standpoint, working from a lived experience of risk perspective. It considered impacts and risks on bodies and environment, emphasizing why change matters, and crafting arguments about what needs to be shifted.

Task 4.8 utilized work from across NetZeroCities to articulate bottlenecks or challenges that currently exist in cities, then leveraged insights generated from deep dives and horizon scanning interviews to articulate constraints or shifts that are possible.

The referenced prior work was brought together into a series of two-stage workshops attended by task partners. Working collectively, participants bridged these insights into action points and tactics that informed a decision knowledge repository establishing scenario pathways that include political, economic, behavioural, and technological actions and tactics. Synthesis from these workshops into the road-mapping tool proved visually cumbersome, and arranging elements chronologically to inform the pathways and response narrative required iteration.

Drawing from deep dive research, the team assessed constraints (factors that limit potential actions) and opportunities (factors that could accelerate progress) for cities. This informed the development of action points and tactics, which created decision and action points guiding cities toward successful transitions. A procedural write-up was initially produced to use as prompts for generating narratives about the desirable future triggered by each catalyst and how a given imaginary city approached navigating it based on tactics and actions derived from the deep dives and workshop participant insights.

This write-up was structured in three sections:

- **What do we understand about the catalyst and its impacts and challenges for cities?** This is the context and scene setting for our scenario. This is in a report format that has already gone through an AI and human editing process.
- **What are the tactics or actions that can be taken to respond to the catalyst in order to arrive at a positive future outcome?** These are the key actions and what can happen in our scenarios. These are split across PESTLE and are listed.
- **What is the impact of some of these actions on city challenges and people in general?** This considers a range of types of risk and is in a series of paragraphs listed format.

This approach condensed the initial workshop outputs in a way that informed a subsequent workshop redesign. Instead of two stages, there was only one workshop with three activities. Participation for the iterated workshops was also distinct, as it reflected the structural change of working individually within partner organizations.

Each scenario involved backstory and understanding of context and catalyst. Through this process, it became clear that the context of a fictional future city should also reflect a variety of European geographies and scales of city. Details from actual city experiences were incorporated alongside more fictional and aspirational components and imaginings. The procedural write-up alongside these details leveraged various trends and pathways from prior work, helping cities understand the interdependencies between different drivers and actions. AI was used to assist in structuring the narratives chronologically.

The scenarios were then transformed into storytelling assets, including visuals and narratives, which can be used for public communication and engagement. The final stage of visualization included several key aspects to be expanded upon.

Rather than produce a scenario detailing only one specific future point, the approach included significant developments showing how the city responded to the catalyst. Within these tactics and actions, innovations from the edge of NetZeroCities and partner thinking were included alongside more developed and socially embedded actions. To tether these to the lived reality of mission cities, references to NetZeroCities case studies and city examples were sought out and embedded where available (or alternative URLs where not).

A composite horizontal visual was produced underneath each scenario narrative mapping. This utilized Midjourney and prompt engineering to illustrate aspects of the narrative, with the visuals then stitched into a canvas using Adobe Suite.

This exercise in strategic foresight drew on insights from a series of futures deep dives, horizon scanning interviews with experts, and scenario-making collaborative workshops to inform 'what if' thinking and respective tactics and actions.

Examples of catalysts used in the scenario generation process:

- **Technological Breakthrough - AI:** A major advancement in AI technology, making it economically viable and possible to create mass multi actor contracts to deliver climate neutrality.
- **Behavioural Shift - Degrowth**: A widespread societal shift towards sustainable consumption patterns, driven by increased awareness and education about climate change impacts.
- **Policy Intervention** - Built Environment: The implementation of a comprehensive carbon ceiling built environment policy, incentivizing contractors and develops to adapt rather than rebuild.
- **Natural Crisis -Mitigation and Adaption:** A significant climate-related disaster, such as a series of unprecedented wildfires, that galvanizes public and political will for urgent climate action.
- **Economic Disruption - Finance Innovation:** A major economic shift, such as the rapid decline of fossil fuel industries, leading to increased investment in green technologies and infrastructure.
- **Political Crisis:** The emergence of a rural urban divide and the loss of political mandate triggers social unrest and a breakdown of public services.

The resulting scenarios deliberately focus on providing strategic moves that lead to positive city futures to shed light on the possible pathways NetZeroCities cities may undertake now. The pathways draw from existing glimmers of systemic change and seed innovations, setting out how each city overcomes the ensuing structural, institutional, and cultural barriers and crisis management they will face to achieve climate neutrality by 2030.

Visually rich scenarios were developed around the main strategic moves that cities can undertake. They draw on targeted deep dives and scenario generation workshops, translating analysis into clear narratives of alternative pathways for change. To navigate across these pathways, visual canvases were created to surface commonalities, trade-offs, and tensions. The canvases act as a shared reference, enabling comparison between routes, identifying complementarities, and revealing where choices may conflict.

4.2. Desirable Future Scenarios

The scenarios below have been mapped to articulate commonalities between them as well as to help cities with an approachable method for navigating future pathways.

- Link to a PDF and Image version of the Scenario Maps can be found here

4.2.1. Scenario 1: 2030 – A City of Transformation Through Bold Built Environment Policy Action

4.2.1.1. City Context: A European Urban Centre

In 2030, Veldon, a bustling city at the heart of Europe, stands as a shining example of how bold, transformative actions can turn urban environments into sustainable, equitable, and carbon-neutral spaces. A decade earlier, the city faced mounting challenges: escalating emissions from the built environment, a housing crisis, and severe resistance from the construction industry. However, a combination of political leadership, economic incentives, and social innovation created a pathway to a new future.

4.2.1.2. The Catalyst: A Policy Shift in the Built Environment

In 2025, a European-wide policy shift imposed carbon ceilings on cities, particularly targeting the construction sector. The policy threatened to stifle growth, particularly in housing, and initially faced strong resistance from stakeholders. However, Veldon's leadership recognized the opportunity for transformative change. Rather than viewing the restrictions as obstacles, the city embraced them as a catalyst for a new approach to urban living.

4.2.1.3. Tactics and Actions for Positive Change

Political Actions: Structural Reforms for Sustainability

- **Demolition Ban:** Veldon implemented a demolition ban, ensuring that buildings, rather than being demolished and replaced, were retrofitted for modern use. This policy drastically reduced the waste and carbon emissions from construction, while maintaining the city's architectural heritage.
- **Radical Retrofitting Scheme**: To address the housing crisis, Veldon launched a radical retrofitting scheme aimed at converting old, inefficient office spaces into affordable housing. By retrofitting the existing stock, the city bypassed the need for new materials and avoided unnecessary emissions.
- **Carbon Budget-Based Planning**: Every building project, from renovation to new construction, had to align with carbon budget-based planning policies, ensuring that all development remained within the city's annual carbon ceiling. These policies encouraged smart, sustainable design and discouraged carbon-heavy alternatives.
- **Just Transition:** A commitment to just transition thinking was embedded in all urban development and housing policies, ensuring that vulnerable communities, particularly in low-income and informal settlements, were not left behind in the green transformation.

Economic Actions: Incentives and Dynamic Solutions

- Dynamic Pricing for Buildings: Veldon introduced dynamic pricing structures for buildings, based on occupancy and the social value they created. Office spaces, for example, were incentivized to be used more efficiently, with low-carbon operational costs tied to their social impact. Buildings that contributed to community well-being, such as affordable housing or community hubs, received preferential rates.
- Maximising Efficiency: The city invested heavily in re-operationalising existing infrastructure, converting vacant office spaces and underutilized buildings into multi-purpose spaces. This allowed the city to decouple new development from material extraction, thus reducing its carbon footprint while addressing growing space needs.

Social Innovations: Creating Equitable, Low-Carbon Communities

- New Ownership Models: Veldon adopted new ownership models like cooperatives and community land trusts. These models empowered residents to take ownership of their living spaces and actively participate in decision-making around sustainable urban development. This democratization of housing and space ownership contributed to a stronger sense of community and responsibility.
- Shifting Comfort Standards: In response to the challenge of reducing emissions from the built environment, Veldon redefined its comfort standards. The city encouraged individualized comfort solutions—such as heated clothing and personal temperature controls—instead of relying on centralized heating for entire buildings. This shift allowed the city to cut energy consumption by up to 35%, decoupling well-being from material extraction and pollution.

Technological Actions: Embracing Digital and Sustainable Innovation

- Digital Tools for Space Coordination: By 2030, Veldon had developed digital tools for the efficient coordination of spaces. These tools allowed residents and businesses to seamlessly book shared spaces—such as meeting rooms, kitchens, and laundry facilities—ensuring that spaces were used to their maximum capacity. This innovation boosted the use of existing buildings to 80% capacity, reducing the need for new construction.
- Investment in Research: Veldon heavily invested in the development of new, low-carbon materials. Through partnerships with universities and research institutions, the city became a hub for innovative construction solutions, ensuring that future development was as environmentally friendly as possible.

Environmental Actions: Radical Energy and Material Practices

- New Energy Systems: Veldon revolutionized its approach to energy by implementing radical new ways of generating and storing energy. The city transitioned to renewable energy sources, including solar panels on all retrofitted buildings and wind farms around the city. Additionally, energy storage systems allowed the city to maximize its green energy use, even during periods of low generation.
- Biomaterial Sourcing: The city integrated biomaterials into its construction practices, ensuring that all building materials were sourced responsibly and sustainably. This shift avoided the pitfalls of traditional practices that could harm biodiversity and ecosystems.

Legal Actions: Stricter Carbon Regulation and Certification

- LCA-Based Carbon Footprint Limits: Veldon implemented Lifecycle Carbon Assessment (LCA) regulations that capped the total carbon footprint of construction projects. These limits were tightened annually, ensuring that construction remained within sustainable boundaries.
- Certification for Regenerative Practices: All building projects had to adhere to stringent regenerative agriculture and carbon storage certification standards. These certifications

ensured that projects actively contributed to carbon sequestration and did not degrade the environment.

4.2.1.4. Outcome: A City of Hope and Innovation

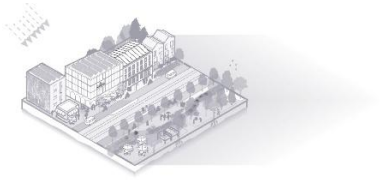
By 2030, Veldon had become a model of sustainable urban living. The city had transformed its built environment without compromising on housing or economic growth. By focusing on radical retrofitting, dynamic pricing, new ownership models, and smart technologies, Veldon had created a thriving, low-carbon urban space that was both resilient and equitable. Its innovative policies and social commitment ensured that the city met its carbon ceiling while fostering a thriving economy and vibrant communities.

As a result, Veldon had not only reached carbon neutrality but had also set an example for other cities across Europe. The lessons learned here were being scaled, showing the world that sustainability, affordability, and wellbeing could be harmonized through bold actions and a commitment to innovation.

Scenario 1:

Radical Built Environment Policy Futures

In 2025, a European-wide policy shift imposed **carbon ceilings** on cities, particularly targeting the construction sector. The policy threatened to stifle growth, particularly in housing, and initially faced strong resistance from stakeholders. However, **Veldon's leadership** recognized the opportunity for transformative change. Rather than viewing the restrictions as obstacles, the city embraced them as a catalyst for a new approach to urban living.



Political

Structural Reforms for Sustainability

Demolition Ban

Veldon implemented a **demolition ban**, ensuring that buildings, rather than being demolished and replaced, were retrofitted for modern use. This policy drastically reduced the waste and carbon emissions from construction, while maintaining the city's architectural heritage.

Radical Retrofitting Scheme

To address the housing crisis, Veldon launched a **radical retrofitting scheme** aimed at converting old, inefficient office spaces into affordable housing. By retrofitting the existing stock, the city bypassed the need for new materials and avoided unnecessary emissions.

Carbon Budget-Based Planning

Every building project, from renovation to new construction, had to align with **carbon budget-based planning** policies, ensuring that all development remained within the city's annual carbon ceiling. These policies encouraged smart, sustainable design and discouraged carbon-heavy alternatives.

Just Transition

A commitment to **just transition thinking** was embedded in all urban development and housing policies, ensuring that vulnerable communities, particularly in low-income and informal settlements, were not left behind in the green transformation.

Economic

Incentives and Dynamic Solutions

Maximising Efficiency

The city invested heavily in **re-operationalising existing infrastructure**, converting vacant office spaces and underutilized buildings into multi-purpose spaces. This allowed the city to **decouple new development from material extraction**, thus reducing its carbon footprint while addressing growing space needs.

Dynamic Pricing for Buildings

Veldon introduced **dynamic pricing structures** for buildings, based on occupancy and the social value they created. Office spaces, for example, were incentivized to be used more efficiently, with low-carbon operational costs tied to their social impact. Buildings that contributed to community well-being, such as affordable housing or community hubs, received preferential rates.

Social Innovation

Creating Equitable, Low-Carbon Communities

New Ownership Models

Veldon adopted new **ownership models** like cooperatives and community land trusts. These models empowered residents to take ownership of their living spaces and actively participate in decision-making around sustainable urban development. This democratization of housing and space ownership contributed to a stronger sense of community and responsibility.

Shifting Comfort Standards

In response to the challenge of reducing emissions from the built environment, Veldon redefined its comfort standards. The city encouraged **individualized comfort solutions**—such as heated clothing and personal temperature controls—instead of relying on centralized heating for entire buildings. This shift allowed the city to cut energy consumption by up to **35%**, decoupling well-being from material extraction and pollution.

Technological

Embracing Digital and Sustainable Innovation

Digital Tools for Space Coordination

By 2030, Veldon had developed **digital tools** for the efficient coordination of spaces. These tools allowed residents and businesses to seamlessly book shared spaces—such as meeting rooms, kitchens, and laundry facilities—ensuring that spaces were used to their maximum capacity. This innovation boosted the use of existing buildings to **80% capacity**, reducing the need for new construction.

Investment in Research

Veldon heavily invested in the development of **new, low-carbon materials**. Through partnerships with universities and research institutions, the city became a hub for innovative construction solutions, ensuring that future developments were as environmentally friendly as possible.

Environmental

Radical Energy and Material Practices

New Energy Systems

Veldon revolutionized its approach to energy by implementing **radical new ways** of generating and storing energy. The city transitioned to **renewable energy sources**, including solar panels on all retrofitted buildings and wind farms around the city. Additionally, energy storage systems allowed the city to maximize its green energy use, even during periods of low generation.

Biomaterial Sourcing

The integrated **biomaterials** into its construction practices, ensuring that all building materials were sourced responsibly and sustainably. This shift avoided the pitfalls of traditional practices that could harm biodiversity and ecosystems.

Legal

Stricter Carbon Regulation and Certification

LCA-Based Carbon Footprint Limits

Veldon implemented **Lifecycle Carbon Assessment (LCA)** regulations that capped the total carbon footprint of construction projects. These limits were tightened annually, ensuring that construction remained within sustainable boundaries.

Certification for Regenerative Practices

All building projects had to adhere to stringent **regenerative agriculture and carbon storage certification** standards. These certifications ensured that projects actively contributed to carbon sequestration and did not degrade the environment.

Figure 2: Scenario 1: Radical Built Environment Policy Futures – graphic overview [High resolution version available on the Net Zero Cities Portal here]

Funded by the European Union

4.2.2. Scenario 2: 2030 – Tondende's Path to a Sustainable, Degrowth-Focused City

4.2.2.1. City Context: A Southern European Small City

By 2030, Tondende has become a beacon for degrowth-driven urban development, making strides in addressing its key challenges, from tourism-induced gentrification to water management and climate change. The city's transformation was not a simple one, but through a careful balance of political leadership, economic innovation, and social mobilization, Tondende has built a sustainable and just future that prioritizes well-being, community, and environmental health over constant growth.

4.2.2.2. Catalyst

In 2025 Tondende was worn down by competing demands of tourism, draught management and deindustrialisation. A series of small crises escalated into a political crisis and Tondende's municipal government and citizens found themselves at a point of needing radical change. Adapting together was demanding socially but small positive impacts immediately reassured Tondende residents that the recalibration was positive.

4.2.2.3. Tactics and Actions for Positive Change

Political Actions: Shaping a Degrowth Future

- **Upskilling Governments in Long-term Thinking:** To respond to the economic and environmental challenges facing the city, Tondende invested in upskilling government leaders to engage in systemic thinking. Local politicians and civil servants were trained to assess the long-term consequences of their decisions, avoiding past mistakes like the Dutch nitrogen ban and Catalan greenwaste burning ban of 2023, which resulted in unintended consequences. This allowed for more effective policy development that aligned with degrowth objectives, prioritizing sustainability over short-term growth.
- **Democratic Conversations for Industry Transformation**: Tondende initiated democratic processes involving citizens, businesses, and stakeholders to decide which industries were necessary and non-polluting for the city's future. These processes took place through cooperative platforms, where local residents had a direct say in shaping the future economy, ensuring that industries that contributed to community well-being, not just profit, thrived.
- **International Cooperation for Degrowth Practices:** Tondende also engaged in intercity and international cooperation platforms with other degrowth-curious cities. This collaboration fostered cross-border learning, allowing the city to share successes and challenges with like-minded cities, while developing joint initiatives in areas such as sustainable tourism, climate resilience, and circular economies.

Environmental Actions: Reclaiming Natural Resources

- **Energy and Resource Use Reconfiguration:** Tondende adopted radical new ways to generate and use energy, shifting towards local, renewable energy sources like solar panels and wind turbines. The city also focused on reusing and recycling materials, developing a circular economy where resources were continually reused, rather than extracted anew, reducing pressure on the planet's limited resources.

Social Actions: Building Community and Reframing Consumption

- **Resource Sharing Models:** Tondende promoted the adoption of sharing economy models, encouraging residents to share resources rather than own them. Community-run cooperatives and tool libraries allowed residents to access goods and services without relying on

consumption-driven growth. This shift to shared resources reduced the environmental impact of overproduction and consumerism, while fostering a stronger sense of community.

- **Communication and Education:** A city-wide communication campaign worked to demystify degrowth and highlight historical examples of sustainable practices—such as preserving food, growing one's own vegetables, and repairing goods. Through these examples, the city showed residents how they could reconnect with simpler, more sustainable lifestyles, while still maintaining a high quality of life.
- **Educational Curriculum Reform:** To ensure future generations were equipped for a degrowth society, Tondende revamped its educational system to include subjects like Regenerative Economics, Wellbeing Economics, and Doughnut Economics. This curriculum shift empowered young people to think critically about alternatives to capitalism and understand how they could contribute to creating a more sustainable and just economy.
- **Gradual Implementation and Pilot Projects:** Understanding that transformation takes time, Tondende implemented pilot projects and gradual steps to test and refine degrowth policies. This included initiatives like community-run gardens, public transport improvements, and circular economy trials. Over time, these smaller-scale successes helped build momentum for larger, city-wide changes.

Technological Actions: Supporting Social and Planetary Solutions

- **Civic and Appropriate Tech:** Tondende invested heavily in the development of civic tech, convivial tech, and appropriate tech aimed at solving societal and environmental challenges, not just generating profits. These technologies helped improve public participation, community-driven decision-making, and sustainable urban practices, such as smart water management systems and low-carbon transportation.
- **Legal Actions:** Establishing a Just Transition
- **Just Transition Framework:** Tondende's commitment to just transition thinking was enshrined in a comprehensive framework that ensured no one was left behind in the city's transformation. The framework included social safety nets, retraining programs, and inclusive policies that allowed workers in polluting industries to transition to new, cleaner sectors.

Economic Actions: Redefining Success and Wealth Distribution

- **Wealth Taxes subsidizing Social Programs:** The city implemented wealth taxes on the highest earners and luxury goods, such as SUVs, to help fund public services and social programs aimed at promoting well-being. This provided the city with the resources to invest in sustainable public infrastructure such as public transport and affordable housing, aligned with the principles of degrowth.
- **Transition Finance Facilities:** Recognizing the need for new financing models, Tondende established Transition Finance Facilities to pool investments from diverse sources, including public funds, private investors, and cooperative funds. These facilities enabled the city to fund projects focused on social and environmental good rather than just financial return, prioritizing long-term community benefits over short-term profits.

By 2030 Tondende's investment in a redefinition of progress and wellbeing had radically shifted priorities for citizens and the city. The gradual approach of piloting and small steps enabled the chance to test and refine, learning iteratively how to make change together. Social safety nets alongside a commitment to demystified and clear communication embedded a shift in priorities, heralding long term community benefits rather than short term profits.

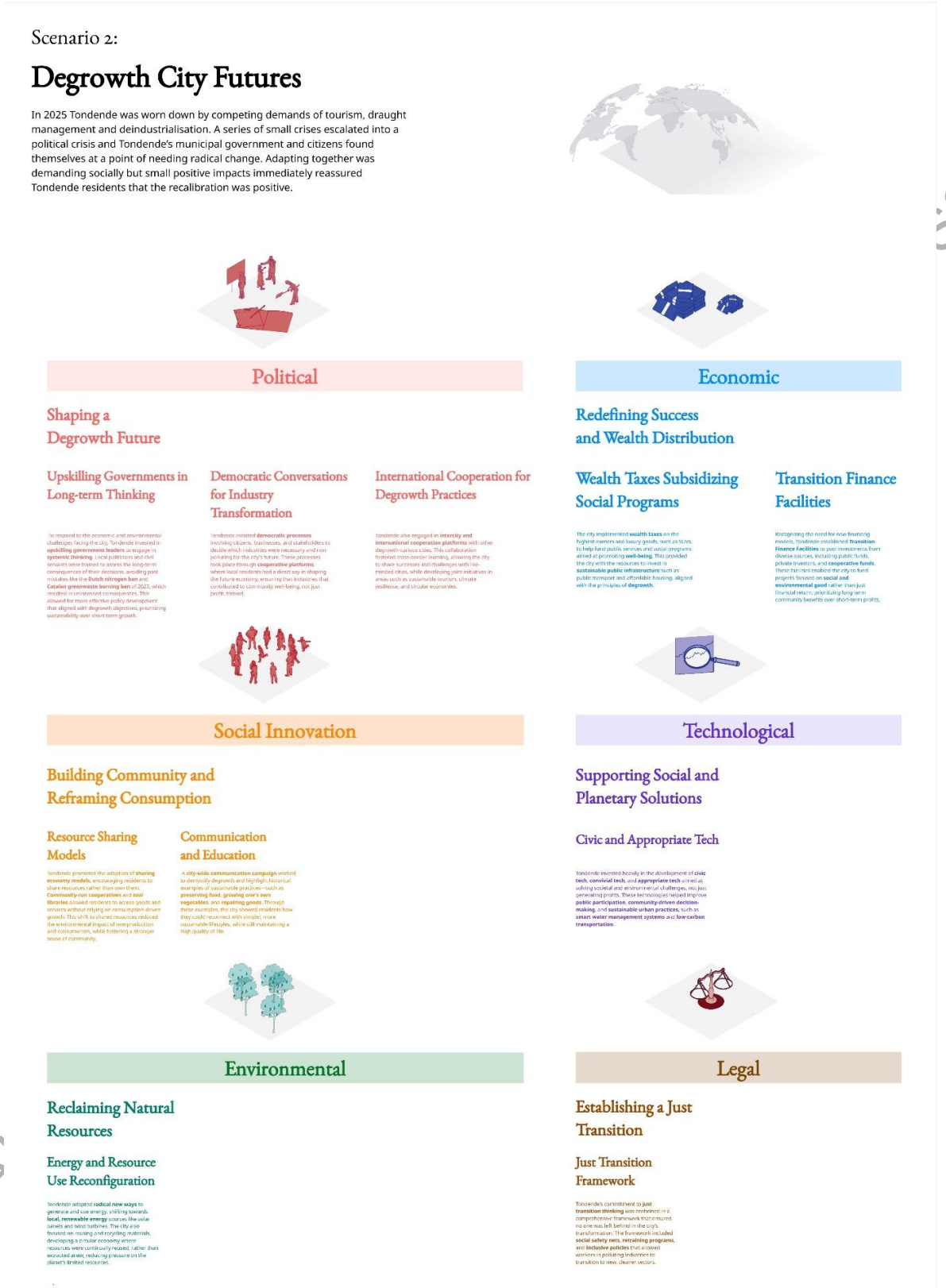


Figure 3: Scenario 1: Degrowth City Futures - graphic overview [High resolution version available on the Net Zero Cities Portal here]

4.2.3. Scenario 3: 2030 – Achieving Net Zero in Heilding – harnessing AI and its discontents

4.2.3.1. City Context: A central European City Focused on optimisation

By 2030, Heilding, a mid-sized European city, has reached its ambitious climate neutrality goal, becoming a model for urban sustainability in Europe. This achievement, though remarkable, was not without its hurdles. The integration of Artificial Intelligence (AI) into urban systems posed both opportunities and challenges that had to be carefully navigated. Through collaboration, innovative solutions, and inclusive governance, the city overcame these challenges, making the transition to a carbon-neutral future a reality.

4.2.3.2. The Catalyst for Change: The Urgency of Climate Action

The catalyst for Heilding's transformation came in the form of an escalating climate crisis. Like many cities, Heilding faced rising energy consumption, inefficient transportation systems, waste management inefficiencies, and the adverse impacts of climate change. In response, the city committed to the EU's Mission for Climate-Neutral and Smart Cities by 2030, aiming to integrate AI technologies into climate action strategies for energy efficiency, waste management, and transportation.

However, the use of AI was not a straightforward solution. The city faced significant challenges that needed to be addressed for AI to effectively contribute to its climate goals.

4.2.3.3. Understanding the Challenges and Impacts of AI on Urban Transformation

High Energy Consumption of AI Models

One of the first barriers was the high energy consumption of AI models. While AI promised to optimize urban systems for sustainability, the training of large-scale AI models—such as those used for traffic management, energy optimization, and waste sorting—was highly energy-intensive. This posed a dilemma: could AI, which consumes large amounts of energy during training, contribute to climate neutrality?

To address this, Heilding developed green AI models that optimized energy usage while minimizing the environmental impact of AI technologies themselves. Collaborating with universities and tech companies, the city created more energy-efficient algorithms, focusing on low-energy consumption without compromising AI's capabilities. This effort aligned AI usage with the city's broader climate goals, including the integration of AI-powered smart grids to ensure optimal distribution and use of renewable energy sources, such as solar and wind.

Unequal Distribution of AI Benefits

AI has the potential to exacerbate social inequalities if not implemented with care. Wealthier neighborhoods often have better access to advanced technologies, while marginalized communities might not benefit equally from AI-driven climate actions. Heilding recognized this challenge and made inclusivity a central pillar of its climate action plan.

To tackle this, the city implemented AI-driven civic engagement platforms to ensure diverse participation in climate decision-making. These platforms allowed all residents to actively engage in the design of urban sustainability projects, from local renewable energy initiatives to transportation planning. Furthermore, the city prioritized AI-powered projects for social equity, ensuring that the benefits of AI—

such as energy-efficient homes and renewable energy access—were equally distributed across all socioeconomic groups.

Accountability and Transparency in AI Decision-Making

The increasing role of AI in urban governance raised concerns about accountability and transparency. AI systems were making critical decisions about energy distribution, waste management, and even traffic flow, but who was accountable if something went wrong?

Heilding established a Chief AI Ethics Officer to oversee the ethical deployment of AI in the city's operations. Ethical frameworks were integrated into AI decision-making, ensuring that all AI systems were transparent, with decisions clearly communicated to the public. This process was backed by AI-enhanced policy simulations that allowed residents and policymakers to review the potential impacts of proposed AI interventions, ensuring accountability and preventing biases.

4.2.3.4. Tactics and Actions: Leveraging AI for Climate Neutrality

The following tactics and actions were taken to harness AI for the city's transformation, addressing the challenges identified above:

Political Actions and Tactics

- **AI Governance**: Heilding established governance frameworks to ensure the ethical deployment of AI across city departments. This ensured that AI-driven climate solutions were not only effective but also aligned with the city's social and environmental values.
- **Ethical AI Decision-Making**: The city developed and published guidelines for the ethical deployment of AI, integrating ethical decision-making processes into all AI applications to prevent unintended consequences.
- **Inclusive Participation**: To ensure democratic integrity, AI-driven platforms were used to enhance public policy integration, enabling real-time engagement from residents in climate action decisions.

Environmental Actions and Tactics

- **Sustainable AI Models**: Heilding encouraged the development of energy-efficient AI models, which were designed to reduce the carbon footprint of AI technologies themselves. This helped the city manage its smart grids and integrate AI into circular economy initiatives like waste reduction and resource reuse.
- **AI in Waste and Water Management**: AI systems were deployed in waste sorting and water conservation, increasing recycling rates and reducing water waste across the city. The use of AI-enabled systems helped monitor carbon footprints in real-time, significantly contributing to the city's carbon neutrality.
- **Green AI Initiatives**: AI-powered energy optimization systems were integrated into building management to reduce energy consumption in municipal buildings, ensuring a green, resource-efficient future.

Social Actions and Tactics

- **AI for Social Equity**: Heilding prioritized AI solutions that promote inclusive access to climate benefits. This ensured marginalized communities, including low-income residents, had access to sustainable technologies such as energy-efficient housing and clean energy sources.
- **Public Education and Awareness**: AI-powered platforms were used to educate citizens about sustainable practices, enabling them to take part in the city's climate goals through real-time information and actionable insights.

- **Civic Engagement in AI Projects**: The city implemented community-led AI projects where local residents were actively involved in the decision-making process. This fostered a sense of ownership and responsibility, ensuring that AI systems met the needs of all citizens.

Technological Actions and Tactics

- **Smart Grids and AI Integration**: The city integrated AI into smart grids, optimizing energy consumption across the city. AI dynamically adjusted to energy demands, ensuring the efficient use of renewable energy sources and minimizing waste.
- Development of AI-Based Solutions for Mobility: AI-driven solutions were implemented in urban mobility, including autonomous vehicles and intelligent traffic management systems, to reduce emissions and improve traffic flow across the city.

Legal Actions and Tactics

- **Regulation of AI Models:** Heilding developed legal frameworks to govern the use of AI in urban planning, focusing on environmental protection and social equity. This ensured that AI-driven solutions were implemented responsibly, in line with the city's climate goals.
- **Data Privacy Laws**: As AI systems processed vast amounts of data, the city ensured that AI technologies complied with strict data privacy laws to protect citizens' personal information and maintain public trust.

By 2030 Heilding had integrated a deep and rigorous understanding of the opportunity and limitations of AI into city governance and norms. Efficiencies were achieved through strategic deployment of technologies that recognised existing digital infrastructure and knowledge architectures. Instead of flattening and making citizen engagement simply efficient, the integration of regulation and ethical frameworks ensured Heilding's AI deployment was in service of a just transition.

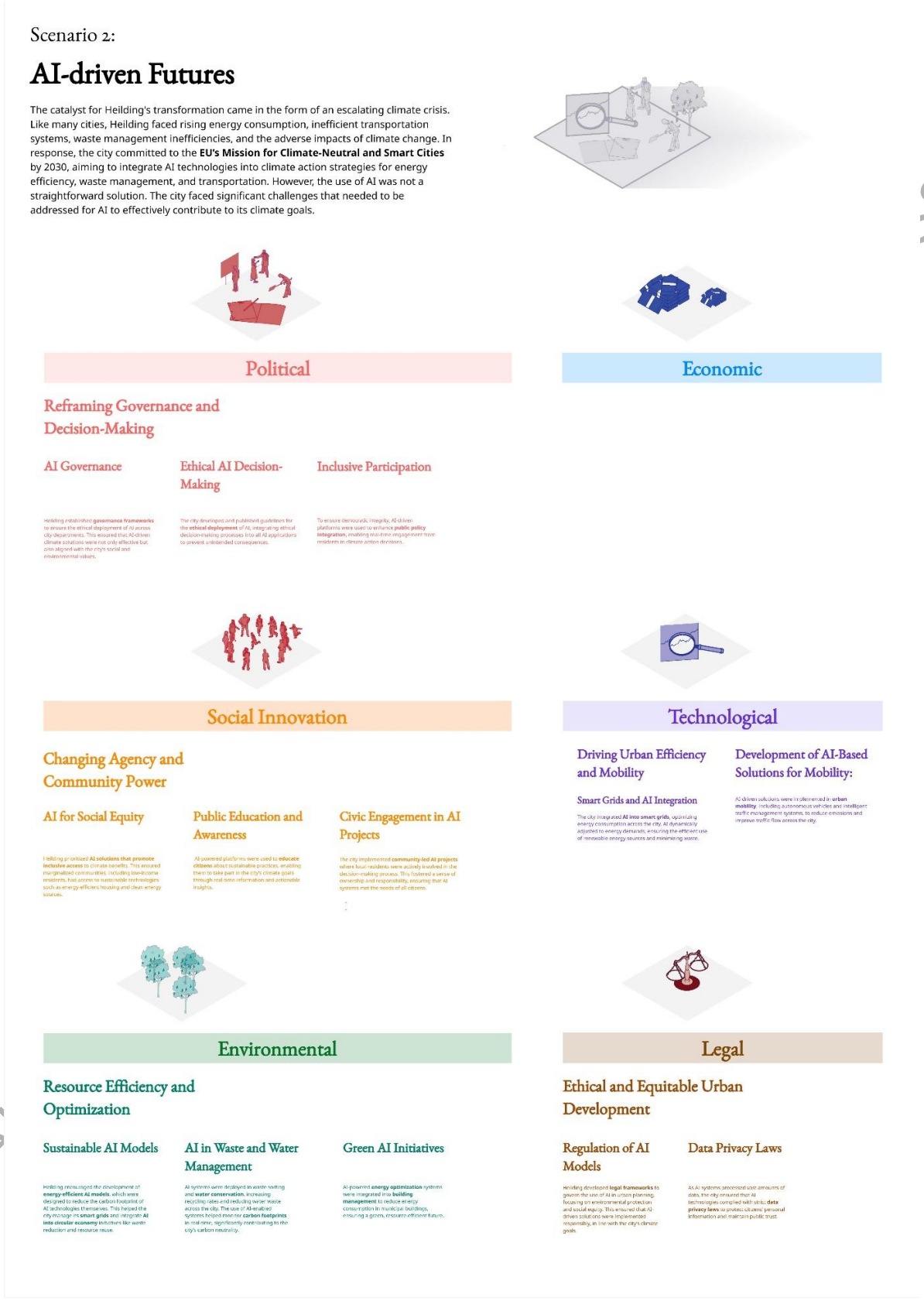


Figure 4: Scenario 3: AI-driven Futures – graphic overview. [High resolution version available on the Net Zero Cities Portal here]

4.2.4. Scenario 4: 2030 – Solvstadt – Navigating adaptation to climate vulnerabilities alongside mitigation

4.2.4.1. City Context: A Mid-Sized European City Focused on Urban Resilience

In 2030, Solvstadt, a city located in the north of Europe, has transformed from an industrial hub into a sustainable, climate-neutral urban center. A city once known for its carbon-heavy industries and sprawling urban development now stands as a leading example of how coordinated political leadership, economic innovation, and social mobilization can create a resilient, low-carbon future. This transformation was driven by a clear commitment to integrate climate adaptation and mitigation, ensuring that Solvstadt could tackle the challenges of climate change head-on.

4.2.4.2. The Catalyst: A Climate-Induced Crisis and a Shift to Integrated Solutions

In 2025, Solvstadt was hit by a series of extreme weather events that highlighted the city's vulnerabilities to climate change. After severe flooding caused by record rainfall, the city's leadership recognized that climate action could no longer be approached in silos—mitigation alone was insufficient to prepare for the future. The city needed to integrate both mitigation and adaptation strategies to build a truly climate-resilient city.

The crisis catalyzed a systemic shift, with Solvstadt committing to a radically updated Climate City Contract (CCC) that combined ambitious carbon neutrality targets with adaptive strategies for resilience. This marked the beginning of the city's transformation into a climate-neutral city by 2030.

4.2.4.3. Tactics and Actions for Positive Change

Political Actions: A Commitment to Long-Term, Inclusive Leadership

- **Breaking Down Governance Silos:** Solvstadt reformed its governance structure by establishing a unified climate policy framework that integrated mitigation and adaptation actions. **A new Climate Action Board was formed**, involving key stakeholders from energy, transport, housing, health, and urban planning. This **multi-sector collaboration** ensured that all climate actions aligned with the city's net-zero target, **making climate action part of the core municipal agenda.**
- **Climate Justice as a Guiding Principle:** Political leaders in Solvstadt emphasized climate justice in all climate-related decision-making. The city **established policies to ensure that the benefits and burdens of climate action were shared equitably, with a focus on vulnerable communities**. This included affordable housing programs and job creation in the green economy, ensuring that the transition to climate neutrality did not leave anyone behind.

Economic Actions: Reimagining Finance for a Climate-Neutral Future

- **Carbon Budget-Based Planning:** Solvstadt implemented a carbon budget-based urban planning model, which **required all new development and infrastructure projects to align with the city's annual carbon budget**. This approach ensured that growth was decoupled from emissions and aligned with the city's climate neutrality target.
- **Leveraging Green Finance:** The city **expanded its use of green bonds and climate finance instruments to fund large-scale infrastructure projects**, including renewable energy systems, energy-efficient retrofits, and green urban spaces. Solvstadt also developed

a **Transition Finance Facility**, pooling public, private, and cooperative investments to fund projects that delivered both environmental and social benefits.

Social Actions: Ensuring an Inclusive and Just Transition

- **Empowering Communities:** Solvstadt recognized the importance of local knowledge and participation in shaping the city's climate future. **Community consultations and participatory planning processes were central to the city's climate strategy**. Local residents, especially from vulnerable communities, were actively involved in designing solutions to climate challenges, from local renewable energy projects to urban green spaces.
- **Social Equity in Climate Policy:** The city implemented policies to ensure that its climate actions were socially inclusive. Solvstadt introduced subsidies for low-income families to retrofit their homes with energy-efficient technologies and invested in green job training programs for workers in polluting industries, **ensuring that the city's green transition was just and equitable.**

Technological Actions: Innovation for Sustainability and Climate Resilience

- **Smart City Solutions:** Solvstadt became a leader in smart city technologies, **using real-time data to optimize energy use, manage waste, and monitor air quality.** The city integrated IoT sensors into its urban infrastructure, allowing for efficient management of resources and enhanced climate resilience. These technologies were particularly valuable in managing flood risks, as sensors provided early warnings and enabled quicker responses.
- **Renewable Energy and Decentralized Systems:** Solvstadt expanded its renewable energy capacity by installing solar panels and wind turbines across the city. A **decentralized energy grid** was established, with energy generated locally and stored in smart grids, reducing reliance on fossil fuels and ensuring that the city's energy supply was both sustainable and resilient.

Environmental Actions: Building Resilience with Nature-Based Solutions

- **Green Infrastructure for Climate Adaptation:** Solvstadt adopted nature-based solutions (NbS) to manage urban heat islands, reduce stormwater runoff, and enhance biodiversity. **The city planted urban forests, created green roofs, and installed permeable surfaces to absorb rainwater and mitigate flood risks**. These measures not only reduced the city's environmental footprint but also improved residents' quality of life by providing green spaces for recreation and health.
- **Circular Economy Practices:** Solvstadt embraced a circular economy model, focusing on reducing waste, reusing materials, and recycling. The city **set up local material banks**, where building materials from deconstructed buildings were collected and reused in new construction projects. This practice not only reduced the carbon footprint of construction but also supported local industries and created green jobs.

Solvstadt by 2030 had not forgotten the trauma of 2025 and the crisis response but many of the old ways of working were already viewed as arcane. Adaptation and mitigation efforts now worked in synergy, with green transition finance and innovation embedded into everyday city decision making. Radical restructuring of governance away from silos enabled the cultivation of a portfolio of interventions.

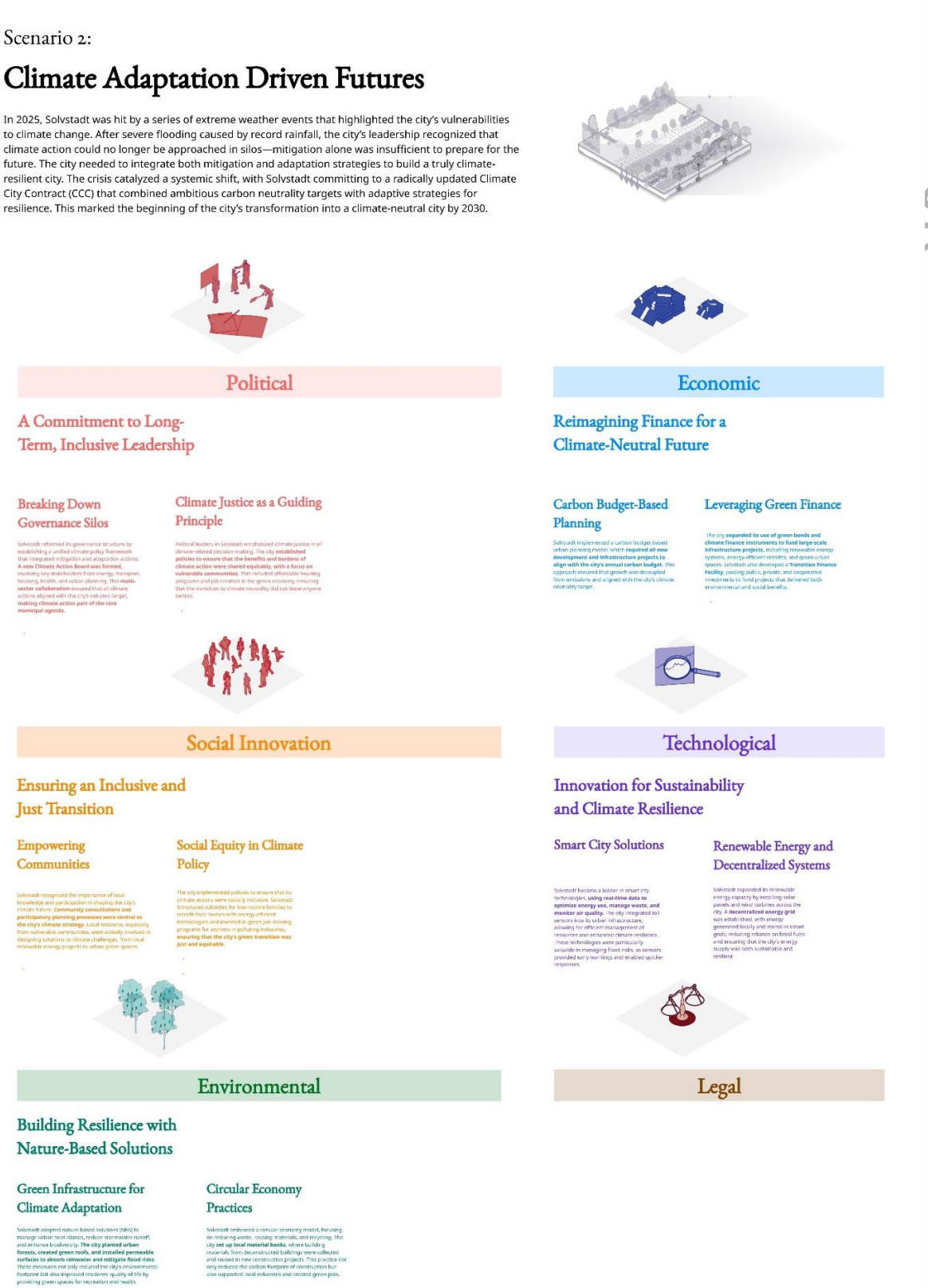


Figure 5: Scenario 4: Climate Adaptation-driven Futures – graphic overview [High resolution version available on the Net Zero Cities Portal here]

Funded by the European Union

4.3. Visual Methodology and Scenario Mapping

T4.8 was initially tasked with producing six visual syntheses of possible future desirable scenarios. These support Mission development, SGA review, and external communications.

The scenario development process employed a visual mapping methodology designed to transform research insights into accessible, navigable tools for cities. This approach drew inspiration from scenario planning methodologies that combine qualitative narratives with systematic frameworks to enable comparison and pattern recognition across multiple futures. Particularly relevant was Agrimonde-Terra—a foresight exercise by INRAE and CIRAD that demonstrates how complex systemic scenarios can be structured to serve as "learning machines" that raise awareness and encourage stakeholder debate (Le Mouël et al., 2018; Mora et al., 2020). While Agrimonde-Terra focused on land use and food security, its methodological approach of combining expert workshops, thematic categorization, and visual synthesis informed the NetZeroCities scenario framework.

4.3.1. Visual Canvases as Exploratory Tools

Each scenario was structured according to the PESTLE framework (Political, Economic, Social, Technological, Environmental, Legal), organizing tactics and actions into thematic categories. This systematic categorization enabled the creation of comprehensive visual canvases—large-format mappings that lay out all interventions across the four scenarios in a directly comparable format. Drawing on principles from urban scenario visualization (Abou Jaoude et al., 2022), these canvases transform complex narrative content into accessible visual language.

The canvases serve multiple analytical functions:

- **Cross-Scenario Pattern Recognition:** By arranging interventions across six dimensions for all four scenarios simultaneously, common pathways become immediately visible. Actions that recur across AI-driven, degrowth, built environment policy, and climate adaptation scenarios reveal convergent strategies—interventions likely to be robust across multiple possible futures.
- **Trade-off and Tension Visualization**: The comparative format surfaces where different catalysts lead to conflicting approaches or where policy choices in one domain may undermine actions in another. This visual tension mapping helps cities anticipate governance challenges.
- **Exploratory Navigation**: The canvases function as decision-support tools rather than prescriptive roadmaps. Cities can use them to explore how interventions in one PESTLE dimension might cascade through others, testing their own proposed actions against the mapped pathways.
- **Iterative Expansion:** The framework is designed to accommodate additional scenarios. Cities can overlay their own pathways onto the canvas structure, comparing their approaches against the four primary scenarios and identifying complementarities or gaps.

To bridge aspirational futures with current practice, each tactical intervention on the canvas includes references to existing city examples and NetZeroCities case studies. These appear as linked citations beneath each action point, demonstrating that proposed interventions are grounded in actual municipal experimentation. Where NetZeroCities case studies were unavailable, examples from European cities were incorporated, creating a traceable path from emergent practice to scaled implementation. This grounding approach recognizes that effective scenario planning in urban contexts must connect exploratory futures to actionable present-day precedents (Chakraborty et al., 2011).

The visual canvases thus serve as both analytical tools for strategic foresight and communication assets for stakeholder engagement, embodying the scenario planning principle that effective futures work must balance rigor with accessibility.

The visual canvases and scenario narratives function as strategic tools for cities navigating climate neutrality transitions. By synthesizing insights from deep dives, horizon scanning, and expert workshops into comparable visual formats, the scenarios enable cities to anticipate barriers, identify opportunities, and test their own pathways against multiple futures. Rooted in research yet designed as conversation starters, they embody the scenario planning principle that effective futures work must balance analytical rigor with accessibility for stakeholder engagement.

4.3.2. AI-Generated Imagery as Imagination Infrastructure

Recognizing the "imagination gap" as a barrier to climate ambition, the scenarios incorporate AI-generated visual narratives created using Midjourney and composited in Adobe Creative Suite. These images function as imagination infrastructure, providing concrete visual references that help stakeholders envision how radical policy shifts manifest in physical urban change (Al-Kodmany, 2002; Abou Jaoude et al., 2022).

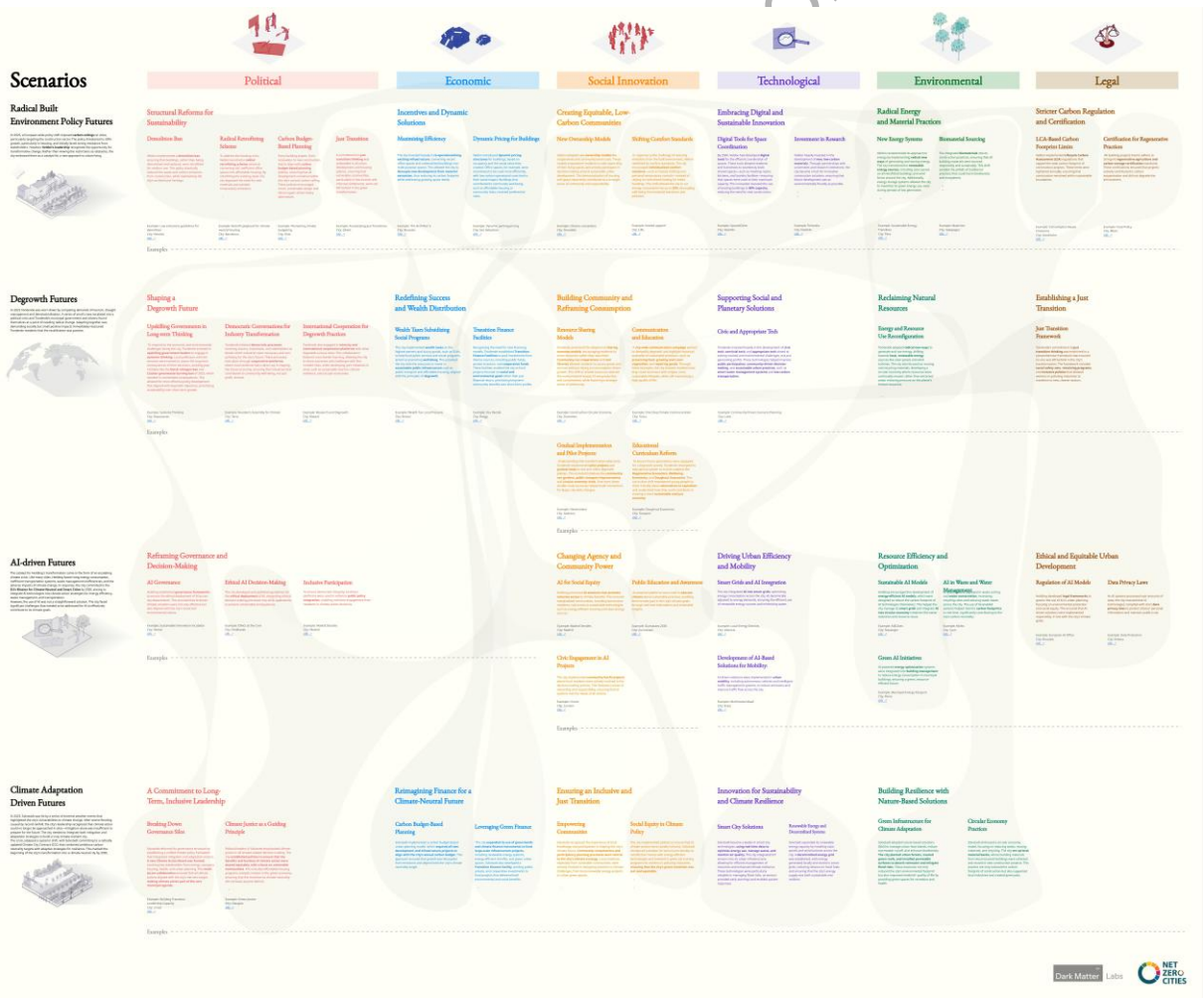


Figure 6: Scenario Map Developed following the Scenario Workshop (DML)

5. Communication and Collaboration across Tasks and Work packages

5.1. Communication Strategy

NetZeroCities' communication strategy is mission-centric, story-driven, and integrated into its learning and support architecture. It influences cities by providing shared language and narratives for climate neutrality, creating incentives through visibility and peer comparison. In consideration of this, Task 4.8's communication and influence strategy evolved throughout the project lifetime. While direct city engagement was not within the task's capacity, the successful NetZeroCities blog platform was leveraged to draw attention and traffic toward the deep dives and scenarios.

5.1.1. Blog Post Series

Three blog posts were produced, focusing on the deep dives and scenarios. Each blog post was accompanied by cross-platform social media promotion to drive engagement. The publication schedule and performance metrics are presented in Table 2.

Blog Title	Organization	Publication Date	Platform Links	Performance Metrics
Preparation vs prevention? How cities can find a balance as they face challenges of climate change	Dark Matter Labs (based on partners' outputs)	10 November 2024	Website LinkedIn X Instagram NZC Portal	1,130+ impressions (LinkedIn) 21 likes, 2 reposts (LinkedIn) 13 likes (Instagram) 65+ impressions (X)
From Neighbors to Networks - How Communities Fund Their Own Future	Democratic Society	12 January 2025 (scheduled)	TBD	Social media promotion commenced 14 January 2025
When efficiency isn't enough? How can sufficiency policies help cities to reduce resource demand while ensuring a good life for all	Demos Helsinki	19 January 2025 (scheduled)	TBD	Social media promotion commenced 14 January 2025
Scenarios for Sustainable Cities Future	Dark Matter Labs (based on partners' outputs)	26 January 2025 (scheduled)	TBD	Social media promotion commenced 14 January 2025

Table 2: Blog publication schedule and performance metrics

The first blog post achieved strong engagement across platforms, with over 1,130 LinkedIn impressions and multi-platform interaction. Detailed website analytics were tracked separately. The staggered publication schedule ensured sustained visibility throughout the project's final phase.

Blog posts overview – Annexes 7-10

5.2. Cross-Work Package Collaboration

Collaboration across work packages primarily took the form of output exchange and bilateral coordination. Task 4.8 partners triangulated emerging signals from cities (WP2), integrated knowledge from various research activities (Tasks 4.3 and 4.6), and used regular WP4 meetings to scan the horizon for risks and opportunities in global trends and events. Preliminary bilateral meetings took place with WP6.5 to align on making outputs more city-facing and integrating them with city support activities. WP9.1 provided storytelling and communication support for blog post development and dissemination.

Conclusion and Key Insights

Task 4.8 developed a comprehensive foresight framework integrating horizon scanning, deep dives, and scenario generation to support Mission Cities in navigating climate transition pathways. The scenario work represents a distinct methodological contribution, translating research insights into navigable futures through visual mapping and narrative storytelling. By grounding four fictional cities—Veldon, Tondende, Heilding, and Solvstadt—in different catalysts (policy intervention, behavioral shift, technological breakthrough, natural crisis), the scenarios enable cities to explore multiple transition pathways simultaneously and identify relevant tactics across PESTLE domains.

The visual canvases function as orientation devices, mapping interventions from existing city examples alongside speculative futures, enabling Mission Cities to compare their own strategies against multiple pathways. This approach addresses the "imagination gap" in climate planning, providing concrete visual and narrative references for radical transformation while maintaining analytical rigor through structured methodology. The scenarios reveal five overarching themes that emerged across all research activities.

Climate change functions as a threat multiplier, amplifying security risks through cascading impacts on food systems, resource availability, and geopolitical stability. The scenarios demonstrate how Mission Cities must integrate adaptation and mitigation strategies with security and municipal planning frameworks to address urban preparedness challenges related to extreme weather events, heatwaves, and systemic vulnerabilities. This nexus appears most explicitly in Solvstadt's crisis-catalyzed governance transformation, where flooding drove systemic integration of adaptation and mitigation.

Alternative governance and financing structures emerged as a critical theme across interviews, deep dives, and scenario narratives. Case studies from Mietshäuser Syndikat (Germany), SomMobilitat (Spain), Energy Island Samsø (Denmark), and community grocery cooperatives (UK) demonstrate that community-driven finance models can enable sustainable project implementation while maintaining local ownership. Tondende's transition finance facilities and Veldon's cooperative ownership models illustrate how these approaches can scale at city level. However, legal and policy barriers, market competition, and grant dependency pose risks to long-term viability. Task 4.8 outputs provide Mission Cities with frameworks for understanding and exploring these alternative approaches.

Systemic risks in the low-carbon transition include resource security challenges, material supply vulnerabilities, and geopolitical dependencies on critical materials for clean technologies such as rare earth metals for electric vehicles. The complexities of decarbonizing urban infrastructure while maintaining environmental justice principles are amplified by external supply chain dependencies, workforce shortages, and the aforementioned security risks. Throughout Task 4.8, emphasis was placed on ensuring that climate transitions are not only ecologically sustainable but also socially just. This includes addressing inequality through inclusive participation, accessible finance mechanisms, and safeguarding vulnerable communities from maladaptation consequences. Justice considerations emerged strongly in expert interviews and informed all four scenarios, from Veldon's just transition policies to Heilding's Chief AI Ethics Officer ensuring equitable technology deployment.

The task consistently highlighted the need for collaborative decision-making frameworks, local self-determination mechanisms, and meaningful public participation. Empowering local communities to design, implement, and govern climate action strategies strengthens both inclusivity and social resilience. Across scenarios, this appears through Tondende's democratic industry conversations, Solvstadt's community consultations, and Veldon's cooperative ownership models. The scenario mapping function serves as an orientation device, connecting present-day transition examples with long-term futures of fictional cities, enabling Mission Cities to visualize pathways, navigate strategic choices, and test their own interventions against multiple possible futures.

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Annex 1 – Integrating Mitigation and Adaptation:
Pathways for urban climate resilience and justice (Demos Helsinki)

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Summary

This **deep dive** provides an exploration of the integration of climate change mitigation and adaptation strategies in urban contexts, with particular attention to pathways for resilience and justice in European cities. It is situated within the broader framework of the NetZeroCities (NZC) programme, which supports the transition towards climate-neutral, sustainable, and inclusive urban futures.

The study **considers** the historical predominance of mitigation over adaptation, the increasing recognition of the need to integrate the two approaches, and the shift in climate narratives that emphasise justice, equity, and human-centric perspectives alongside technical solutions. Key issues addressed include the lag in adaptation planning, challenges in financing holistic climate action, risks of maladaptation, and the importance of embedding justice frameworks and local self-determination. The role of nature-based solutions (NbS) as integrative tools is also **examined**.

Drawing on recent academic and grey literature, together with the expertise of the NZC consortium, the deep dive **highlights** both opportunities and risks associated with integration. Opportunities relate to governance improvements, funding alignment, the incorporation of local knowledge, and the multiple co-benefits of NbS. Risks include siloed approaches, insufficient financing, policy incoherence, and inequitable impacts.

The deep dive **points towards** key considerations for cities, including governance innovations, the definition of local adaptation objectives, the expansion of engaged sectors, the integration of funding mechanisms, and the enhancement of participation among vulnerable groups. By adopting integrated and justice-oriented approaches, cities can avoid unintended trade-offs, strengthen resilience, and design climate strategies that deliver co-benefits for people, ecosystems, and future generations.

Keywords

Climate adaptation; climate mitigation; climate resilience; just transition; urban governance; NetZeroCities; nature-based solutions; climate finance; maladaptation; multispecies justice.

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1. Introduction and Objectives

This horizon scanning deep dive is part of NetZeroCities' efforts to explore key concepts influencing the transition to a zero-emission future. This report is based on the analysis of findings from recent academic research, insights from grey literature, and the expertise within the NetZeroCities consortium. Its focus is on the integration of the two overarching strategies that cities can employ to address climate change: **mitigation** and **adaptation**.

As global temperatures continue to rise, evidence indicates that mitigation efforts alone are insufficient to prevent the negative impacts of climate change. Cities must not only persist in efforts to cut emissions but also work toward strengthening their adaptation strategies, building the necessary resilience to manage unavoidable consequences. Historically, mitigation and adaptation have been approached as separate endeavours. This report, however, examines the growing call for their integration and the challenges cities face in realising this shift. It also explores the factors that have led to the current landscape, where European cities must enhance their climate responses through more comprehensive and synergistic approaches. To support this transition, the report identifies the key risks and opportunities for integrating mitigation and adaptation while outlining potential pathways for European cities.

2. Context

2.1. Background

European cities are **increasingly experiencing the effects of climate change**, with climate extremes that will further increase in frequency and severity (EEA, 2024a). The record-breaking temperatures of summer 2023 illustrate this trend, with global temperatures in 2023 increasing by 1.35 °C compared to the pre-industrial average from 1850–1900 (Lindsey & Dahlman, 2024; Niranjan, 2024). Some risks have already reached critical levels, including risks to health due to heatwaves, to ecosystems and biodiversity, to inland flooding and to solidarity mechanisms (EEA, 2024a). Despite general advancements, efforts to reduce emissions have largely been unsuccessful (IPCC, 2022), leaving cities with the urgent need to enhance resilience to confront the unavoidable impacts. At the same time, cities must continue striving to cut emissions in order to prevent further damage.

Cities contribute over 70% of CO2 emissions and are particularly vulnerable to climate change, as they house the majority of the global human population (Sharifi, 2021). This significant role in both contributing to and suffering from climate change effects has made cities crucial agents of climate action (Kyprianou et al., 2023). In the face of climate change, cities can engage in actions that result in **mitigation**, **adaptation** or **maladaptation** to its effects (IPCC, 2022). Mitigation and adaptation are the primary strategies for responding to climate change and form the two key elements of preparedness for its negative impacts. The urgency of addressing both simultaneously while avoiding the risks of maladaptation has become increasingly evident (IPCC, 2022).

- **Mitigation** refers to strategies and actions aimed at tackling the root direct cause of climate change –the concentration of greenhouse gases in the atmosphere, either by reducing the amount of released emissions (e.g. by reducing energy consumption, switching to renewable energy sources or legal frameworks to limit emissions) or reducing the current concentration of CO2 by increasing carbon sinks (e.g. through increasing forested areas, or improving land use practices) (IPCC, 2022). Mitigation is in the core of actions for carbon neutrality targets e.g. Net Zero by 2050.

- **Adaptation** is defined, in human systems, as the process of adjustment in response to actual or expected climate change effects. Adaptation measures are designed to minimise harm and capitalise on potential opportunities (IPCC, 2022). Adaptation focuses on building resilience in

both ecological and societal systems. Adaptation strategies are diverse in scope and outcomes. Examples include: altering agricultural practices to cope with changing precipitation, building coastal infrastructure to protect against sea level rise, re-design infrastructure to withstand extreme weather conditions, enhancing public health measures and emergency response to address climate risks, and planning relocation of vulnerable populations.

In ecological systems, adaptation is the process of autonomous adjustment to the current climate and its effects through ecological and evolutionary processes. Ecological systems are capable of adapting and mitigating within limits. (IPCC, 2022).

- **Maladaptation** refers to actions that inadvertently increase vulnerability to climate change or exacerbate its impacts on people, biodiversity and ecosystems. These outcomes may include higher greenhouse gas emissions, increased vulnerability, reduced equity, or decreased welfare (IPCC, 2022). Often, maladaptation happens as an unintended consequence. Marginalised groups are particularly vulnerable to the adverse effects of maladaptation.

Measures to reduce greenhouse emissions and shield populations and ecosystems from the effects of climate change **differ substantially in nature and development.** However, mitigation and adaptation should be viewed as **interdependent strategies**—like two sides of the same coin (Howarth & Robinson, 2024). The urgency of climate change calls for cities to develop comprehensive climate action plans that not only implement these strategies simultaneously but also **interrelate** them effectively. A combined understanding of adaptation and mitigation is an opportunity to increase societal resilience. Mitigation and adaptation plans are being developed rapidly in many cities across the globe, driven by local initiatives and emerging alliances that support organisations across multiple jurisdictions (Kang et al., 2024). However, despite the progress and the imperative, recent evidence suggests a **persistent dichotomy**, indicating that this integrated approach is still far from being realised (Huang-Lachmann & Guenther, 2020).

2.2. The mitigation-adaptation dichotomy

2.2.1. Mitigation prevails over adaptation

International, national, and local climate efforts have historically **focused primarily on mitigation**, leading to a disparity in the development of adaptation plans (Cömert Baechler, 2023; Reckien et al., 2018; Sharifi, 2021). This trend continues at the EU level. According to Grafakos et al. (2020), from a large sample of 885 European cities, 75% have adopted mitigation strategies alone, while 57% consider both mitigation and adaptation plans. No city had implemented adaptation plans alone. Similar conclusions have been reached by other studies (Heidrich et al., 2013; Melica et al., 2022; Pietrapertosa et al., 2019; Reckien et al., 2014; Reckien et al., 2018). The prevalence of mitigation is attributed to several interconnected factors, fundamentally arising from **cities' governance capacities** for implementing both policies, as well as **international networks and agreements** that inadvertently promote mitigation over adaptation.

- **Institutional context and governance capacity at the city level:** Cities generally possess governance and decision-making frameworks that enable them to implement and manage mitigation strategies more effectively than adaptation. Their typically robust regulatory and policy mechanisms provide greater control over urban technical systems through well-defined quantitative metrics and evaluation methods, such as those used for energy, transportation, and waste management (Cömert Baechler, 2023). Mitigation targets are clearly defined in quantitative metrics of CO2, which, when compared to adaptation targets, facilitates the integration of policies for decarbonisation (Howarth & Robinson, 2024). In contrast, social and ecological resilience lack universal evaluation metrics (see section 3.1). Consequently, mitigation efforts are viewed as having more direct and measurable outcomes and are more

appealing to cities aiming to demonstrate progress and secure ongoing public and international support (Cömert Baechler, 2023). Moreover, the integration of adaptation and mitigation strategies is challenged by differences in spatial, temporal, jurisdictional, and institutional scales, leading to complexities that result in conflicting policies with contradictory objectives (Landauer et al., 2019).

- **Alignment with international and national climate objectives:** Cities often participate in international climate networks and benefit from global agreements primarily focused on mitigation (Cömert Baechler, 2023; Pietrapertosa et al., 2019). National climate priorities tend to align with international policy objectives, which are supported by strong regulatory frameworks and offer long-term global benefits. The external support from international networks, reinforced by national priorities, provides a framework for city action that often includes technical and financial resources supporting the implementation of mitigation strategies. Mitigation actions are perceived as more cost-effective in urban planning because they address evident existing sustainability goals, whereas adaptation strategies are typically more localised and lack equivalent legislative support. As a result, there is a disparity in resource allocation, with more efforts being directed toward reducing CO_2 emissions than building resilience (IPCC, 2022).

The **EU Missions framework** has been implemented as an innovative and promising approach for funding, R&I and implementation of climate action (European Commission, 2023). In particular, the Mission for **Climate-Neutral and Smart Cities,** focused primarily on emissions mitigation to reach climate neutrality, and the **Mission for Adaptation to Climate Change,** focused on achieving climate resilience, are leading the implementation of climate pathways at the city and regional levels. The emphasis on multi-level governance and systemic approaches ensures that local actions align with national and EU-wide objectives. Recent discussions have sparked debates on how to **align synergistic efforts between the two missions** (EU Science & Innovation, 2022). This stems from the increased recognition of the need to address mitigation and adaptation together. For instance, a joint Horizon EU call between both Missions was launched in 2023 (European Commission, 2023). The potential areas of synergy between the missions within policies, strategies, capacity building, and joint programming are currently being discussed.

2.2.2. The urgent need for mitigation-adaptation integration

- **Identification of synergies and trade-offs**: Despite the advancements, mitigation actions alone cannot resolve the current impacts of climate change. For instance, even if the goals of Net Zero are met by 2050, weather extremes will still be on the rise (Howarth & Robinson, 2024). Given the urgency of climate impact, the need to implement holistic strategies combining mitigation and adaptation is broadly recognised. If well-implemented, integrated strategies can result in synergies of climate action that are able to build resilience while having positive effects on cutting and/or absorbing greenhouse emissions (Sharifi, 2021). However, they can also lead to trade-offs that exacerbate the negative effects of climate change and/or affect the capacity of communities to cope with its effects (Sharifi, 2020) (see Table 1).

- **Mitigation measures** can have trade-offs in adaptation if they increase climate vulnerability—for example, by exacerbating heat islands, flooding, eroding the livelihoods of marginalised communities, and/or broadening inequality gaps. Conversely, adaptation measures might inadvertently increase greenhouse gas emissions by reducing efficiency and raising energy demand (Sharifi, 2020). Understanding these synergies and trade-offs remains challenging due to the inherent complexity and contextual nature of the interactions between mitigation and adaptation, with outcomes depending on the interplay of multiple spatial and temporal dimensions (Boyd et al., 2022). There is broad recognition that these interactions have not been sufficiently studied, and that there is a lack of literature, frameworks, and tools to facilitate the

identification of synergies and trade-offs (Pereira & Alho, 2019; Sharifi, 2020; 2021). At the local level, addressing this gap is resource-intensive and requires specific technical capacities (Grafakos et al., 2020), which, in turn, demands institutional coordination and prioritisation (Boyd et al., 2022). These complexities leave cities without adequate references or guidance for best practices, leading to stagnation (Sharifi, 2020; 2021). As a result, cities vary in their ability to identify co-benefits and trade-offs (Boyd et al., 2022)

- **Challenges for effective integration:** Real integration means that cities should be able to increase synergies while avoiding trade-offs in combined actions. There is consensus and substantial evidence supporting the imperative for integrated approaches (Grafakos et al., 2020; Howarth & Robinson, 2024; Huang-Lachmann & Guenther, 2020; Pasimeni et al., 2019; Pereira & Alho, 2019; Sharifi, 2021). However, examples of successful integration are still limited. Although research on integration is on the rise, particularly in Europe, it is still insufficient to provide actionable directions (Göpfert et al., 2019a; IPCC, 2023b; Sharifi, 2022).

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Sector	Synergies	Trade-offs
Urban green infrastructure	Green infrastructure, such as parks, green roofs, and urban forests, naturally contribute to carbon sequestration while enhancing urban resilience by providing stormwater management and reducing heat islands, further reducing energy demands for cooling.	The implementation and management of green infrastructure may involve significant emissions of CO2 depending on the type of infrastructure and context. Emissions are reported mainly from transport and machinery during the construction, and from the use of fertilisers and irrigation during management.
Building design	Passive building design related to albedo, shading, orientation, and natural ventilation reduces need for air conditioning and helps in achieving thermal comfort during heatwaves.	Air conditioning of hospitals and elderly homes and vulnerable populations are effective adaptation measures. However, unless renewable energy sources are used, they considerably increase the energy demand and emissions.
Urban design and land use planning	Compact urban development emphasising density, land use mix, and improved connectivity promotes active and public transportation, reducing energy demands for travelling. As habitation space is smaller, it reduces energy for cooling and heating buildings and water consumption.	Highly dense urban areas with limited green and open spaces can intensify heat islands and intensify the energy for cooling. Increased density and rapid growth of high-rise buildings has resulted in intensive demand for steel with negative consequences for mitigation.
Energy	Decentralised and distributed energy systems based on renewable sources reduce emissions, improve efficiency, and are less reliant on water use. They enhance resilience by minimising the risk of component failures and reducing vulnerability during storms, floods, and extreme temperature events.	Redundant energy infrastructure based on renewable sources still demands substantial capital investment, which can undermine the distributional benefits of the energy transition. This may limit the availability of resources for other critical adaptation measures, such as poverty alleviation, particularly in vulnerable localities.
Water	Water efficiency measures are primarily linked to adaptation, but they also contribute indirectly to mitigation due to the close connection between water and energy. Stable water supplies often lead to increased demand, making efficient management critical. Rainwater harvesting can be used for non-potable purposes, easing water scarcity, while rainwater and greywater recycling can reduce the energy demand for freshwater treatment.	Adaptation measures to address water scarcity can be costly and may increase emissions due to the water-energy nexus. For example, desalination plants can enhance water supply resilience but are both expensive and energy-intensive. Similarly, rainwater harvesting systems, while beneficial, can lead to cost-related trade-offs.
Transport	Active and public transportation, combined with economic measures such (fuel and vehicle taxation, parking) are effective strategies for reducing emissions, offering multiple co-benefits, including increased physical activity and reduced air pollution. Enhanced adaptive capacities result from cost savings, improved public health, and lower congestion-related costs, such as productivity losses. Public transportation has proven more resilient in adverse events, facilitating emergency access and quicker evacuations.	Implementing efficient active and public transportation systems requires large-scale infrastructure modifications, resulting in direct emissions. Additionally, the management of such infrastructure may lead to gentrification and the displacement of vulnerable, low-income users. Vehicle and fuel taxes, along with public transport tariffs, can also disproportionately impact low-income households, exacerbating financial burdens and loss of jobs.

Table 1. Synergies & trade-offs examples in combined mitigation and adaptation actions at city level (Source: Sharifi 2020, 2021)

Typically, cities tend to implement mitigation and adaptation **strategies in silos,** with policies often focusing on one strategy at a time, within different institutional frameworks or across varying spatial and temporal scales (Howarth & Robinson, 2024; Huang-Lachmann & Guenther, 2020; Hurlimann et al., 2021; Landauer et al., 2019; Sharifi, 2020). **Systemic barriers**, such as the limited technical capacity of local governments to coordinate departments, establish shared goals and priorities, and integrate funding mechanisms, pose significant challenges to effective integration (Boyd et al., 2022). **Integration adds complexit**y to planning processes and necessitates the efficient use of scarce human, technical and economic resources.

The complexities related to integration risks conceptualising climate action through the lens of a false dichotomy of having to choose between allocating resources to either adaptation or mitigation (see Shaw, 2023). However, isolated strategies are not only cost-ineffective but also fail to account for the complexity required to prevent maladaptation, often resulting in unintended trade-offs and missed opportunities for synergies. Furthermore, these fragmented approaches contribute to policy incoherence and resource inefficiencies (Howarth & Robinson, 2024).

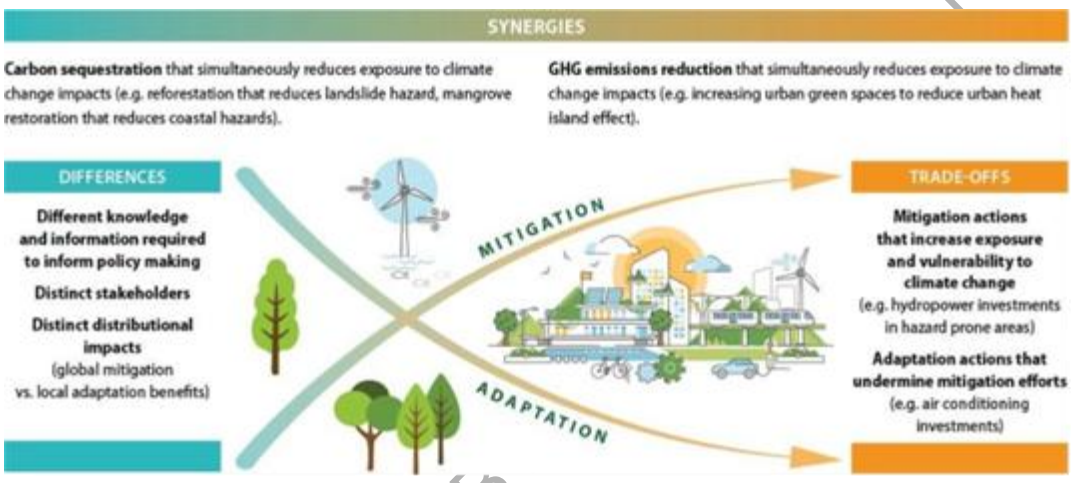

Figure 1. Aligning climate change mitigation and adaptation policies: differences, synergies and trade-offs (Source: OECD, 2021).

2.3. Evolution of climate narratives and research focus: from techno-scientific to holistic and human-centric perspectives

Over the past 40 years, there has been a **significant shift in climate change narratives**. In a nutshell, early research primarily focused on gathering and interpreting **quantitative environmental data**, such as emissions and temperature changes, in order to understand the causal effects of rising biophysical quantities. This quantitative analysis has served as the foundation for climate action based on technical and localised solutions (Baggio, 2021). Over time, as the real-world implications of climate predictions have become clearer, the techno-scientific focus has faced the need to expand its approach to better understand how these predictions and numbers impact societies. (Baggio, 2021).

The need for a mindset shift has become increasingly evident as more empirical research broadens our understanding of how various socio-technical systems contribute to environmental crises and how human communities perceive and are disproportionately affected by them. This understanding highlights the imperative of addressing the **social, ecological, and technologica**l dimensions of the environmental crisis **as integrated systems.** Consequently, there is a growing focus on studying climate

change through the lenses of **human vulnerabilities, community resilience, and political and institutional capabilities** (Baggio, 2021; Klein, 2017).

The focus of climate action is expanding towards a **more holistic and human-centred** conceptualisation of sustainability transformations, including the integration of topics of equity and justice, livelihood diversification, health services, migration and peace (IPCC, 2023a). It highlights the need for more collaborative efforts, transdisciplinary and political will. However, these narratives are still in the early stages of being translated into impactful actions. The early stages of empirical research often constrain practitioners seeking to integrate more socially oriented dimensions into projects of climate action (IPCC, 2023b; Castán Broto et al., 2023). Nonetheless, the ongoing momentum keeps pushing forward the exploration of actions that address climate issues while improving societal standards, the quality of livelihoods and socio-ecological wellbeing.

3. Key issues

This section highlights the most relevant topics from the horizon scanning, presented as seven key issues in narrative form. These issues are particularly significant from a city perspective, offering **insights into the emerging challenges and opportunities** cities should consider when designing climate strategies that enhance synergies between mitigation and adaptation measures while minimising trade-offs.

3.1. The shortfall of adaptation efforts

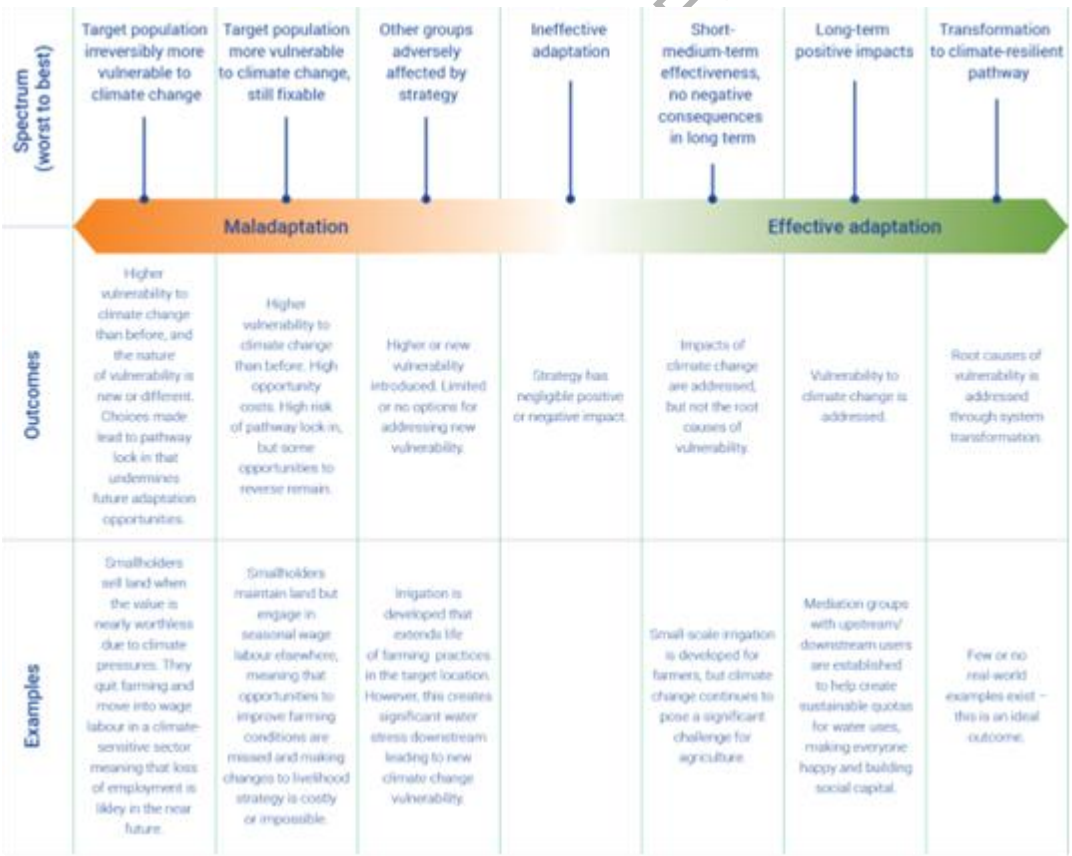

Figure 2: Simplified continuum of adaptation outcomes, from irreversible maladaptation to transformative adaptation (Source: UNEP 2021)

The current and future impact of climate change leaves little question that **adaptation measures need to be put in place and that adaptation will have an impact on people's livelihoods.** However, implementing adaptation in general has proven challenging in all contexts. The IPCC report (2022) highlights that even though adaptation efforts have increased, its **progress is insufficient and unevenly distributed**, leaving serious gaps between the goals that societies are setting for themselves and the implementation of these measures. Current approaches to adaptation tend to focus on the short-mid term, are sector-specific, and focus more on planning than on implementation (IPCC, 2022). This drastically reduces the transformational opportunities required by the urgency of the situation.

One key to understanding adaptation's challenging implementation is its **lack of evaluation methods** (Reckien et al., 2023). To date, there are no clearly transferable methods or universal metrics to monitor the effectiveness and progress of adaptation measures (Goonesekera & Olazabal, 2022; Howarth & Robinson, 2024; Loroño Leturiondo et al., 2023). The diverse nature of adaptation actions makes their implementation highly dependent on contextual factors such as the severity of climate change, data availability, and the degree of resilience and vulnerability of local communities and ecosystems (Howarth & Robinson, 2024; IPCC, 2022). As such, understanding adaptation relies on **qualitative indicators that are not easily quantifiable** (Boyd et al., 2022) and this hinders its planning under traditional urban planning and decision-making frameworks. For example, not every adaptation action can be modelled into Earth scenarios (IPCC, 2023a). Also, financing adaptation tends to be challenging due to the need to **invest in highly speculative** and uncertain scenarios on long-term horizons. Although adaptation finance represents great opportunities, there is a critical gap between its conceptualisation and demonstrable impactful solutions (Fankhauser et al., 2023; Howarth & Robinson, 2024).

While recognised as context-specific, adaptation strategies are often transferred from one city's best practices—typically larger, more resource-rich—to others or applied uniformly, assuming the same conditions across different areas of the same city. This **one-size-fits-all approach neglects the unique conditions and diverse needs** of various local populations (Castán Broto et al., 2023). Furthermore, adaptation responses frequently **exclude the most vulnerable groups** from the planning process and provide unequal access to benefits (Prall et al., 2023; Reckien et al., 2023), exacerbating systemic vulnerabilities. Despite this, adaptation has traditionally been portrayed as a **neutral intervention, devoid of political or social implications** (Castán Broto et al., 2023).

Many actors are now strongly advocating for **new and more disruptive adaptation narratives** (Castán Broto et al., 2023). The core message is the imperative to employ adaptation actions for effective reduction of climate risk, while achieving multiple societal co-benefits at the same time, even beyond climate change. This includes the **benefits of decarbonisation (mitigation), the inclusion of marginalised voices, and improving livability, human health and environmental integrity.** Adaptation to novel climate scenarios needs to happen in fair and inclusive ways, respecting local culture (Gilmore et al., 2024). In this sense, it is imperative to redefine adaptation in terms of urgency, justice, social inclusion and mitigation synergies.

3.2. Integration of justice frameworks

Adaptation efforts will have a significant impact on people's livelihoods, underscoring crucial **equity issues in the distribution of burdens and benefits.** The IPCC emphasises the need for more thorough discussions on topics like healthcare, relocation, migration, security, and peace in direct relation to climate action (IPCC, 2023b). For example, relocation can effectively reduce risk but only when it is done in a safe, orderly, and voluntary way. There is growing awareness that climate strategies must be responsive to local realities, societal barriers, and access to support, with success defined by capturing more nuanced and personal expressions of vulnerability (Gilmore et al., 2024). Yet, in contrast, current imaginaries of climate-resilient futures tend to focus on problem-solving with **technological solutions, promote individual responsibility and safeguard the values, experiences and lifestyles of the more privileged groups** (Chu & Shi, 2022).

Cities must embrace the challenge of designing adaptation plans that recognize the diversity of experiences of vulnerabilities, especially of marginalised communities due to their intersecting identities (Gannon et al., 2022; Chu & Shi, 2022). But in doing so, it is essential not to homogenise societal groups within communities, which are often institutionally well represented. Scholars of **intersectionality** have examined **how various systems of oppression intersect, resulting in diverse experiences of discrimination and vulnerability** (Collins & Bilge, 2020). Their insights are increasingly being applied to the context of climate justice. Intersectionality emphasises understanding the range of potential responses to adaptation, the power structures shaping these responses, and their contributions to discrimination (Castán Broto et al., 2023; Chu & Shi, 2022; Ravera et al., 2016).

Including justice in climate responses involves ensuring that **benefits and burdens are fairly distributed** across all societal sectors and natural ecosystems. It also requires addressing existing and future disparities in adaptation and mitigation strategies and dealing with the **socio-political roots of vulnerability** (Chu & Shi, 2022). Key aspects to consider include participatory and inclusive decision-making, affordability and accessibility of resources and services, fostering community resilience and sustainable livelihoods (including housing and jobs), addressing historical injustices, and respecting local and indigenous knowledge systems (Baggio, 2021).

However, while climate justice has been a significant topic in theoretical and academic discussions, the institutionalisation of justice frameworks into local climate action planning and related policies has largely been ineffective (Cannon et al., 2023; Prall et al., 2023). Implementing these frameworks requires reimagining climate resilience by incorporating elements beyond technical solutions to **redefine the success in relation to values and ethics of care.**

3.3. Financing holistic climate actions

The success of implementing and evaluating integrated mitigation and adaptation actions greatly depends on the availability of financial resources. The cost of climate change is no longer hypothetical. Hence public and private organisations need to better articulate their climate finance needs and map them against the available funding sources to detect financing gaps (Fankhauser et al., 2023). Between 2017 and 2022, funding for urban climate initiatives more than doubled, reaching a total of USD 831 billion (Press-Williams et al., 2024). However, there are substantial **gaps in understanding the distribution of climate costs and the effectiveness of funding schemes** (Grafakos et al., 2020).

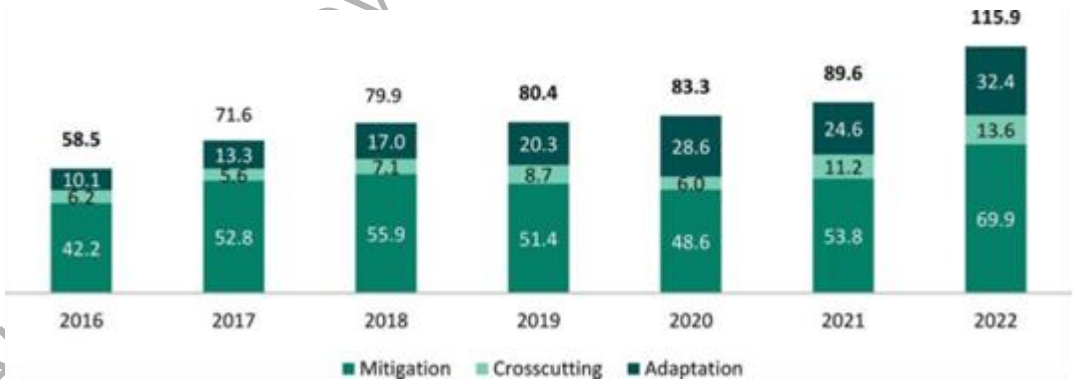

Figure 3: Thematic split of climate finance provided and mobilised between 2016 and 2022 in USD (Source: OECD)

Global and multinational networks and frameworks (e.g. EU Missions, Climate City Capital Hub, C40 Cities, etc.) play an important role in supporting cities with funds to promote and institutionalise climate actions. They also **affect the course and trajectory of those actions** as they support the development of integrated goals, visions and legislations (Göpfert et al., 2019a). An overwhelming

majority of funds are directed to mitigation (IPCC, 2022; Shum et al., 2022). In fact, only 1.2% of total urban climate finance flows (USD 10 billion) are directed to adaptation (Press-Williams et al., 2024). Furthermore, only USD 7 billion are used for multiple objectives including both mitigation and adaptation (Press-Williams et al., 2024). As a consequence, even though climate finance has shown a positive trend in recent years, the current financial schemes are insufficient and limit the development of adaptation options (IPCC, 2023b). In other words, **siloed finance upholds siloed policies and easily leads to maladaptation** (Olazabal, M. personal communication, March 12, 2024).

In the context of adaptation, a critical gap exists between its conceptualization and proven solutions, creating considerable **uncertainty** around investment (Fankhauser et al., 2023). The 2024 State of Cities Climate Finance Report estimates that adaptation needs for cities in emerging markets and developing economies lie at USD 147 billion per year until 2030, and USD 165 billion per year from 2030 until 2050 (Press-Williams et al., 2024). Due to numerous uncertainties about climate impacts and risks, as well as shortcomings in the scenario-based models, data, and methodologies employed, these estimates are probably significantly lower than the true values (Press-Williams et al., 2024). It has been recognised that financial needs cannot be determined without a nuanced understanding of climate objectives and so it is essential to **define local goals of adaptation**, such as acceptable levels of risk, the desired outcomes, and regulatory expectations. But on the other hand, despite the uncertainties green finance investors are embracing the increased profitability of adaptation, projecting a market worth **$2 trillion by 2026** (Shum et al., 2022).

Still, current funding for adaptation is often seen as poorly structured. For instance, **financing mechanisms often fail to consider adequate time scales,** favouring short-term and specific problem-solving (Gilmore et al., 2024), overlooking the longer time scales required for adaptation efforts, whose benefits may not be evident for a decade or more (IPCC, 2022). Additionally, the sustained perception that climate impacts are distant in the future discourages organisations from making necessary financial commitments. At the same time, climate change impacts are not only physical and long-term; they are already affecting organisations in various ways across different time scales. For instance, mitigation efforts require substantial investment in clean and renewable energy, driving the transition toward low-carbon economies with significant financial risks and opportunities for different sectors and investors (TCFD, 2017). Moreover, adaptation is often overlooked in related investments such as **infrastructure development, capacity building** (Gilmore et al., 2024) and **security** (Lavandier, 2023). The IPCC (2022) also warns that the increasing costs of climate change will further strain financial resources for adaptation, as cities will need to allocate more funds to repair growing losses and damages.

Adaptation requires a significant upfront investment (IPCC, 2022); therefore, it is essential to **develop new finance streams** (Gilmore et al., 2024) and to mobilise current funding schemes to broaden their scope of climate actions into synergies with mitigation outcomes (beyond e.g. net-zero). It is especially important to increase climate finance flows to cities in emerging markets and developing economies, which currently receive only 11% of the total urban climate finance (Press-Williams et al., 2024). Innovation in finance structures should involve **partnerships between public, private and third sectors**, and for this, better and more accessible information has been recognised as a vital leverage. Better knowledge transference can be done through **financial disclosure** of climate-related data horizontally across sectors (Fankhauser et al., 2023; TCFD, 2017).

Funding directed to local governance can greatly benefit from transitioning from a fragmented and siloed **'funding by project' towards a 'funding by programme' logic.** This transition can enhance efficiency, reduce administrative burdens, and support the holistic design of climate action (Teubner, 2024). Funding programs should consider climate risk across the whole policy spectrum, directing funds not only to direct adaptation efforts but also to broader resilience initiatives (Fankhauser et al., 2023). In times of regional and national green policy pushback, cities need to build capacities to access funds and remove barriers, and at the same time, ensure that funds are appropriately spent in ways that their impact reaches those who are in most need.

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3.4. Support to local self-determination

Most severely affected localities by climate change are taking the initiative to decide how to adapt to current and future climate effects (Coger et al., 2022; GCA, 2023a; GCA, 2023b). **Locally led action** has the advantage of **addressing vulnerabilities, directing energy and resources toward the local known issues and enhancing engagement and participation of a diversity of communities**, who hold the deep knowledge about their territories (Gilmore et al., 2024; Morgado Simões, 2024). Examples of these actions of adaptation are seen globally in the most vulnerable regions to climate change (GCA, 2023b). In Europe, examples can be found particularly in regions prone to flooding, heatwaves and sea level rise (Morgado Simões, 2024).

Even though the local **self-determination to act needs to be recognised and supported** (Coger et al., 2022), its promotion should not be seen as an excuse for convenience. On the contrary, it should be critically discussed within foundations based on equity, justice and participation. Self-determination must be supported by regional and national governments and other international entities by **providing enough resources, sharing knowledge and helping localities build capacity.** Self-determination should ensure that local and indigenous people's experience and knowledge systems are taken into consideration in planifications, as well as addressing their needs and those of the local natural ecosystems (Gilmore et al., 2024; GCA, 2023b).

Self-determination becomes especially relevant in scenarios of severe weather events and adaptation choices that **disrupt livelihoods.** For instance, in the context of displacement of communities, there are risks that vulnerable populations would not be able to leave their homelands even in scenarios of significant impact (Coger et al., 2022). This highlights the importance of safeguarding the relocation of people while maintaining their cultural ties to place, environment and social networks. Climate measures, especially those that destabilise the everyday experience, should be carried out with **consent, transparency and accountability in order to promote equity and protect dignity** (Gilmore et al., 2024).

In this context, climate change is increasingly recognized as an **issue of conflict management and security**, underscoring the interconnections between **climate action and urban hazard mitigation plans**, which are often treated as separate planning strategies (Matos et al., 2023). The need for integration arises from the shared goal of hazard mitigation and adaptation plans: reducing vulnerability to future hazards, especially as the impacts of climate change become more apparent. For example, national security actors are advocating for collaboration between military institutions and public and private sectors in adaptation planning, foresight and implementation (Lavandier, 2023). Consequently, local climate strategies may need to **broaden their scope by collaborating with sectors traditionally not included in adaptation planning**, such as food production, public health, human welfare organisations, security sectors, and cultural institutions. The expertise within these sectors can provide valuable insights into safeguarding safety and dignity in the face of climate change.

3.5. Nature-based solutions for integrated adaptation and mitigation

Nature-based solutions definition:

> *"Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges (climate change, natural disasters, social and economic development, human health, food security, water security, ecosystem degradation and biodiversity loss) effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." (IUCN, Nature-based solutions).*

Examples:

- **Green infrastructure:** green roofs and green walls to reduce heat islands, manage stormwater and enhance habitat and food for pollinators.
- **Street trees and urban forests:** to reduce air pollution and promote wellbeing.
- **Permeable surfaces**: to absorb and filter rainwater and reduce flood risks.
- **Coastal buffer zones:** restore dunes, mangroves and marshes to protect against storms, higher sea levels while providing habitats for wildlife.

Better understanding human-environment relation has direct implications for urban policy and management practices. A growing body of research is backing up the notion that theoretical frameworks and methodologies should continue to develop to **better integrate people and their surrounding natural systems** in response to climate challenges (Baggio, 2021). **Climate change and biodiversity loss** are increasingly considered as interconnected pieces of the same environmental crisis, especially after the first collaborations between IPCC and IPBES (IPCC 2022; IPCC 2023b). It has become evident that climate issues and biodiversity loss need to be essentially tackled together to avoid trade-offs and maladaptation. This means that new topics need to be included in the adaptation and mitigation narratives to bring awareness that climate action should not be planned only in terms of human benefit and that natural species and ecosystems also adapt to and mitigate the effects of climate change (IPCC, 2023a).

	Associated ecosystem services							
Nature-based Solution	Coastal protection	Reduction in riverine flood impacts	Reduction in urban flood impacts	Filtering pollution	Carbon sequestration	Habitat creation	Heat mitigation	Recreational opportunities
Protecting/ restoring coastal habitats	●			●	●	●		●
Protecting/ restoring upland forests		●	●	●	●	●	●	●
Creating urban green spaces			●	●		●	●	●

Figure 4: Examples of the multiple co-benefits offered by NbS. Source OECD, 2021

In this context, **Nature-based solutions (NbS)** have been increasingly recognised as a valuable framework for integrating adaptation-mitigation actions while possibly improving biodiversity and the wellbeing of human and nonhuman urban residents (Maller, 2021). NbS are perceived as a great promise for climate action; for instance, 91% of European cities contemplate NbS in their mitigation and/or adaptation plans (EEA, 2024) and as a first step for integrating mitigation and adaptation measures (Pasimeni et al., 2019; Mazzeo & Polverino, 2023). This is due to the **great array of perceived co-benefits and synergies** for mitigation and adaptation when implementing solutions that include green infrastructure and their recognised effectiveness in providing risk reduction and enhancing environmental resilience while simultaneously absorbing and storing CO2. NbS are generally highlighted as effective in improving bio-retention to manage stormwaters and improving building insulation to manage heat islands, which reduces the energy demands, enhances biodiversity and improves human health and wellbeing (Senosiain, 2020). Green infrastructure such as green roofs and walls, green corridors and green spaces are the most common strategies where co-benefits were accounted for (Boyd et al., 2022).

However, the concept of **NbS is still the subject of debate,** with concerns for misunderstandings that NbS alone could provide all solutions to climate change (IPCC, 2022), and that they need to be applied at larger scales city-wide to be effective (Senosiain, 2020). Ecosystem-based mitigation and adaptation actions are context-specific and from a broad array of existing solutions not all are equally effective. If not well implemented, **they can lead to trade-offs and maladaptation.** For example, NbS initiatives are less likely to be implemented in lower-income neighbourhoods. At the same time, if social aspects are not integrated into their planning, NbS can lead to issues of green gentrification (Maller, 2021). Another concern is the oversimplification and romanticization of green spaces, leading to an implementation that does not recognise the **complexity of ecological dynamics,** even leading to unintended consequences like disrupting ecosystemic balance or aggravating human-nature conflicts (Luther, 2023; Parris et al., 2018). It is often assumed that green infrastructure can also create habitats for plants and insects, and provide benefits for pollinators. However, some researchers argue that these assumptions are rarely locally validated (Apfelbeck et al., 2020) and that the complexity of natural systems makes predicting all potential trade-offs an impossible task. These challenges make it difficult to decide **when to prioritise the integrity of ecosystems or the safety and concerns of human residents**.

New definitions of NbS (see IUCN definition) are shifting from a problem-solving approach that prioritises development needs to a broader recognition of societal needs and the interconnected needs of all species within urban areas (Maller, 2021). This shift embraces a more relational socio-ecological ontology, acknowledging the shared factors affecting both vulnerable human communities and ecosystems, and celebrates the entanglement of human and ecological well-being in city planning. These perspectives open up future scenarios where adaptation and mitigation actions are integrated into deeper transformations, promoting **imaginaries of mutual socio-ecological regeneration and flourishing** (Connolly, 2020). However, this evolution raises questions about how to effectively operationalize and institutionalise these ideas in urban planning while accounting for the complexity and unpredictability of nature and its metabolic processes and still addressing the effects of climate change.

Some directions point toward **expanding the scope of climate-biodiversity urban action** to include a broader range of concerns, such as **ethics, justice, and inclusion in decision-making** in a more direct relation to urban nature. For instance, the concept of **"multi-species justice"** has been increasingly proposed as a promising framework to address interrelated vulnerabilities (Maller, 2021). Within these ideas, key leverage points include ensuring **participatory planning** with all relevant stakeholders to represent the needs of all actors and adopting an **adaptive approach to NbS management** and governance that can react and adjust solutions as needed. However, these concepts are still in their early stages and require further experimentation.

4. Risks and Opportunities

This section outlines the recognized risks and opportunities for cities to **better integrate and implement climate mitigation and adaptation actions** to enhance synergies and avoid trade-offs, ultimately addressing the causes and effects of climate change while advancing sustainability transformations, improving livelihoods, and fostering wellbeing and flourishing ecosystems. Ultimately, a sustainable vision of the future should always include an awareness of combined effects of both mitigation and adaptation.

4.1. Opportunities

Opportunity type	Impact
Strategic integration of adaptation and mitigation to foster governance synergies	• Optimised resource and skill allocation • Policy coherence • Integration of funding strategies • Foster innovation • Exploration of local novel governance models
Addressing the knowledge gap	• Increased context-specific knowledge on adaptation/mitigation synergies and trade-offs and technical capacities • Transdisciplinary and collaboration with new societal sectors: healthcare, welfare, security, food production, etc • New tools for sense-making and complexity
Integration of justice frameworks for more inclusive climate strategies	• Addressed equity and intersectional vulnerabilities • Equal access to benefits • Increased social resilience against climate uncertainty • Redefine success of climate outcomes based on ethics of care
Securing holistic financing of climate action	• Broaden scope of funding mechanisms to finance programmes with integrated approaches • Defined long and short term investment priorities • Partnerships with private and third sectors • Disclosure of financial climate-related data and learn from others
Local approach to climate response	• Local goals of adaptation, defined acceptable levels of risk and desired outcomes • Broad societal participation into climate decision-making • Integration of local and indigenous local knowledge systems • Consent, transparency and accountability when protecting dignity • Integrated urban hazard mitigation and climate change strategy
Leveraging Nature-based Solutions	• Benefits from urban ecosystems services while improving quality of biodiversity and societal well being • Introduction of ethics and justice frameworks (e.g. multispecies justice) to address ecological and societal integrated vulnerabilities • Participatory planning and adaptive management of NbS

Table 2. Opportunities relating to climate mitigation and adaptation strategies

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4.2. Risks

Type of risk	Impact
Persistent mitigation-adaptation dichotomy	• International networks continue reinforcing dichotomy • Stagnation of adaptation strategies due to uncertainties and lack of evaluation methods • Siloed approach due to lack information on synergies and trade-offs • Unintended trade-offs and missed opportunities of synergies • Policy incoherences and resource inefficiencies
One-fits-all solution approach neglect contextual realities	• Overdependence on transferable best practices overlooks local needs • Over-reliance on international climate targets shifts focus from local adaptation needs • Over-reliance of techno-scientific narratives overlooks the need for societal change
Governance and structural challenges	• Complexity, systemic barriers, and limited resources reinforce the lack of integration • Depoliticisation of the climate debate results in a lack of commitment and prioritisation • Lack of participatory decision-making imposes misleading adaptation goals (e.g., acceptable levels of risk) and outcomes
Increase vulnerability to climate risk	• Persistent exclusion of vulnerable groups in planning exacerbates vulnerabilities • A shallow approach to inclusion homogenises vulnerable communities, neglecting intersectional identities • Adaptation measures become less effective, and risks increase as climate change effects become more severe
Financial risk	• Uncertainty in demonstrating impact reinforces low investment in adaptation • Insufficient investment in vulnerable regions leads to uneven adaptation efforts • Poor conceptualisations overlook adequate time scales for investment • Increased costs of climate change divert funds to repair losses and damages instead of building resilience. • Administrative burdens and lack of capacities result in missed opportunities to access adequate funding

Downplaying of local leadership	• Self-determination and need to timely reactions leads to uncoordinated and unsupported local action • Failure to include local knowledge misses opportunities to recognize synergies and trade-offs
Maladaptation when implementing NbS	• Failure to consider social aspects can exacerbate inequalities, e.g., green gentrification • Shallow implementation of ready-made solutions can lead to unintended ecological trade-offs • Lack of frameworks or tools to address ethical choices leads to stagnation or poor decisions • Linear management of NbS cannot react to the unpredictability of natural systems.

Table 3. Risks relating to climate mitigation and adaptation strategies

5. Key takeaways for cities

5.1. Governance innovations for integrating climate actions

To transcend the mitigation and adaptation dichotomy and align these strategies with broader societal and environmental goals, cities should move towards breaking down silos within governance structures and fostering integration across city departments. Adopting a multi-level governance approach ensures that climate actions are matched to the appropriate level of government and the specific needs of different communities, enabling more targeted and effective responses. Innovative governance models can enhance cities' capacity for anticipation, experimentation, and responsive action. Climate adaptation and mitigation must be treated as horizontal issues that permeate all areas of urban policy, while maintaining clear ownership and accountability to ensure these strategies are effectively implemented. Importantly, cities must continue further developing their adaptation strategies while continuing to advance their mitigation efforts. It is essential to communicate that adaptation and mitigation work hand in hand, with neither being sacrificed for the other, to ensure a balanced and just response to the climate crisis.

5.2. Knowledge and capacity supporting place-based approaches

To integrate climate strategies, cities should develop both technical and non-technical capacities, incorporating new knowledge and learning tailored to their unique contexts. This involves building a deep understanding of their specific adaptation needs, as well as recognizing the synergies and trade-offs that arise when combining these efforts with mitigation actions. By doing so, cities can enhance their self-determination, pursuing solutions that are best suited to their local realities. While established networks and programs can provide valuable support, it is crucial that the knowledge they offer is adapted to fit local circumstances. Cities should also leverage peer learning, especially with other cities facing similar challenges, and explore transformative capacities such as foresight, innovation, experimentation and embedding awareness.

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5.3. Define local climate objectives

Cities must go beyond national and international targets to define their own climate objectives in collaboration with their communities. This involves determining how they want to adapt to climate change and setting clear parameters, such as acceptable levels of risk and what constitutes well-being and healthy lifestyles in their specific context. To achieve this, climate action should broaden its scope to incorporate often-overlooked dimensions like dignity, care, and well-being. It is essential to build on the evolving climate narratives that emphasise ethical and human-centred approaches, reimagining climate action in ways that connect these human dimensions to environmental integrity.

5.4. Expand engaged sectors

Cities must expand their collaborations beyond the traditional sectors involved in climate strategy — such as environmental departments, land management, infrastructure, transportation, energy, water management, business, finance, and academia—and actively engage with other sectors that play a crucial role in climate transitions. Since climate change adaptation will disproportionately impact livelihoods, sectors that ensure peace, safety, equity, and resource access are particularly important. These include food production, healthcare and public health, human welfare organisations, security sectors, and cultural institutions. Besides, integrating adaptation as a lens within these sectors is essential, requiring capacity building to equip them with the necessary tools and knowledge to effectively contribute to climate resilience.

5.5. Ensure funding integration

Cities must shift from a project-based to a program-based approach to funding to ensure a more comprehensive and sustained climate action. Building capacity for climate response includes equipping cities with the skills to navigate complex financing landscapes, secure available funds, and allocate them effectively, ensuring that both mitigation and adaptation actions are adequately supported. Integration between local governments and funding institutions is crucial, with an emphasis on aligning financing with long-term local adaptation objectives. This approach should consider both short- and long-term time scales, reinforcing the need for immediate investments to secure future resilience. Cities should also question frugal fiscal policies that restrict proactive and preventive actions, recognizing that such policies may hinder self-determination. Cities should partner with public, private and third sectors to leverage diverse resources to fund the initiatives that align with their specific needs.

5.6. Enhance local participation to address vulnerabilities

Local participation is essential to ensure that climate actions are inclusive and represent the diverse voices within a community, particularly those of vulnerable and marginalised groups. The recognition of local intersectional needs is crucial when defining adaptation objectives and preferred strategies. Cities should move beyond conventional "citizen engagement" models to embrace a deeper understanding of different perspectives, using concrete co-creation tools that foster genuine collaboration. This includes integrating traditional and Indigenous knowledge, which offers valuable insights into local landscapes and ecologies, and the participation of actors who are able to speak for the rights of nature and biodiversity. Exploring different emerging frameworks (e.g. intersectionality, multispecies justice) can help cities to learn and internalise the broad diversity of perspectives and work toward ethics of care and inclusion.

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Annex 2 – AI Towards Climate Neutrality: Exploring the Role of Artificial Intelligence in Achieving Sustainable, Carbon-Neutral Urban Futures (Polimi)

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Summary

This deep dive **examines the potential and limitations of Artificial Intelligence (AI) in supporting the transition towards climate-neutral cities within the NetZeroCities (NZC) framework**. By analysing opportunities and risks across key emission domains—energy, mobility, agriculture, water, and waste—the study highlights both the transformative possibilities and the systemic challenges of deploying AI for climate action.

The analysis shows that AI can enable more efficient energy management, optimize urban transport, improve agricultural practices, enhance water distribution, and support waste reduction and circular economy initiatives. At the same time, AI development and deployment come with considerable costs, including high energy and water consumption, risks of maladaptation, technological lock-ins, and equity concerns.

Beyond sector-specific applications, the deep dive also explores the role of AI in strengthening **systemic levers of change**, including urban governance, policymaking, and public participation. Emerging experiments demonstrate how AI can foster citizen engagement, support collective intelligence, and generate data-driven policy insights. However, issues of transparency, accountability, bias, and democratic integrity remain central challenges that must be addressed.

Key takeaways emphasize that while AI offers powerful tools to accelerate climate neutrality, it should not be treated as a silver bullet. Instead, cities must pursue **multifaceted strategies** that integrate AI with broader policy, behavioural, and cooperative approaches. This includes investing in greener AI models, ensuring inclusive participation, safeguarding privacy and fairness, and embedding AI within just and equitable climate strategies.

Keywords

Artificial Intelligence; Machine Learning; Generative AI; urban governance; climate neutrality; NetZeroCities; energy management; mobility; circular economy; public participation; systemic levers.

1. Introduction and Objectives

City life is bustling and increasingly becoming a hotbed of social and environmental challenges. As urban populations swell, so do the pressures on our planet, particularly concerning climate change. Cities are massive carbon emitters, making innovative environmental management strategies a must (UN Environment Program, 2024). Among these, the promise of Artificial Intelligence (AI) as a game-changer in achieving climate neutrality stands out (Mastrola, 2023). With the rise of AI and Generative AI, there is a determination to maximize its powerful promise to solve a variety of societal and environmental issues. However, AI is still a fast-evolving technology that has yet to prove its ability to provide effective solutions to the problems cities face, especially in sustainability and carbon neutrality. It is essential for cities to have a comprehensive understanding of both the advantages and the challenges that AI can facilitate in their ambitions to become carbon neutral.

This brief report explores AI's role in urban sustainability, weighing its current applications, future prospects, and the hurdles cities need to overcome. While AI offers tremendous potential, it shouldn't overshadow the necessity for diverse, hands-on approaches to tackling our biggest environmental issues as well as the socio-technical and ethical implications intrinsic to the technology.

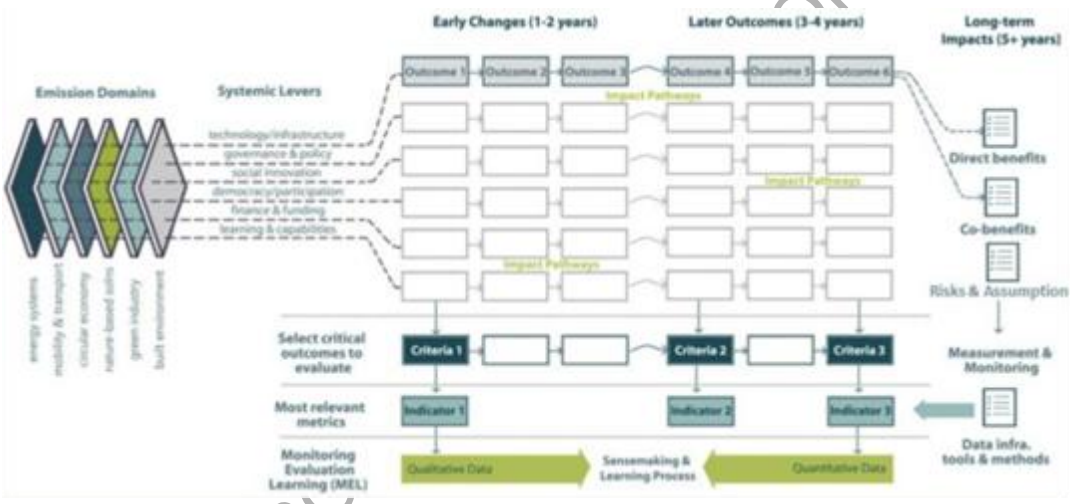

Fig. 1: NZC Theory of Change

2. Context

Cities account for more than 70% of global carbon dioxide emissions, with urban energy consumption projected to increase by nearly 40% by 2030. The growing urban population, estimated to reach 68% of the world's population by 2050, exacerbates these challenges (UN-Habitat, 2022). This rapid urbanization demands radically new strategies to manage environmental impact, making AI a promising tool.

However, AI also has limits and barriers to uptake and implementation often leading to new (and sometimes unforeseen) unsustainable consequences. AI development per se consumes large quantities of energy and water, often making it an answer unfit for purpose. In considering this technology to implement solutions that can help reach climate neutrality, cities need to carefully consider potential gains and losses.

To provide an overview of current applications, we start from the NZC Theory of Change (fig. 1) and cluster some of the most notable projects cities are experimenting with according to the emission domains where AI can have greatest impact, namely: energy, mobility, waste, water, agriculture. For

each, we describe the current experimentation and the associated risks and implications. We further describe the opportunities of uptaking AI in some of the systemic levers of change, in particular governance and participation. We conclude with the key takeaways of this brief overview for cities.

3. Leveraging AI for Climate Neutrality: Navigating Risks and Opportunities in Emission Sectors

The categorization of the risks and opportunities follows aApplications of AI for cClimate nNeutrality with: focus on emission domains. The opportunities are backed with real world examples of AI application.

3.1. AI for Energy Management

3.1.1. Opportunity

Energy management is crucial for achieving climate neutrality, as it directly influences urban carbon emissions. AI technologies provide advanced solutions for predicting, optimizing, and controlling energy consumption patterns, integrating renewable energy sources, and ensuring efficient distribution. In particular, AI is already employed in cities for the optimization of energy use and predictive energy management. However, it is essential to consider the energy consumption of AI itself to fully understand its sustainability.

Copenhagen's Signature AI Project: In Copenhagen, AI plays a critical role in optimizing energy consumption in municipal buildings. The Signature AI Project by the Copenhagen Solutions Lab and Copenhagen Municipality reduces energy use, carbon emissions, and heat and electricity bills. AI uses weather and building usage data, to predict heating and ventilation needs for kindergartens and daycare centers, optimizing energy consumption and indoor climate in around 300 properties under 3,000 m² (Copenhagen Solutions Lab, 2021). This project has significantly contributed to energy savings and reduced carbon emissions.

Smart energy management, exemplified by smart grids, uses AI to optimize energy distribution. These grids (currently used in several cities, like Amsterdam, Lyon, and Florence), analyze real-time data on consumption and generation to balance supply and demand efficiently. According to Wray (2023), smart grids are anticipated to be major contributors to energy savings, driven by AI analytics, demand-responsive networks, and urban microgrids that are modernizing urban grid infrastructure.

Intelligent Energy Storage: AI also plays a role in optimizing energy storage. For example, AI can manage battery storage systems, optimizing charging and discharging cycles to extend battery life and efficiency, which is crucial for integrating renewable energy sources into the grid. This could be applied for example in energy storage systems for electric vehicles.

Home Energy Management System (HEMS) in Phoenix, Arizona: Simmons et al. (2019) conducted a study on HEMS, which uses weather and market forecasts to optimize appliance usage, manage battery storage, and maximize solar power. Combining Moving Horizon Estimation (MHE) and Model Predictive Control (MPC), the system balances comfort and cost, reducing energy consumption by 21% and costs by 40%. This optimized energy management, enhances grid stability and reduces load-following cycles for utilities.

3.1.2. Risks

The infrastructure required for smart grids is complex and costly, and integrating AI technologies into existing systems can be disruptive. While the goal is to conserve energy, technologies like Generative AI demand significant power, highlighting the need for greener AI solutions. Large language models like GPT-3 and GPT-4 further increase energy usage. Training these models consumes large amounts of electricity, comparable to the annual consumption of many households. As AI continues to grow, it is crucial to develop transparent and sustainable practices. This includes promoting energy-efficient AI models, encouraging digital sobriety, and implementing policies that focus on renewable energy sources (Calvert, 2024). Governments cannot achieve this alone; the entire AI ecosystem, the private sector, research organisations, and the society overall must be involved in co-imagining and co-developing AI solutions that maximize capacity without excessive energy use.

3.2. AI in Urban Mobility

3.2.1. Opportunity

AI holds significant promise for reducing greenhouse gas emissions from road transport, with many promising solutions currently in experimental or simulation stages. These examples show that for AI to effectively mitigate emissions, a responsible integration within commercial products and public infrastructure should be foreseen. Machine learning (ML) offers new opportunities across the road transport value chain, particularly in enhancing batteries and biofuels, intelligent transportation systems, and promoting lower-carbon transportation modes. However, to fully harness AI's potential, high-quality big data are essential, as they provide the foundation for predictive analytics and decision-making. Combining new data sources such as real-time sensor data, social media feeds, and satellite imagery, with advanced theoretical insights from areas like deep learning and statistical modeling, can amplify recent ML advancements (Sathiyan et al., 2022). Examples of successful AI applications in this space include intelligent transportation systems and autonomous vehicles, even if risks persist, especially linked to the need of modifying existing infrastructures and privacy.

Intelligent Transportation Systems (ITSs) have the potential to significantly reduce emissions by integrating sensor and communication technologies with data processing. These systems can analyze real-time data to plan, monitor, and control transit. By optimizing public transport systems, ITSs can help reduce wait times and ensure timely and cost-effective travel for users. This improvement in the public transport experience could accelerate and promote a shift from personal vehicles use to higher use of shared vehicles or public transport (Sandalow et al., 2023).

Autonomous vehicles, guided by AI, promise even greater efficiency by eliminating human error and optimizing driving patterns to reduce fuel consumption and emissions. Several applications are under development in the private sector to support this evolution, including the adoption of a Mobility as a service (MaaS) paradigm that is promising to offer a good alternative to personal transport through applications like self-service electric cars, short distance carpooling, and smart parking management all AI-powered for optimization.

In Europe, several cities are experimenting in this direction: Reykjavik is investing in increasing the efficiency of its transport systems, also developing apps (i.e., Strætó) that help manage a smart bus transport network. Copenhagen has developed an integrated system for public transport encompassing an intelligent bus priority system, fully electrified car sharing, and an infrastructure that enhances commuting by foot and by bike. Geneva has implemented an efficient smart parking system, deployed through a network of sensors capable of lowering the number of vehicles searching for a place to park by 30%.

3.2.2. Risks

Although promising, the deployment of AI in urban mobility is not without its hurdles. Modifying existing urban infrastructures to make them AI-ready requires significant investment as well as the development of completely new infrastructures that imply technological, regulatory, and commercial challenges for municipalities. For instance, autonomous vehicles require extensive testing and regulatory approval, which can be a slow and contentious process. Additionally, the infrastructure needed to support autonomous vehicles, such as smart traffic signals and dedicated lanes, requires significant investment. Public acceptance and trust in AI-driven transportation solutions are also critical factors that need to be addressed through transparent communication and robust safety protocols.

3.3. AI for Agriculture

3.3.1. Opportunity

Urban agriculture is becoming increasingly important as cities look for ways to reduce their carbon footprint and improve food security. In India's vast agricultural lands, AI is revolutionizing farming with precision techniques that optimize the use of water, fertilizers, and pesticides, increasing crop yields while reducing the environmental impact of farming practices. In this area, several technological applications are notable, encompassing smart irrigation, drought prediction, and urban farming, even if relevant barriers persist linked to the costs of equipment and lack of technological literacy.

Smart irrigation technology aims to enhance agricultural productivity with minimal manpower by using sensors to detect water levels, soil temperature, nutrient content, and weather forecasts. Microcontrollers manage irrigation by controlling pumps based on sensor data.

Machine to Machine (M2M) technology facilitates communication and data sharing across the agricultural field network (Shekhat et al as cited in Talaviya et al., 2020). Machine Learning for Drought Prediction. In Tanzania, Lalika et al., (2023) demonstrated how this can benefit the community, specifically stating AI's ability to process real-time data and provide early warnings about impending drought conditions. Early detection enables farmers, policymakers, and overall communities to take proactive measures, such as implementing water-saving practices or adjusting agricultural daily tasks. By leveraging AI, we can better prepare for and mitigate the impacts of droughts, ultimately contributing to more resilient and sustainable agricultural systems. Urban farming: AI can also be deployed to support urban farming, for instance by making it energy and water efficient, and minimizing the effort for citizens. One example is the start-up Plenty that developed an AI and robotics run vertical farm for cities, resulting in a 99% reduction in land-use and 95% reduction in water use. In Amsterdam vertical farming company GROWx, together with Wageningen University, Signify and Be-bots have built a robotic and AI driven vertical farm which automates the cultivation of crops.

3.3.2. Risks

Despite these advantages, there are several barriers to the widespread adoption of AI in urban agriculture. The cost of AI-powered farming equipment can be prohibitive for small-scale urban farmers. More so, the access to these types of AI tools are actually not easy to gain. Farmers or farming communities need to undergo capability training in order for them to learn and use AI systems into their farming practices. Numerous universities help bridge this gap through their research work, however, these are only small scale pilots and the widespread use of AI in farming is nowhere near being available to small scale farmers. Additionally, there is a need for training and supporting farmers to effectively use

AI technologies. In this case, city governments would need to invest in supporting capacity building for farmers in order to facilitate the use of AI tools for agriculture to ultimately off-set carbon footprint and increase food security. Ensuring that AI-driven urban agriculture initiatives are inclusive and accessible to all communities is essential for promoting equity and sustainability.

3.4. AI in Water Management

3.4.1. Opportunity

AI can play a big role in helping water infrastructure transition to low-carbon through more effective water usage and distribution. Europe counts a total of 3.5 million kilometers in water pipelines, where often significant parts require drastic renewal. This poses significant challenges to utility companies as well as risks for the sustainable supply of safe drinking water, and waste water management. These interventions will require up to 20 billion euros annually, while challenges such as drought and increased water demand call for the implementation of measures boosting the water grid's efficiency and sustainability. AI-powered systems are promising to help face these challenges by monitoring water quality, detecting leaks, and predicting demand, while ensuring that water resources are used efficiently in the entire locality. For example, AI can analyze data from sensors placed in water distribution networks to identify leaks in real-time, allowing for prompt repairs and reducing water loss. Predictive models can forecast water demand based on factors such as weather conditions and population trends, enabling more efficient water allocation. Other applications of AI are for improved catchment area management, for instance on water quality and the prevention of flooding and contamination, water efficiency on the demand side, drought forecasting and planning, and adequate sanitation. Leading examples of AI applications in smart water management can be found in Finland, where the pilot Silo.AI demonstrated how machine learning algorithms can be used to predict the quality of the water and monitor the water treatment process constantly, and the Netherlands, where the project SW4EU demonstrated its use for water quality control and optimisation.

3.4.2. Risks

AI models, particularly large ones like GPT-3 and GPT-4, consume significant amounts of water. These models require vast amounts of data and computational power, leading to substantial water usage both onsite for cooling servers and offsite for electricity generation (Ren, 2023). Although there has been an effort by big tech companies to address water usage, transparency regarding AI's water footprint remains insufficient. Better reporting and clarity in AI model documentation and public disclosure, similar to carbon footprint disclosures, would benefit city governments by providing essential data to manage local water resources more effectively.

3.5. AI in Waste Management

3.5.1. Opportunity

Onto waste management, AI has the potential to revolutionize waste management by improving efficiency and promoting recycling. AI-powered waste sorting systems can automatically identify and separate different types of waste, reducing contamination and improving the quality of recyclable materials. Predictive analytics can optimize waste collection routes, reducing fuel consumption and emissions from waste collection vehicles. Additionally, AI can help identify patterns in waste generation, enabling cities to implement more effective waste reduction strategies.

One exemplar application can be found in Amsterdam where AI plays a crucial role in promoting a circular economy within urban centers by focusing on waste reduction and management, resource recovery, and the optimization of product life cycles in industrial processes. AI can help design products that are easier to recycle and manage waste streams more efficiently, contributing to a more sustainable urban environment. AI-driven waste management systems optimize waste collection routes and improve recycling rates, reducing the environmental impact of waste management. Resource recovery technologies use AI to identify and extract valuable materials from waste streams, enhancing resource efficiency and promoting a circular economy.

3.5.2. Risks

Implementing AI in waste management requires overcoming several obstacles. The initial cost of AI-powered sorting and collection systems can be high, and there may be resistance from waste management workers and unions. Ensuring the accuracy and reliability of AI systems in diverse and changing environments is also challenging. Furthermore, promoting a circular economy through AI requires collaboration between various stakeholders, including manufacturers, consumers, and policymakers.

4. Leveraging AI for Climate Neutrality: Unlocking Systemic Levers for Change Applications of AI for Achieve Climate Neutrality: focus on systemic levers

4.1. AI for public participation

AI can play a big role in getting people involved in sustainability efforts. AI-driven platforms and tools can gather and analyze feedback from citizens, improve communication between city officials and residents, and encourage active participation in urban planning and sustainability efforts. This can help create a more informed and engaged community, which is essential for achieving climate neutrality. AI-driven education tools can help educate and mobilize urban populations toward sustainability goals, increasing awareness and fostering community involvement. AI tools can help mobilize urban populations by providing real-time information and resources on sustainability initiatives. This includes AI-powered platforms that encourage citizens to participate in green activities, track their carbon footprint, and adopt sustainable practices.

AI tools can also be adopted to reinforce direct democracy, helping public organisations offer improved public services that are more responsive to the needs of people (Cabannes, 2015). Building on this, Governments are increasingly using digital platforms to invite citizen participation in policymaking, enhancing democratic legitimacy, inclusiveness, and government effectiveness (Aitamurto & Chen, 2017). AI can support these efforts by providing advanced data analysis, improving the efficiency and reach of these platforms, and ensuring that diverse voices are heard in the policymaking process. These platforms leverage recent technological innovations to facilitate large-scale collective intelligence in public decision-making processes, ranging from participatory budgeting to constitution-making (Aitamurto et al., 2016).

These efforts have recently led to the exploration of the potential of AI for mass digital participation which is portrayed to improve public decision-making by harnessing the collective intelligence of citizens. This approach, based on the idea that "many heads are better than one," posits that aggregating individual

knowledge and opinions leads to better decisions than those made by a single member or experts alone (Landemore, 2017). This participation generates epistemic, democratic, and economic value by diversifying and enriching knowledge and engagement in law and policy-making processes (Aitamurto & Chen, 2017). In this space, GenAI and Natural Language Processing (NLP) are instrumental in managing and synthesizing the vast amounts of data generated by citizens. For instance, in Madrid the "Decide Madrid" platform employs NLP techniques to categorize proposals, suggest relevant proposals to users, group citizens with similar interests, and summarize comments, thereby facilitating more effective and meaningful citizen participation (Arana-Catania et al., 2021). Like this, many examples in other cities are leading the way, including Better Reykjavik, Taiwan, and Hamburg. This last city uses DIPAS (a system based on NLP) to structure citizen contributions, helping administrators navigate and interpret feedback more accurately and efficiently. GenAI is showing particular promise for deliberative democracy, as it can also help address barriers to participation that arise when specific skills are needed. These barriers often manifest as disparities in participants' ability to use digital tools, produce relevant texts, or create appropriate visual representations of ideas, prototypes, and visions (Tappert et al. 2024). In the domain of GenAI, models like GPT can produce outputs that closely resemble human responses to prompts typically presented in natural language interfaces. This capability not only enriches participant perspectives by offering diverse viewpoints but also aids in envisioning future scenarios and interpreting data. This potential is being explored through diverse experimentations, such as the work by von Brackel-Schmidt and colleagues (2024). The researchers present a case involving participants in envisioning the future of The Hamburg metropolitan city in 2040. The case demonstrated that participants, irrespective of their backgrounds, could rapidly visualise their concepts for the city's future without requiring specific artistic or technical skills. While these types of integration of GenAI herald significant potential, they also present challenges. These concern the capacity to balance the possible unintended consequences (Belanche et al. 2024; Sætra 2023). For instance, GenAI's ability to fabricate persuasive yet factually inaccurate content represents a relevant risk, particularly in the manipulation of deliberative discourse and possible dissemination of misleading information or fake news.

Such risks are profoundly pertinent to the deliberative context, where the truthfulness, accuracy, and quality of information are of prime importance.

Co-design with AI is another emerging area where AI can significantly impact public participation. This involves citizens working collaboratively with AI systems to design solutions for urban challenges. By leveraging GenAI, participants can rapidly generate visualizations, prototypes, and other creative outputs without needing specialized artistic or technical skills. This approach democratizes the design process, allowing a broader range of citizens to contribute their ideas and perspectives. For example, in the "Helsinki Summer Streets" project, the City of Helsinki used the UrbanistAI platform to engage a diverse group of citizens and local business owners in co-designing pedestrian-friendly streets. Participants worked in small groups to create and visualize various design scenarios, which were then voted on and refined in collaboration with city planners. This inclusive process not only enhanced the design outcomes but also ensured that the final plans reflected the community's vision and needs.

- AI in Digital Citizen's Participation
- Democratising AI: Principles for Meaningful Public Participation

Beyond democratic participation, AI can also strengthen other types of bottom up activities in cities. One example is Citizen Energy Communities, currently seen as a promising approach to creating sustainable and reliable energy systems despite limits linked to scaling and long-term maintenance. The role of AI in such processes could be multiple: from aiding citizens' initiatives with asset management and community platform building, to the development of alternative pricing and business models for local energy exchange. However, this is hard to implement if investments and support do not also come from commercial parties.

4.2. AI for city governance and policy making

AI can transform urban governance by enhancing public service delivery, increasing transparency, and engaging citizens in sustainability initiatives. It can streamline administrative processes, improve decision-making, and foster a more participatory approach to urban planning. It can enhance public services and optimize service delivery, making it more efficient and responsive to citizens' needs. It can also support more transparent governance analyzing and displaying data transparently, increasing accountability and fostering trust between citizens and government officials. For instance, by processing historical climate data, machine learning algorithms can forecast future trends with surprising accuracy, guiding policy decisions (Onyema et al., 2022) and mitigation strategies. With this, cities can be better equipped to harness large environmental datasets that can be used to plan for the climate transition (PECB, 2024).

See: Progress report on bridging data gaps

Concerning this, organisations are increasingly focusing on the intersections of climate and data, exploring the potential applications of AI and ML. In 2020 Refinitiv and the World Economic Forum launched the Future of Sustainable Data Alliance at Davos, and the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) launched a workstream on bridging data gaps a few months later. Another notable example is the European Commission's "Destination Earth" (DestinE) initiative. DestinE aims to develop a highly accurate digital model of the Earth to monitor and predict environmental changes, support sustainable development, and enhance urban planning. The key features of the initiative include: the integration of Large Environmental Datasets from various sources, including satellite observations, ground-based measurements, and socio-economic data, to create a comprehensive digital twin of the Earth; the creation of high-Resolution Simulations of natural phenomena and human activities, providing insights into the impacts of climate change and helping to predict future environmental conditions; the support for Policy and Decision Making through the provision of accurate and up-to-date information.

DestinE is expected to significantly improve the ability of cities to manage and utilize environmental data. It will provide tools for better predicting climate-related events, optimizing resource use, and implementing effective climate action plans. This initiative exemplifies how collaboration and advanced AI technologies can address complex environmental challenges and drive the transition towards climate neutrality (European Commission, 2022).

AI is also portrayed to dramatically change democracy (Inerarity, 2024). Here, there is however no certainty about the positive or negative consequences of the technology on democracy as the transformation is still underway. Technologies are redefining key aspects of our political systems, not least by challenging economic financing and the notion of an informed citizenry. This demands public reflection and open debate to counteract the tendency of seeing technology as inevitable and neutral. It must be remembered that algorithms are also a source of inequality, as it attempts to decipher society's true essence and preferences based on user behavior and activities online. Although this is intended to liberate people from the influence of authoritative figures and organisations, it also perpetuates existing hierarchies and inequalities while also disproportionately valuing those already well-positioned. Democracy thrives on dialogue and sharing of diverse perspectives, however by favoring misinformation and the creation of echo-chambers AI can corrode democracy.

See: UNESCO: Artificial Intelligence and democracy

5. Key takeaways for cities

As explored, AI bares substantial potential in optimizing efficiency in several emission domains:

- it can optimize energy consumption of buildings, energy distribution and energy storage thus contributing to energy savings while also demanding significant energy to function itself, highlighting the need for greener AI solutions;
- it can radically improve the efficiency of urban mobility by reducing congestions and lowering emissions, however this also requires overcoming financial barriers as well as regulatory, technological and commercial ones;
- it can help to radically improve the relevance of urban farming for future food production, however this comes with costs associated to the difficulties in accessing the technology and the level of digital literacy of final users;
- it can help improve water usage and management, although not without costs associated with transparency regarding AI's water footprint;
- it can revolutionize waste management by improving efficiency and promoting recycling, but attention needs to be given to implementing new paradigms linked to the circular economy.

Beyond this, AI also presents overarching challenges, including technological, social and regulatory ones. Data collection and management is a significant one among those: using AI to achieve climate neutrality needs **effective data collection and management.** AI systems are only as good as the data they're fed. One practice that has been helpful for cities is when they join a coalition with other cities and share data amongst the members to build more robust data sets (Taylor et al., 2018). Ensuring cities can do this requires prioritizing human resources, procurement, and legislative support to legitimize use. Further, developing AI infrastructure and competencies within cities is a long-term process that demands commitment from city governments and external stakeholders. The City of Amsterdam wrote this intention in their City AI strategy stating the following key investments and actions: (1) Technical Infrastructure: Invest early in technical infrastructure, including data acquisition, preparation, machine learning techniques, hardware, computational power, a safe working environment, and knowledge representation; (2) Departmental Knowledge: Invest in AI knowledge specifically within legal, purchasing, and audit departments to ensure informed decision-making and compliance; (3) AI Education for Civil Servants: Ensure that every civil servant completes the National AI Course to gain basic AI knowledge.

Finally, as the use of AI involves collecting and processing vast amounts of data, concerns about **privacy and security** are central**.** Ensuring AI systems are transparent and accountable is essential for maintaining public trust and preventing misuse. Additionally, the potential for **bias in AI algorithms** is significant. If AI systems are trained on biased or incomplete data, they can perpetuate and even exacerbate existing inequalities. Thus, ensuring AI technologies are developed and deployed fairly and equitably is crucial for promoting social justice and sustainability. This is a big deal in climate action, where vulnerable populations are often the most affected. Relying too heavily on AI and tech solutions thus can also distract from other crucial aspects of climate action, like changing behaviors, policy measures, and international cooperation. AI is a powerful tool, but it's not a silver bullet. It needs to be part of a broader, multifaceted strategy towards climate neutrality.

5.1. The Need for a Multifaceted Strategy

While AI has significant potential to contribute to urban sustainability, it is essential to recognize that it should not be the sole focus in addressing climate and sustainability challenges. The over-reliance on AI and technological fixes can overshadow the fundamental need for direct and multifaceted (multi-scale and multi-modal) approaches to climate action. Addressing the core issues of climate change requires comprehensive strategies that include policy measures, behavioral changes, and international cooperation.

Policymakers and urban planners should invest in energy-efficient AI technologies to support the development and deployment of AI systems that minimize energy consumption and reduce their

environmental footprint. Implementing robust data privacy and security measures is essential to protect citizens' data and maintain public trust. Addressing bias in AI models by using diverse and representative datasets ensures fairness and equity in their applications. Inclusive AI strategies that involve communities in developing and implementing AI-driven sustainability initiatives can better address local needs and preferences. Integrating AI into a comprehensive climate strategy that includes policy measures, international cooperation, and behavioral changes is necessary to harness the full potential of AI for climate action. By adopting these strategies, cities can leverage AI to drive sustainability and achieve climate neutrality, contributing to a more sustainable and equitable future for all.

While AI is great at cutting down carbon emissions, the tech itself isn't entirely green. Training large AI models gobbles up a lot of computational power, which means hefty energy use. The carbon emissions from data centers and other infrastructure can sometimes cancel out the benefits. While AI offers transformative possibilities for driving the transition towards climate-neutral cities, it is crucial to recognize that it should not be the primary solution to climate and sustainability challenges. The over-reliance on AI and technological fixes can overshadow the fundamental need for direct and multifaceted approaches to climate action. Addressing the core issues of climate change requires comprehensive strategies that include policy measures, behavioral changes, and international cooperation.

Implementing robust data privacy and security measures is essential to protect citizens' data and maintain public trust. Addressing bias in AI models by using diverse and representative datasets ensures fairness and equity in their applications. Inclusive AI strategies that involve communities in developing and implementing AI-driven sustainability initiatives can better address local needs and preferences. Integrating AI into a comprehensive climate strategy that includes policy measures, international cooperation, and behavioral changes is necessary to harness the full potential of AI for climate action. By adopting these strategies, cities can leverage AI to drive sustainability and achieve climate neutrality, contributing to a more sustainable and equitable future for all.

Gauging from these, while AI holds substantial promise for enhancing urban sustainability and aiding in the fight against climate change, it must be viewed as a supplementary tool rather than a primary solution. The complex and multifaceted nature of climate challenges requires an equally complex and multifaceted response that views the inclusion of public participation at every stage of the AI development, from the decision to adopt an AI tool to initial concept design to real-world deployment and beyond, to identify and reduce harms. AI can provide valuable data insights, optimize resource use, and enhance predictive capabilities, but the foundational work of policy development, behavioral change, and stakeholder collaboration remains paramount. By balancing the innovative potentials of AI with comprehensive, ground-level climate actions, cities can more effectively move towards achieving climate neutrality and ensuring a sustainable future for generations to come. By integrating AI into broader sustainability efforts, cities can harness the power of technology to drive meaningful change, while also promoting social equity, economic resilience, and environmental stewardship. Through collaborative efforts and thoughtful planning, the goal of climate-neutral urban environments can become a reality, paving the way for a healthier, more sustainable future for all.

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Annex 3 – Navigating Electrification Risks in European Cities: Strategies for Sustainable Transition Amid Rising Demand and Geopolitical Challenges (DML)

Authors: Ivana Stancic, with contributions from Alexandra Hansten and Aleksander Nowak (Dark Matter Labs)

Summary

This deepdive addresses the electrification risks that cities in Europe face in the transition to sustainable, low-carbon energy systems. It explores key challenges such as rising energy demand, critical materials shortages, and the complexities of decarbonizing urban infrastructure while ensuring environmental and social equity. The deliverable provides an in-depth analysis of the risks associated with sourcing and production of clean energy technologies, environmental impacts, workforce shortages, and the financial barriers to the energy transition.

The report highlights opportunities for cities to mitigate these risks through strategies like urban mining, circular economy practices, skills development, innovative financing, and regional cooperation. It emphasizes that a coordinated approach across cities is essential to overcoming these challenges and achieving the EU's climate goals, particularly net-zero emissions by 2050.

Keywords

Electrification, Energy transition, Resource Security, Circular economy, Green technologies, Urban mining, Skills development, Financial mechanisms, Climate targets, Geopolitical risks, Workforce shortages,

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1. Introduction and Objectives

The need for European cities to transition towards clean energy sources is undeniable. However, the processes, as well associated benefits, opportunities, trade-offs, risks accompanying this transition are crucial to consider to design and implement societally equitable and truly environmentally sustainable pathways. This piece of work aims to contribute to increased understanding of the transition complexity helping cities better strategize on ways forward, goals, and decision-making processes.

The following questions are explored:

- Which sectors account for the highest energy use in European cities, and how do they relate to the greatest opportunities for adaptation?
- How can cities address increasing energy demand while urgently reducing greenhouse gas emissions (2.2.)?
- Which concepts, products, components, and materials are central to the energy transition, and why is it important to capture their systemic implications (2.4.)?
- What are the risks of sourcing and producing (3.1.), as well as environmental (3.2.), social (3.3.), and economic (3.4.) implications of these concepts, products, and materials?
- And what are the key findings and key takeaways (4.0), that could support pathways for European cities (5.0)?

2. Context

The EU's total remaining built environment carbon budget for limiting warming to 1.5°C is around 15 Gt CO2e (Friedlingstein et al., 2022). This means Europe must reduce its CO2 emissions by approximately 40% by 2030, necessitating a drastic acceleration in reduction efforts.

Achieving these goals demands **tripling the current renovation rates with a focus on deep energy-saving retrofits that cut building energy use by at least 60%** (International Energy Agency, 2021).

The EU's Renovation Wave initiative aims to upgrade 35 million buildings by 2030, simultaneously boosting green jobs and tackling energy poverty (European Commission, 2024). Realizing these goals requires a holistic strategy that integrates demand reduction, energy efficiency, and renewables, supported by robust enforcement, monitoring, and digital tools like renovation passports. Balancing the growing energy demand driven by comfort, climate extremes, and technological growth with this finite carbon budget—and geopolitical uncertainties over energy supply—creates a formidable challenge. Yet, coordinated, ambitious action across Europe's cities and countries is indispensable to secure a sustainable, resilient energy future consistent with net zero by 2050.

Furthermore, the Russia's invasion of Ukraine and the resulting disruption of relations with Russia have placed Europe's **energy security under severe pressure, exposing the risks of dependence on a limited number of external suppliers.** This shock accelerated the **urgency for diversification of energy sources** and highlighted the **geopolitical dimension of the clean energy transition.**

Many European cities now face the dual challenge of ensuring a reliable and affordable energy supply in the short term, while simultaneously pursuing long-term sustainability goals. The fragmentation of global trade, combined with volatile fossil fuel markets and competition for critical clean energy technologies, further complicates this task (International Monetary Fund, 2023).

In this context, electrification (among others of heating through heat pumps, combined with expanded renewable electricity such as solar PV) is critical (European Climate Foundation, 2022). Mandatory Minimum Energy Performance Standards (MEPS), **nationally tailored renovation plans**,

and aligned financial incentives must drive widespread uptake, ensuring **equitable access** particularly for vulnerable households (Climate Bonds Initiative, 2023).

For urban centers—where consumption is most concentrated—this means navigating a tight balance between securing immediate energy needs and investing in the infrastructure that will enable decarbonization. Without a coordinated approach at both national and municipal levels, cities risk being locked into expensive stopgap solutions, undermining the resilience and equity of Europe's transition to a sustainable energy system.

2.1. An Overview of Energy Consumption in European Cities and Associated Decarbonization Impact

European cities rely heavily on a stable and affordable energy supply to meet the demands of diverse sectors, including heating and cooling, transportation, agriculture, industry, and electricity provision. Despite substantial progress in renewable energy adoption, a significant portion of the EU's energy consumption remains fossil-fuel based, contributing notably to greenhouse gas emissions and climate change challenges (European Environment Agency, 2023) (Fig 1.).

There is **marked variation in energy consumption volumes across** European countries and urban areas, reflecting obvious differences in climate, economic structure, technological adoption, as well as cultural and lifestyle patterns. These disparities suggest differentiated decarbonization pathways and opportunities for energy demand reductions, balanced with human comfort needs and shifting behavioural patterns related to energy use (International Energy Agency, 2023) (Fig 2).

Furthermore, **shifting climatic zones, add to the further complexity** when considering decarbonization pathways, as the dynamically changing conditions need to be taken into account. For example, while Southern cities face continuously growing cooling requirements, Northern cities are now also experiencing increasing demand for cooling during ever warmer summers, having until recently focused primarily on heating needs.

Sectorally, the **mobility sector** stands out as a primary target for emissions reduction due to its substantial share in urban energy consumption and relatively **straightforward technological alternatives through electrification** and modal shifts. This sector shows some of the greatest differences in emissions across cities, largely shaped by infrastructure and policy choices (European Environment Agency, 2023; International Energy Agency, 2023g) (Fig 3). By contrast, household energy use, principally for space heating, cooling, and appliances presents a more complex challenge. It accounts for a similar scale of urban energy consumption and corresponding emissions, with significant potential for energy efficiency improvements and electrification of heating through heat pumps. Closely following is the industrial sector, where energy-intensive production processes demand targeted decarbonization strategies including process electrification, adoption of green hydrogen, and circular economy approaches (European Environment Agency, 2023; International Energy Agency, 2023).

Recognizing these sectoral dynamics and geographical variations is essential for designing decarbonization policies that not only reduce emissions but also address sufficiency and redefine what constitutes urban liveability in line with EU climate commitments.

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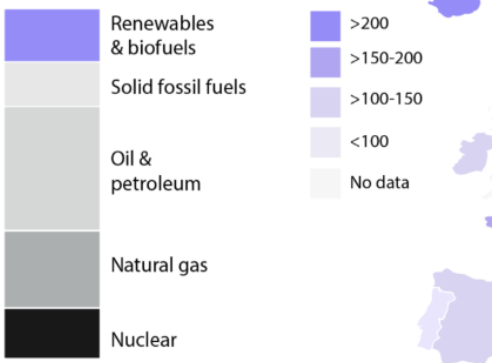

Fig 1. European Energy consumption per fuel

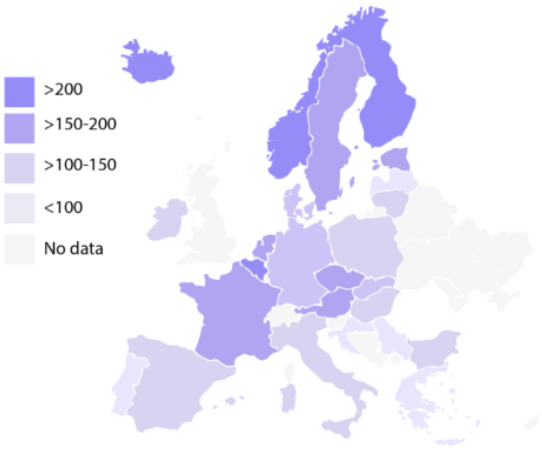

Fig 2. European Energy consumption (annual kWh/capita)

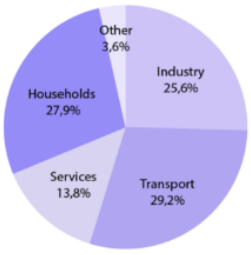

Fig 3. European Energy consumption by sector

2.2. Increasing Energy Demand in a Conflict with the Urgency to Reduce Emissions

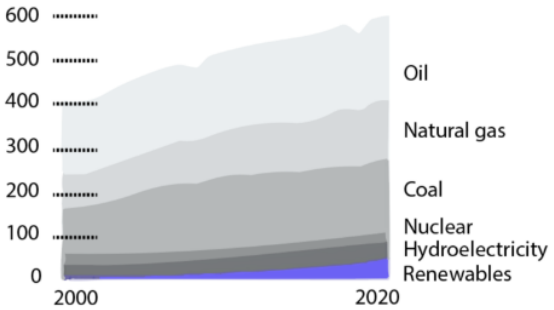

Fig 4. Global increase in demand is higher than all renewables installed (TWh)

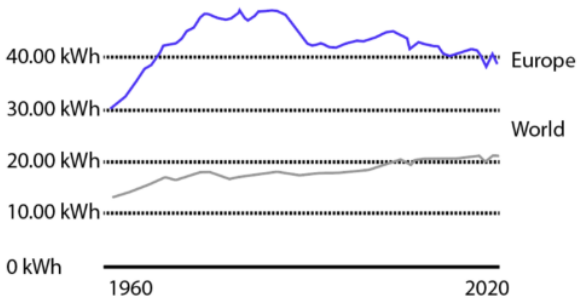

Fig 5. European energy use per capita is double compared to world average

In recent years, global energy **demand has risen at a pace exceeding the total installed capacity of renewable energy sources,** meaning renewables have so far only been able to meet the growing demand rather than surpass it (International Energy Agency, 2023) (Fig 4). Within this global context, the **European Union's per capita energy consumption still remains about twice the world average**, reflecting unique challenges in managing urban energy consumption while pursuing decarbonization (International Energy Agency, 2023) (Fig 5.).

European cities face a complex dilemma: **rising standards of comfort, technological advancements, and industrial growth consistently elevate energy demand.** This trend is further intensified by increasingly extreme weather patterns, leading to augmented heating and cooling needs to maintain indoor climate conditions conducive to health and productivity.

- Buildings are major consumers of energy in European cities, representing approximately 40% of the EU's total energy use. This energy is largely devoted to heating, cooling, lighting, and operating appliances. Since 2000, the building stock in Europe has grown by about 300%, while the energy demand per building continues to rise at an annual rate of approximately 4% (International Energy Agency, 2023).
- Cooling services, driven by urban heat and climate change, currently account for nearly 10% of global energy demand and can constitute over 50% of the total energy consumption during peak summer months in warmer regions—trends also manifesting across Southern European cities (International Energy Agency, 2023b). Notably, global energy consumption for indoor cooling has more than tripled over the last three decades, with forecasts indicating continued acceleration as temperatures rise.
- Heating, encompassing space heating and water heating, remains the largest contributor to building energy use globally, accounting for nearly 50%. Electrification of heating is progressing, with projections indicating that the share of electricity in heating will approximately double by 2030. Moreover, recent extreme cold spells have driven spikes in winter energy demand, further exacerbating challenges for urban energy systems (International Energy Agency, 2023b).

These dynamics create periods of **extreme peak demand**, especially during very hot summers or harsh winters. Such peaks strain grid infrastructure and increase the risk of **power outages**, which in turn jeopardize public health and safety by exposing large urban populations to climate-related stress (International Energy Agency, 2023c).

Recent examples include the June 2024 blackout across parts of the Balkans during a heatwave that drove cooling demand to unprecedented levels, and the 2025 heatwave in Italy, where cable overheating and surging demand stressed the power system. While not directly climate-related, the Iberian Peninsula blackout of April 2025 — which cut 60% of Spain's electricity supply within seconds — further illustrates how fragile grids can become when faced with sudden shocks.

Balancing this mounting and volatile energy demand while accelerating emission reductions presents one of the key risks in the transition to net zero cities. Addressing this requires integrated energy planning, deployment of flexible, low-carbon heating and cooling technologies, and demand-side management strategies tailored to Europe's diverse, and changing climatic and urban contexts.

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2.3. Current Predominating Systems and Products of the Green Transition

- **Electric Vehicles:** The rapid adoption of electric vehicles (EVs) represents a transformative step toward sustainable, low-carbon transportation and is a cornerstone technology in decarbonizing road transport. However, the production of EV batteries and motors requires several critical minerals and rare earth elements. Therefore, a holistic approach to electrification must consider the environmental and social implications of raw material extraction to ensure overall sustainability (International Energy Agency, 2023d).
- **Solar Panels**: Photovoltaic (PV) technology is expected to lead the transformation of the global electricity sector. In 2022, global solar capacity increased by 26% and must continue growing at this pace to meet the Net Zero Scenario goals. Solar panels rely on materials such as silicon, cadmium, tellurium, and rare earth elements, whose extraction can be linked to environmental degradation and supply chain vulnerabilities. Additionally, the majority of the PV value chain is geographically concentrated, with China dominating production, creating strategic and supply risks (European Commission, 2020).
- **Wind Turbines:** Wind power is one of the most cost-effective climate mitigation technologies. A key component of wind turbines is the generator, which demands rare earth elements and a variety of materials such as concrete, steel, plastics, composites, aluminium, chromium, copper, iron, manganese, molybdenum, nickel, and zinc. The typical wind turbine lifetime ranges between 25-30 years, raising concerns about waste management and emphasizing the importance of embedding circular economy principles in turbine design and end-of-life processing (European Commission, 2020).
- **Air Conditioning:** Approximately 2 billion air conditioning units are currently in operation worldwide, positioning space cooling as a major driver of increasing global building energy demand. Besides the electricity consumed, air conditioning contributes to greenhouse gas emissions through refrigerant leaks, with many refrigerants having a global warming potential thousands of times greater than CO_2 (International Energy Agency, 2023e).
- **Heat pumps:** Heat pumps are indispensable for reducing emissions and natural gas use and are an urgent priority within the EU's climate strategy. Their rapid adoption will increase electricity demand substantially, making the implementation of energy-efficient practices, demand response measures, and simultaneous improvements in building envelopes critical to mitigating impacts on power systems (International Energy Agency, 2023f).
- Building envelope retrofit: Since 2010, increased energy efficiency measures in building envelopes have contributed to a 4% global reduction in heating demand across advanced economies (European Environment Agency, 2022). Retrofitting building envelopes has the potential to reduce building energy consumption by 50–75%. Innovations in materials and adaptive envelope systems are therefore crucial components of effective retrofitting strategies. Importantly, embodied carbon and pollution impacts of insulation materials must also be carefully evaluated to achieve truly sustainable building upgrades (EU Smart Cities Information System, 2023; Greenspec, 2023).

2.4. The Importance of Capturing the Entanglements and Systemic Impacts of the Green Transition

Green transition is characterized by a complex entanglement of sectors, technologies, and **resource flows that cannot be understood or managed in isolation.** Energy demand from buildings, transportation, industry, and power generation is intricately linked with the deployment of diverse low-carbon technologies, each **relying on critical materials and supply chains that introduce systemic vulnerabilities**. These interconnections create feedback loops where changes or disruptions in one domain propagate across others, underscoring the need to analyze the entire system holistically to avoid unintended consequences.

Moreover, the **extraction and processing of critical minerals** essential for clean technologies such as electric vehicles and renewable energy infrastructure **carry their own environmental and social risks**. These resource dependencies highlight that sustainability challenges are not confined to carbon emissions alone but span ecological integrity, social welfare, and geopolitical stability. Addressing the green transition's challenges effectively requires capturing these multi-dimensional entanglements and adopting integrated strategies that reflect the full scope of risks and opportunities across interconnected domains.

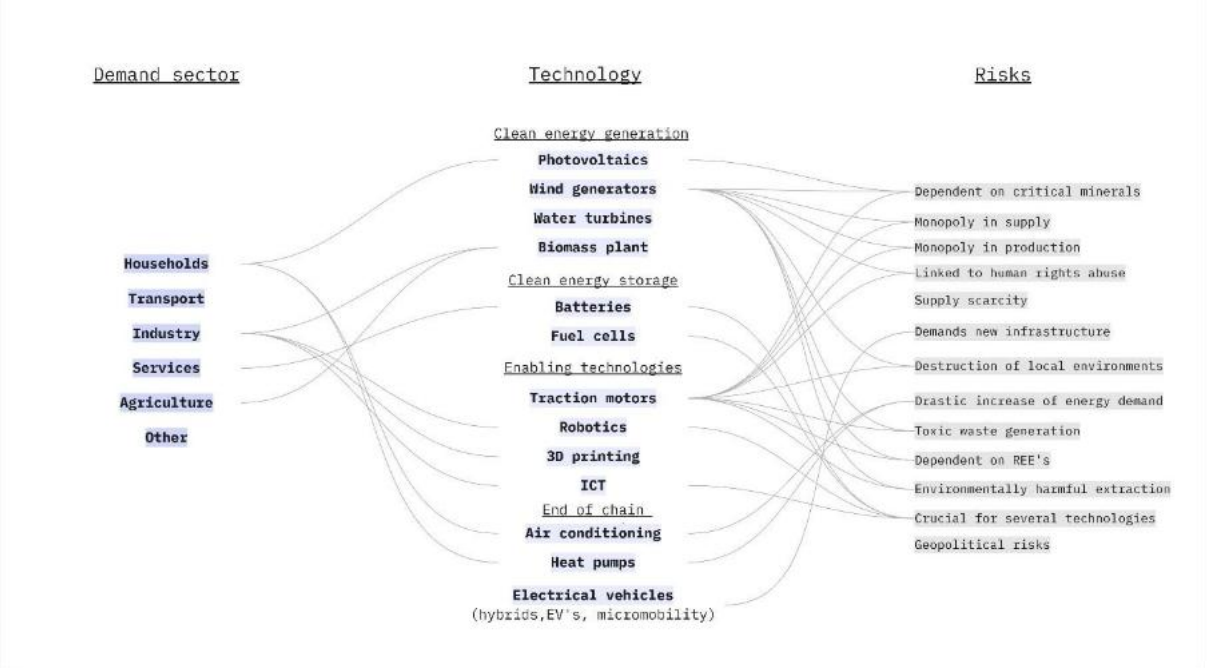

Fig 6. An overview of detected risks associated with the energy transition of cities (Graphic by Dark Matter Labs)

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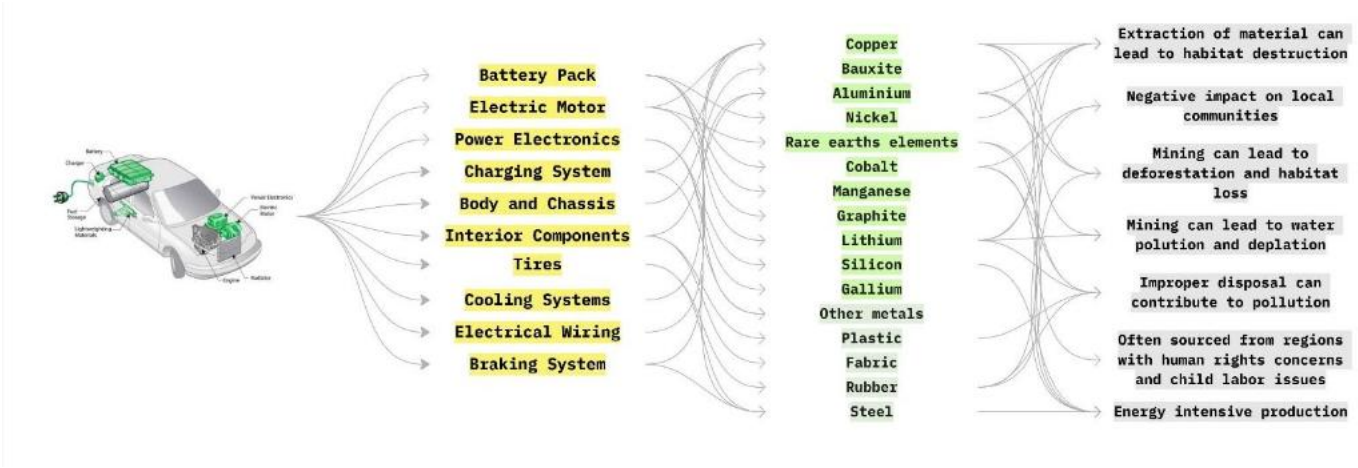

Fig 7. Example: Risks associated with electric car production (Diagram by Dark Matter Labs)

3. Risks

3.1. Sourcing and Production Risks: Escalating Demand for Critical Materials and Supply Chain Vulnerabilities

Components for clean energy technologies generally require a larger number of resources and energy to produce compared to conventional fossil-fuel based alternatives (International Institute for Sustainable Development, 2018).

"A typical electric car requires six times the mineral inputs of a conventional car and an onshore wind plant requires nine times more mineral resources than a gas-fired plant." (International Energy Agency, 2021).

According to the International Energy Agency's latest report, efforts aligned with meeting the goals of the Paris Agreement are estimated to require a 400% increase in mineral demand by 2040. Accelerating this further to hit global net-zero by 2050 would mean an increase in mineral input demand by 600% in 2040 compared with today's levels—a surge in demand for critical minerals such as cobalt, lithium, and rare earths, given their crucial role in manufacturing wind turbines, electric vehicles, and energy storage batteries (International Energy Agency, 2022).

"In total, between 2022 and 2050, the energy transition could require up to 6.5 billion tonnes of materials cumulatively, of which 95% is accounted for by steel, copper, and aluminum" (International Energy Agency, 2022).

The capacity for mining and refining in a sustainable way and at the speed required is limited. The International Energy Agency estimates the average duration of mining projects from discovery to initial production is approximately 16.5 years, making it difficult for the supply side to rapidly respond to sudden surges in demand (International Energy Agency, 2021b).

Another pressing risk for mineral supply stability is climate change. Several critical minerals needed for the energy transition are sensitive to climate impacts. Copper and lithium are both highly susceptible to water stress. More than 50% of current production for these minerals occurs in regions with high water stress and climate vulnerabilities, such as Australia, China, and Africa, raising uncertainty about supply reliability (International Institute for Sustainable Development, 2018).

3.2. Environmental Impact Risks: Embodied Carbon, Pollution, and Waste in Clean Energy Systems

Transitioning to clean energy technologies will undoubtedly be a driving force in the shift to a low-carbon economy. However, it is crucial to adopt a holistic perspective and account for potential negative side effects that could arise (International Institute for Sustainable Development, 2018).

- The mining industry has been identified as the second-most-polluting industry globally, and the green energy transition risks catapulting it to the number one position. This means our planned green transition is far from perfectly green. Rare earth elements are crucial for clean energy, but current mining methods significantly damage communities and surrounding environments through heavy metal discharges, acid rain, and water contamination (Nayar, 2023).
- Energy sourcing in cities substantially influences greenhouse gas emissions and contributes to the emergence of urban heat islands. For example, indirect greenhouse gas emissions related to cooling technologies have nearly tripled and continue to rise despite energy efficiency improvements and less carbon-intensive energy production (International Energy Agency, 2023).
- Waste and end-of-life management pose major challenges: high-demand minerals currently suffer from poor end-of-life collection and recycling rates. Mining rare earth elements produces large amounts of toxic waste hazardous to human health and the environment. “For every ton of rare earth produced, the mining process yields 13 kg of dust, 9,600–12,000 cubic metres of waste gas, 75 cubic metres of wastewater, and one ton of radioactive residue… Overall, for every ton of rare earth, 2,000 tons of toxic waste are produced” (Nayar, 2023).
- Improvements in recycling technology are vital, but so far no technology has proven economically viable compared to raw material extraction. Modifying accounting systems to reflect the entire systemic impact could incentivize circularity patterns, currently estimated at around 7% and declining (Circularity Gap Report, 2023).

Another pressing issue is **the lack of recycling capacity**, which contributes to intensive waste generation. Enhancements in this sector are crucial for reducing waste and limiting environmental impacts by curbing demand for virgin materials (International Institute for Sustainable Development, 2018).

3.3. Social Impact Risks: Geopolitical Challenges and Workforce Shortages in the Energy Transition\

3.3.1. Geopolitical and social risks due to high geographical concentration of material supply

Much of the minerals needed for clean energy transitions are **highly geographically concentrated**, with **China playing a predominant role in both extraction and production stages**. This concentration raises social distress and geopolitical risks, creating vulnerable and fragile supply chains (International Institute for Sustainable Development, 2018).

In nations with high political instability and weak governance in the mining sector, **mineral extraction has been associated with increased violence, conflict, and human rights abuses** (International Institute for Sustainable Development, 2018). Several critical minerals needed for the energy transition are also sensitive to climate change, with considerable risks of supply chain disruptions. For example, **copper and lithium** are highly susceptible to water stress, and more than 50% of the current production of these minerals occurs in regions facing high water stress and extreme heat waves such as Australia, China, and Africa (International Energy Agency, 2021b).

3.3.2. Risks of lack of workforce for implementation of energy transition

Worker shortages alongside an inadequately trained and aging workforce create substantial challenges for sourcing personnel needed for sustainable building activities, including both renovations and new construction - an existing major obstacle for the building sector (Euractiv, 2021). Without making this industry more attractive and inclusive, securing adequate numbers or quality of workers becomes impossible. Migration patterns will complicate this situation further, as they may not align with labour demands regarding timing or location. Climate and conflict-related displacement will not necessarily bring people to regions designated for planned retrofits or green construction programs. Even where this alignment occurs, competing labour priorities will emerge, including caregiving responsibilities and food security improvements. As these competing demands intensify, decisions about allocating workers to building renovations versus other essential tasks will likely become a major strategic issue.

Estimates suggest that **some three to four million construction workers in Europe alone need to upgrade or diversify** their skills to meet the ambitious targets set by EU energy policies, including the Energy Efficiency Directive, Energy Performance of Buildings Directive, and Renewable Energy Directive (European Climate, Infrastructure and Environment Executive Agency, 2023). This substantial skills gap poses both a major bottleneck and an opportunity to reshape Europe's labor market towards greener, more sustainable jobs.

Demographic trends and an aging workforce, particularly in construction and energy engineering sectors, further intensify the shortages at a time when demand for labor to build and maintain new energy infrastructure is surging (Clean Energy Wire, 2025). The transition also requires integration of emerging technologies such as heat pumps, renewable heating and cooling systems, and advanced performance contracting, highlighting the need for specialized training and cross-border recognition of skills and qualifications (European Climate, Infrastructure and Environment Executive Agency, 2023).

To address these challenges, EU-wide initiatives such as the BUILD UP Skills initiative and the European Construction Blueprint have been developed, providing comprehensive toolkits

and roadmaps to upskill the workforce. Funding programs like Erasmus+ and LIFE Clean Energy Transition (CET) underpin these efforts by supporting member states in labor market adaptation, skills mapping, and targeted education and training programs (European Climate, Infrastructure and Environment Executive Agency, 2023). Yet, despite these efforts, the integration and coordination of workforce development policies at the national level remain critical to closing the gap timely and efficiently.

Experts stress that recognizing the workforce as a strategic asset and fostering collaboration among policymakers, educational institutions, and industry stakeholders are vital for overcoming the workforce shortages threatening Europe's journey to climate neutrality. Flexible training models such as micro-credentials and modular learning can accelerate the reskilling of the existing workforce, while attracting younger generations to green careers is essential to sustain long-term labor supply (InnoEnergy, 2025). Failure to act decisively risks delaying deployment schedules, escalating costs, and ultimately undermining the EU's net-zero ambitions (European Commission, 2025).

3.4. Economic Risks: Escalating Costs and Financial Barriers to the Energy Transition

Cities, as the primary hubs of energy consumption, economic activity, and population density in the European Union, face acute economic challenges due to the high costs associated with the green transition. Urban areas account for the majority of energy use and greenhouse gas emissions, especially from buildings, transport, and infrastructure, making them crucial battlegrounds for achieving climate targets. However, increasing capital expenditures for deep building renovations, renewable energy infrastructure, and sustainable transport solutions may strain municipal budgets and investment capacities (European Central Bank, 2025).

Unlike national governments, cities often have more limited fiscal autonomy and borrowing capacity, which can constrain their ability to finance large-scale projects needed for rapid decarbonization. Without adequate financial support schemes, including grants, subsidies, and blended financing mechanisms, many cities—particularly small and medium-sized ones—may struggle to implement costly retrofit programs or to upgrade public transport and energy infrastructure on the timescale required (Pisani-Ferry et al., 2025).

The impending end of EU-wide recovery funding such as the Recovery and Resilience Facility (RRF) in 2026 poses a critical risk for cities reliant on this support to leverage private investments. The projected funding gap of approximately €180 billion for 2024-2030 could disproportionately impact urban areas that need sizable upfront investments to modernize energy systems and reduce carbon emissions efficiently (European Central Bank, 2025).

Furthermore, rising costs in clean technology sectors—for instance, manufacturing and installing heat pumps or solar panels—require cities to coordinate closely with regional and national governments to pool resources and integrate green infrastructure planning into broader urban development strategies. This coordination is essential to achieve economies of scale, reduce risks for investors, and prevent widening disparities between wealthier and poorer cities or neighborhoods (Bruegel, 2025).

Social equity concerns also intensify in urban environments, where vulnerable populations face heightened exposure to energy poverty and the socioeconomic effects of energy price increases related to green investments. Cities must balance ambitious climate actions with protecting residents from disproportionate cost burdens, requiring targeted subsidies, tariff structures, and stakeholder engagement to ensure a just transition (Pisani-Ferry et al., 2025).

In sum, cities are at the frontline of implementing the EU's green transition but face unique economic risks linked to financing capacity, cost escalation, and social equity. Strengthening urban financial

instruments, fostering innovative funding models, and enhancing multi-level governance cooperation are critical to enabling cities to proceed at pace without sacrificing inclusivity or fiscal sustainability (European Central Bank, 2025; Pisani-Ferry et al., 2025).

4. Key takeaways for cities

While European cities experience per capita energy use twice the global average, the global energy demand continues to **grow faster than the implementation of strategies** that would increase the renewable capacity. This trend, driven by **increasing comfort expectations** of ever greater parts of society, technological growth, or extreme climate events, intensifies the challenge of full decarbonization. Cities must address these **dual pressures** of both rising demand and meeting the climate targets.

Impacts of technologies, sourcing of resources, and energy demand are deeply entangled across sectors and geographies. Isolated interventions e.g. those which see electrification without critical mineral dependencies risk greenwashing and ineffective outcomes. Therefore, cities need to select and implement solutions based on comprehensive, science-based evaluations of their systemic impacts—climate, social equity, environmental, and economic.

Some of the municipalities Net Zero Cities consortium are implementing risk mitigation strategies that directly address electrification, circular economy while considering the transition risks mentioned. **These cities aim to e.g. reduce critical mineral dependencies, address the transition financing gaps, or retrain AEC (architecture, engineering, construction)** professionals through incentive mechanisms. The most successful are the blended approaches; those which combine **demand management (reduction)** with **innovative financing, workforce development, and regional cooperation to build resilient urban electrification** pathways.

4.1. Addressing Sourcing and Production Risks Through Urban Mining and Circularity

Europe's recycling and circularity capacity is critically underdeveloped compared to the scale of the challenge. When considering electrification through systemic lens, without embedding circular economy principles, cities may face supply chain vulnerabilities. Some of them, however, managed to initiate processes that demonstrate how urban areas can systematically reduce their dependence on virgin materials in electrification pathways while building local resilience muscle. Urban mining initiatives that treat cities as material reservoirs rather than consumption endpoint already exist.

For instance, Amsterdam, with its urban mining targets, is one of the leaders (see e.g. "Prospecting the Urban Mines" program that maps future materials from demolition and renovation (Metabolic, 2017; Amsterdam Smart City, 2024). The city has identified **nearly one third potential reduction in import dependency** through building material passports and urban material recovery systems. Their Urban Mining Factory specifically targets critical raw materials recovery from printed circuit boards (Circular Industries, 2024), while the Port Circular Strategy aims to generate an industrial ecosystem where one company's waste becomes another's raw materials across 116 active circular projects. Meanwhile at the Johan Cruijff ArenA, and, and Ikea store in Haarlem, food organic waste is turned into energy through container “plug-and-play” like system. **Furthermore, Barcelona's Zero Waste Plan 2021-2027** demonstrates systemic material reuse strategy at city scale (Etikord, 2024). The city operates 134 neighbourhood Green Point Networks for complex materials including electronics. The scheme is linked to incentive system for citizens through user card. It is linked to the household's water supply contract and enables discounts to be obtained for waste management charges. Similarly, **Vienna**

targets 30% reduction in primary raw materials by 2030, with 80% reuse/recycling rates for demolition materials.

Multiple more grassroot organisations have committed to similar goals before and laid foundation for take-up by city authorities. These include

- Rotor DC: a cooperative in Belgium that organises the reuse of construction materials. They dismantle, process and trade salvaged building components.
- Mobius: a French organisation supporting material reuse in the construction industry by providing advice, sourcing and supplying reusable construction materials.
- Brda: a Polish cooperative focused on the reuse of recycled materials and circularity through projects, research and advocacy, workshops with citizens and competitions.

Finally, it is important to recognize that not only city-level but a regional coordination amplifies impact. The Cities are implementing shared material databases and cross-border secondary material flows, with Nordic countries developing collaborative circular economy systems in mining value chains (Newcastle University, 2024).

4.2. Mitigating Environmental and Social Impacts Through Environmental Justice Frameworks

Social risks of decarbonization pathways should be taken into consideration and aim at mitigating energy poverty to prevent exclusion and inequity from undermining climate progress. Some of the examples of pathways are EU initiative include community owned solar installations on schools (Torreblanca district, POWERTY project) through which local residents see significant energy bill reductions, get energy education and unified under one community program (Euronews, 2024). Lyon's SLIM Program addresses energy poverty through systematic identification of households that struggle with their energy bills and guides them towards subsidies financing for housing renovations and energy upgrades (Eurocities, 2024). Whereas C40 Cities Clean Construction Accelerator committed to reducing embodied emissions by 50% in new buildings by 2030 in over 45 cities (GreenBiz, 2024).

4.3. Addressing Workforce Shortages through Comprehensive Skills Development

Cities are addressing the need for millions of European AEC workers to upgrade their skills through coordinated training programs that specifically target the demands of electrification, such as energy retrofits and renewable energy installations. Programs like EUCERT, which scales heat pump training across 14 countries with standardized certification (European Heat Pump Association, 2024), as well as initiatives such as SKILLSAFE-EU, the Domestic Heat Pump Installation Scheme, the European Solar Academy, and Energy Cities Network, are all working to bridge the skills gap and increase the attractiveness of green jobs. These efforts are part of a broader effort to equip the workforce for the clean energy transition. In this context, cities play a central role by facilitating local training programs, supporting the scaling of green job initiatives, and fostering partnerships with industry stakeholders.

4.4. Innovative Financing Mechanisms - Addressing the Funding Gap

Addressing the €180 billion funding gap for electrification and energy retrofits is a critical challenge for cities, especially as the EU Recovery and Resilience Facility (RRF) ends in 2026 with significant funds still to be disbursed (Socialists and Democrats, 2024). Innovative financing models are key to overcoming this gap. Amsterdam's revolving fund model, which combines the Amsterdam Climate & Energy Fund (€45 million for commercial projects) and the Sustainability Fund (€40 million for smaller projects), demonstrates a successful strategy for scaling clean energy projects while ensuring financial returns for reinvestment (C40 Cities, 2024).

Additionally, citizen investment models, such as Local Climate Bonds, are enabling municipalities to engage the public in funding efforts, as seen in Camden and Islington, where low-cost borrowing options are being made available to communities (Green Finance Institute, 2024). The Climate City Capital Hub, launched in 2024, is further expanding financing opportunities by coordinating €2 billion in investments from the European Investment Bank (EIB) for consortium cities (NetZeroCities, 2024). These models show how blending public and private capital, alongside community engagement, is key to scaling the electrification efforts required for the energy transition.

4.5. Regional cooperation reducing supply chain vulnerabilities

Cities are coordinating regional approaches. Some of the strong incentives to do so, especially in current times of increasing geopolitical vulnerability in Europe, is to reduce dependence on foreign exporters control (e.g. China) over rare earth refining and long mining timelines. The NetZeroCities Twinning Learning Programme pairs 184 cities across 14 countries for 17-20 month exchanges, fostering collaborative resilience (NetZeroCities, 2025). Belfast and Galway focus on retrofits, while Soria, Cologne, and Vitoria-Gasteiz work on urban regeneration, sharing risk strategies among the partners.

Further examples include shared procurement through the CircularPSP Initiative (European Commission, 2024), demand management strategies such as the Amsterdam's Flexpower with its smart charging networks or Malmö's resource hub, optimizing renewable energy use and promoting material efficiency (NetZeroCities, 2025).

Further regional initiatives like the European Battery Alliance, aiming for €250 billion in annual domestic battery value (EBA250, 2024), and Solar Industry Regions Europe, building solar manufacturing clusters, drive energy sovereignty and supply chain diversification.

4.6. Systemic Implementation Pathways

Impacts of technologies, resource sourcing, and energy demand are deeply entangled across sectors and geographies. Isolated interventions risk greenwashing and ineffective outcomes. Cities need to select and implement solutions based on comprehensive, science-based evaluations of their systemic impacts—climate, social equity, environmental, and economic.

This section aimed at identifying clear replication pathways for consortium cities to address electrification risks **systematically (and systemically) rather than reactively.**

- Immediate implementation opportunities include adopting Amsterdam's €85 million revolving fund model with proven ROI metrics, expanding citizen investment platforms, and implementing EUCERT-style standardized training across all green technology sectors.

- Medium-term coordination strategies involve strengthening regional procurement cooperation following the CircularPSP model, scaling urban mining initiatives through shared material databases, and developing post-2026 financing strategies as traditional EU funding transitions.
- Long-term resilience building requires institutionalizing city climate funds following proven Bristol/Amsterdam models, formalizing multi-city cooperation for supply chain diversification, and embedding circular economy principles in all electrification planning to fundamentally reduce critical mineral dependencies.

These approaches provide practical alternatives to the potentially extractive model of electrification, showing how cities can achieve climate neutrality while building resilient communities and circular economies. Successful electrification risks mitigation requires integrated approaches combining demand reduction, social equity, innovative financing, and regional cooperation rather than addressing individual risks in isolation.

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Annex 4 – Reducing Resource Demand in Climate-Neutral and Just European Cities: Sufficiency as a Policy Tool for Fair and Sustainable Urban Transitions (Demos Helsinki)

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Summary

This NetZeroCities deep-dive report explores how sufficiency can serve as a tool for fair and sustainable transitions in European cities working toward climate neutrality. As research increasingly shows that efficiency and technological innovations alone are insufficient to meet climate neutrality targets, sufficiency complements the strategies by addressing the scale and fair distribution of resource demand and consumption. Sufficiency is understood as meeting people's needs while staying within planetary boundaries. For cities, it can mean finding ways to reduce demand for energy, materials, land and water while ensuring a good life for all.

Based on a literature review and a synthesis of research and city practices, the report examines how sufficiency principles can be applied in local policymaking. It identifies housing, mobility and food as key sectors for demand reduction and presents examples of practical measures such as promoting smaller and shared living spaces, shifting road space from cars to pedestrians and cyclists, and introducing more plant-based meals in schools. Cross-cutting approaches, such as integrating sufficiency into municipal strategies, supporting citizen-led initiatives, and adopting frameworks like the doughnut economics model, are also effective ways to embed sufficiency in local governance.

Sufficiency is particularly timely for the EU Cities Mission and Mission Cities could look into sufficiency-oriented approaches in order to better tackle consumption-based emissions, strengthen social justice, and close the gap between current trajectories and climate goals. Embedding sufficiency as a guiding principle enables cities to connect climate action, wellbeing, and equity, which positions them at the forefront of Europe's just transition.

The findings of this report emphasise that while many municipalities already implement measures aligned with sufficiency, few have yet developed comprehensive strategies guided by sufficiency principles. Moving from isolated actions to integrated policy mixes is a central challenge. Successful implementation requires coordination across departments, alignment between policies, and a combination of both "pull" measures that enable sustainable practices and "push" measures that limit unsustainable ones. Experimentation, evaluation and adaptation to local conditions are crucial to understanding what works. Cities can also build knowledge by piloting and sharing results through networks such as the EU Cities Mission.

Citizen participation and cooperation with stakeholders are identified as essential elements of sufficiency-oriented policies. Because sufficiency measures often touch on areas seen as part of private life, broad public dialogue is needed to build legitimacy and acceptance. Deliberative citizen panels are highlighted in research as particularly suitable tools. The report also highlights the importance of ensuring that costs and benefits are distributed in a just manner, and that local governments need to

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collaborate with civil society, companies and social movements, and support bottom-up initiatives aligned with sufficiency. Communicating co-benefits (e.g., better health, lower living costs and improved quality of life) is another key factor in increasing political and public support.

A key takeaway of the report is that sufficiency offers cities a complement to efficiency and technological innovation. Adopting sufficiency principles can guide cities to design fair and effective policies that reduce emissions while improving social equity. The report recommends that municipalities begin by embedding sufficiency thinking into their governance and asking new questions about necessity, need satisfaction, and equitable resource use.

Keywords

Climate neutrality, sufficiency policy, consumption-based emissions, cities

1 Introduction

The concept of sufficiency has gained increasing attention in recent years as a way of decreasing emissions and environmental footprints while securing sustainable wellbeing for all within planetary boundaries. An increasing interest in reducing resource demand stems from a situation where research shows that technological changes and efficiency improvements alone are too slow to reach the Paris Agreement objectives (Vogel & Hickel, 2023).

Efficiency measures are insufficient in addressing the overall resource use and reducing emissions and environmental footprints on a global scale (Linnanen et al., 2020), and demand-reduction strategies, such as sufficiency, are therefore seen as necessary to reach sustainable and equitable societies within planetary boundaries (Vogel & Hickel, 2023).

In 2023, the Intergovernmental Panel on Climate Change (IPCC) identified sufficiency as one of the key strategies for adaptation and mitigation in cities (IPCC, 2023). The IPCC defines sufficiency as "**a set of measures and daily practices that avoid demand for energy, materials, land, and water while delivering human well-being for all within planetary boundaries**" (ibid, p. 29). In other words, sufficiency focuses on meeting people's needs while staying within ecological limits.

Local governments have particular potential and a key role in designing and implementing sufficiency policies, as they are the closest administrative level to citizens and in most cases responsible for important public services and infrastructure at local level in areas where sufficiency policies can be implemented (Iten, Seidl & Pütz, 2024), such as mobility, urban planning and housing. In the future, sufficiency-oriented policies may become one of the tools for EU Mission Cities to complement their current decarbonisation strategies in order to reach their climate neutrality goals in a just and equitable manner.

This report provides an overview on how sufficiency principles can be applied in policy-making and what kind of opportunities and challenges are identified in applying them. This report focuses on reviewing existing research on sufficiency policy.

It provides a literature review and reflections on what the review results imply for municipalities who wish to apply sufficiency principles in local policy. It hopes to function as a first step towards broader consideration on whether sufficiency could be a useful lens to include in the EU Mission on Climate Neutral and Smart Cities, and the NetZeroCities platform.

The report starts with identifying key sectors where demand-reduction strategies and policies are needed. It then looks at definitions of sufficiency and how sufficiency policy instruments can be used to address challenges identified in the key sectors. The fifth chapter explores challenges and opportunities in the design and implementation of sufficiency policies, and the concluding chapter reflects on next steps for cities interested in applying sufficiency principles in local policy.

2 Why are sufficiency strategies needed and which sectors are prioritised?

Usually, local climate targets include the territorial emissions from the geographical territory of the municipality, but these climate neutrality goals (and the related calculation methods) exclude a large share of emissions caused by consumption, for instance by the building sector.[1] A study involving C40 cities shows that 85% of the consumption-based greenhouse gas emissions associated with goods and services consumed in cities are generated outside the city, and often not included in cities' climate neutrality targets and emission reduction calculations (C40 Cities, Arup, & University of Leeds, 2019.)

These estimations show that in order to really reduce their emissions, cities need to not only address their territorial emissions, but also consumption-based emissions. In order to do that, efficiency, but also demand reduction strategies are needed.

Indeed, the latest report on 1,5 degree lifestyles from the Hot or Cool Institute shows that to align with the 1,5 degree target by 2035, average lifestyle emissions need to be cut by 82% to 94% in high income countries, 64% to 81% in upper-middle income countries, and 29% to 67% in lower-middle income countries. The report highlights that without systemic changes, these levels of reductions from lifestyles will not be reached. (Hot or Cool Institute, 2025)

While national and local contexts largely influence which areas have the biggest emission reduction potential that could be reached by decreasing demand, modelling such as the one published by the Hot or Cool Institute can give some indications on areas where cities' efforts for demand reduction might be most useful.

According to the report, the biggest impact potential can be found in food and nutrition, transport and housing (Hot or Cool Institute, 2025). Also the UK Committee on Climate Change states that there is a clear case for demand-side policies as part of decarbonisation strategies, and they also highlight the fields of home energy use, shifting to healthier and more sustainable diets and reducing travel by air and car (Committee of Climate Change, 2023).

Based on above-mentioned calculations on the need for demand reduction strategies, and the areas where local governments often have mandate and power to act, **this report focuses on the sectors of housing, mobility and food**. Whereas other areas, such as consumption of goods, are also relevant for cities, and solutions such as promoting sharing of goods are important, they are outside the scope of this report. The section below looks into the current situation in those sectors and provides further information on why efficiency improvements in those sectors have not been sufficient to reach emission reduction targets.

In housing, the overall size of buildings and their technical equipment have been increasing over the last decades, while increased energy efficiency has not been sufficient to counteract the need for more energy for heating and cooling, ventilation and lighting caused by these developments. This means that energy efficiency measures have not led to a significant reduction of energy use in buildings. (Koch et al., 2024). Increasing housing sizes has also contributed to land-take and biodiversity loss caused by that, as well as to increased environmental footprints from construction materials (Lorek & Spangenberg, 2019)

At the same time, many European cities suffer from housing shortage and lack of affordable housing, while also struggling with reducing the environmental and climate impacts of new construction. For instance, a study in the UK showed that the UK's previous government's target to build 300 000 new apartments annually in England to meet the affordable housing crisis would consume the entire 1.5°C carbon budget by 2050 (zu Ermgassen et al., 2022).

In high-income nations, transport emissions are substantial, largely due to a reliance on fossil-fuel-based vehicles, with hybrid and electric cars forming a small proportion of the market. Air travel also

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significantly contributes to transport footprints, though its impact is less pronounced in countries with extensive rail networks. In upper-middle-income countries, cars are the primary mode of transport, followed by public transportation. Lower-middle-income countries show uneven demand, with private car use being lower than in other income groups. Motorcycles and buses constitute the largest share of transport, while walking and cycling also play a significant role in those countries. (Hot or Cool Institute, 2025)

In mobility, a sufficiency benchmark calculating a “sweet spot” or a consumption space that on one hand ensures wellbeing, but on the other hand avoids material excess states that for mobility, a sufficiency benchmark could be approximately 4 200 - 8 000 passenger kilometers per person per year, compared to the current 25 000 passenger kilometers per capita in car-dependent countries (Hot or Cool Institute, 2025).

Related to food and nutrition, food systems are the largest contributor to the transgressing of five planetary boundaries, and account for approximately 30% of global greenhouse gas emissions (Rockström et al., 2025).These emissions could be halved by transforming the food system. In line with sufficiency thinking, the latest EAT-Lancet report notes that less than 1% of the global population are in a situation where their basic needs are met, but within planetary boundaries. At the same time, more than 70% of the food-related environmental impacts are driven by the wealthiest 30% people, highlighting the need for food justice. (Rockström et al., 2025)

Hot or Cool Institute’s calculations show that dietary shifts adopting e.g., plant-based or vegetarian can cut emissions between 1000 and 2500 kg CO2 per capita, depending on the country. Countries with large current meat consumption (such as France) show the largest potential in reducing emissions by changing food consumption and production. (Hot or Cool Institute, 2025)

After looking at overall instruments for sufficiency policy, the following chapter will explore definitions of sufficiency and how sufficiency policy responds to the above outlined challenges.

3 Definitions and approaches to sufficiency

Sufficiency focuses on meeting people’s needs while staying within ecological limits. It is about changing direction and finding ways to satisfy needs within planetary boundaries, focusing on wellbeing and preconditions for good life. For local communities, living well within the planetary boundaries can mean healthier diets, stronger communities and improved well-being (Hot or Cool Institute, 2025). Sufficiency strategies ask cities and citizens to reflect on questions such as:

- How much is enough? (Iten, Seidl, Putz, 2024, p. 1709)
- Which of our individual emissions are really needed, and which of them could be avoided?” (Linnanen et al., 2020, p. 23)

The UN Environment Programme (UNEP) connects sufficiency with the idea of a just transition. Rather than only focusing on technical measures, it emphasises the normative and transformative goals of sufficiency. UNEP states that “**sufficiency refers to the need to increase resource use in low-development contexts to enable dignified living, while reducing consumption levels in those parts of the population who live well above the capacity of the planet**” (UNEP, 2024, p. vii). Since planetary boundaries cannot be exceeded, sufficiency underscores the need for fair distribution of resources to ensure everyone’s basic needs are met (Xue & Eräranta, 2025).[2]

As cities often carry responsibilities for both the environment and social welfare, the concept of sufficiency could be a way of integrating local economic, environmental equality efforts, and finding co-benefits and synergies between them. While the concept brings together these different fields, re-focusing on sufficiency also has the potential to unite sectors and bring more municipal departments but also new stakeholders to create visions and measures for a future where wellbeing is secured within planetary boundaries.

It is relevant for local governments to note that sufficiency approaches have also started to emerge at the EU and national level. Applying the IPCC definition of sufficiency, the European Commission has begun to integrate sufficiency into its policy agenda as a response to the ongoing polycrisis. Through its Horizon Europe programme, it supports research and innovation projects on sufficiency-related solutions (see e.g., FULFILL) and has recently launched a call for projects focusing on sufficiency measures in the built environment. (EC, 2025).

In France, *"la sobriété énergétique"* (energy sufficiency) has already become a core pillar of national energy policy—alongside energy efficiency, nuclear power, and renewable energy (Bourliauget, 2025). Integrating sufficiency into urban strategies enables cities to balance climate goals with social equity and long-term resilience—making them leaders in Europe's transition to climate neutrality.

Sufficiency is further emerging in the agenda of EU city networks. The Energy Cities network, which represents several hundred European member cities, calls sufficiency the 'missing pillar' of a resource-wise Europe. It frames sufficiency as a "**pragmatic response to the scarcity and poor distribution of resources that Europe is already facing and will have to confront even more in the coming years**" (Guyon, 2023, p.11). Ahead of the 2024 European Parliament elections, the network urged the next Parliament and Commission to embed sufficiency principles in policy to strengthen social justice, planetary responsibility and resilience (Guyon, 2023).

EU Mission Cities, it is timely to explore how sufficiency approaches can accelerate local climate neutrality goals while ensuring social inclusion and resource balance. Practical sufficiency policy instruments are explored in the next chapter.

4 Applying sufficiency principles in policy

This chapter starts with an overview on types of sufficiency policies and instruments identified in research. It will then explore policies suggested and implemented in housing, mobility and food, as well as how cities address sufficiency at a cross-cutting strategy level. This chapter focuses on reviewing suggested and implemented policies, whereas chapter five will look at the challenges, opportunities and enabling conditions for their local implementation.

4.1 Overview of sufficiency policy instruments

Sufficiency policies can be defined as **individual or sets of policies that create conditions for sufficiency in consumption and/or production** (Iten, Seidl & Pütz, 2024). They are policies for "less, lighter, slower, closer, and more personal modes of consumption and production to comply with planetary boundaries while satisfying fundamental human needs" (Iten, Seidl & Pütz, 2024).

The Hot or Cool institute's latest report on 1.5 degrees lifestyles follows the Avoid-Shift-Improve framework used by the IPCC, and states that sufficiency approaches focus on the "avoid" and "shift" **strategies that go beyond improving technologies and try to redefine and question what is necessary and desirable, while recognising that many human needs can be met in different ways, and that social expectations and norms of desirable lifestyles can change**. (Hot or Cool Institute, 2025).

In Hot or Cool Institute's model, sufficiency strategies need to:

- Redefine aspirations and build collective new visions (e.g., in citizen assemblies, or by contributing to reaching social tipping points through regulation of advertising and marketing)
- Edit in alternative and more sustainable ways to satisfy needs (e.g., low carbon and nature positive options)
- Edit out harmful and carbon intensive options (e.g., phasing out incentives for extensive consumerism such as frequent flyer rewards)

- Focus on equitable access, fair distribution and needs-based prioritisation (e.g., wealth caps or progressive taxes) (Hot or Cool Institute, 2025).
- Sufficiency policies have also been categorised into pull and push measures. Pull measures promote sufficiency (for instance by providing subsidies for public transportation), whereas push measures phase out unsustainable consumption or production (for instance restricting or making private car use less attractive) (Iten, Seidl & Pütz, 2024).
- Sufficiency policies apply various policy instruments, such as:
- Regulatory instruments (e.g., reducing the amount of parking spaces, banning private cars on certain days, restricting the establishment of new shopping malls, or limiting advertising of certain goods or in public spaces),
- Economic instruments (e.g., introducing flight taxes, road tolls and congestion charges, or removing VAT from second hand products),
- Nudging (e.g., making low carbon choices more accessible or providing individualised sufficiency advice),
- Cooperation (e.g., community-based wind power initiatives, increasing the shared use of living space through regulation, or supporting existing and establishing new public institutions that promote practices of sharing, renting, reusing and social innovations), and
- Information (e.g., communication to specific target groups, marking high-carbon products similar to current cigarette packages, or better integration of climate into official dietary recommendations) (Linnanen et al., 2020).

However, reviewed sufficiency policy research generally considers the regulatory and economic instruments to be more effective than nudging and information that can function as supportive tools (Linnanen et al., 2020). However, the cases reviewed by Iten, Seidl & Pütz (2024) show that regulatory policies towards sufficiency are still rare, and softer measures such as information campaigns are still more common. Some of the research reviewed by Iten, Seidl & Pütz (2024) also points to the challenge where many measures are additive and end up diversifying consumption options instead of reducing overall consumption.

4.2 Housing

To respond to the dual crisis of environmental degradation and housing crisis, sufficiency measures are seen as a way to contribute to affordable housing for all within planetary boundaries. For instance, they can address the situation in many cities where space is being allocated to investment apartments and second homes that remain unused or underused, while the same cities often struggle with lack of affordable housing (Koch et al., 2024).

The current unequal distribution of living space indeed means that 17% of the people in the European Union live in overcrowded housing despite the fact that the living space in capita overall is increasing (Lage, 2025). In comparison to traditional housing policy, adapting a sufficiency framework to housing means not only agreeing on what should be the lowest acceptable housing standard, but also agreeing on an upper limit for excess housing (Gough et al., 2023). This means aiming for more effective and fair use of the existing housing and building stock, while reducing the need for new construction (and thereby reducing the material footprint of housing).

4.2.1 Approaches to housing sufficiency

Hot or Cool Institute's (2025) modelling points at the highest impact potential in the housing sector coming from smaller living spaces, renewable-based heating and cooling, and stronger energy efficiency measures (retrofitting). In comparison, sufficiency measures on lower temperatures in homes and measures to increase the use of recycled and low-carbon building materials are estimated to have considerably lower impacts (e.g., in Finland, lower indoor temperatures are calculated to have potential to save 20 kg CO2e/capita/year and use of recycled and low-carbon building materials 50 kg/CO2/capita/year - compared to 310 kg CO2e/capita/year from smaller living spaces and 440 kgCO2e/capita/year from retrofitting). (Hot or Cool Institute, 2025)

Sufficiency policies in housing primarily refer to limiting the demand for square meters used for housing and aiming at more equal distribution of housing space in order to be able to stay within the planetary boundaries, while ensuring sufficient housing for all. While sufficiency measures often target the demand for space, they are often combined with efficiency measures such as energy retrofits and renewable-based heating.

4.2.2 Examples of sufficiency policy measures in housing

Various concrete housing sufficiency measures have been identified in literature. The table below is a non-comprehensive categorisation of measures identified in the reviewed research literature and roughly estimates which measures could be more relevant to local level and which measures might often require national level intervention. It should be noted that the division of power between local, regional and national level varies between countries and there is a large variation on housing and planning systems within Europe. After the table, a couple of non-EU case examples are provided for inspiration.

Objective	Examples of suggested local measures	Examples of suggested national measures
Enabling and promoting shared space and co-housing solutions	Municipal advisory to citizens interested in co-housing and bringing together interested citizens Land lease regulations favouring or architecture competition requiring sufficiency solutions Enable use of suitable municipally owned spaces for resident groups	National planning regulations enabling flexible solutions
Enabling and promoting housing mobility and downsizing based on (changing) needs	Practical and financial support to (elderly) people looking to downsize within their local community (e.g., OptiWohn project in Germany) Investing in social housing and alternative housing forms that enable more flexibility and easier re-allocation when needs	Removal of real estate transfer tax when moving to smaller apartment

	change	
Promotion of conversion of existing building stock to housing	Provide municipal advisory specifically on converting buildings and the related regulations and support opportunities Monitor vacancies in the building stock to identify buildings that could be converted to housing and set requirements for building owners to report vacancies	Include demolition permits in planning regulation in addition to building permits to decreased un-necessary demolition of existing buildings
Decreasing the per capita housing consumption	Council tax surcharge on long-term empty and vacant homes (e.g. Wales) Planning or lease conditions only allowing certain uses (e.g. new builds only for owner-occupiers in Amsterdam) License-requirement on second homes or holiday rental (e.g., Barcelona)	Progressive property taxes based on per-capita floor area Regulating maximum per capita housing consumption Regulating minimum occupancy rate or maximum un-occupancy duration Second home tax Funding tools for converting bigger residences into smaller ones

Table 1: Examples of suggested sufficiency policies in housing (Source: Iden, Seidl & Pütz, 2024; Breucker and Defard, 2023; Xue & Eräranta, 2025; Gough et al., 202; Lorek & Spangenberg, 2019)

4.2.3 Local case example

Housing Solutions for Sufficiency: How two U.S. cities are promoting conversion of existing buildings into housing
Citywide Adaptive Reuse Ordinance in Los Angeles Approved in December 2024, the current Citywide Adaptive Reuse Ordinance in Los Angeles, US, builds upon the original 1999 ordinance, which aimed to revitalise the city's downtown by converting commercial buildings into residential units. The updated initiative seeks to address the city's affordable housing crisis and facilitate the conversion of vacant office buildings into housing. Previously, only buildings located in the Downtown L.A. area and constructed before 1974 would be eligible for conversion, but the new law broadens eligibility for buildings and structures at least 15 years old (the eligibility is not tied to a specific year anymore) or buildings 5 to 15 years old that receive the approval from specific Zoning Administrators through a Conditional Use Permit. This permit instrument allows for conversion of buildings to uses that contrast with the ones from the zoning they are inserted - i.e. from commercial/parking to residential. It also implies flexibilization of construction requirements for residential units such as minimum size or parking requirements per unit. Additionally, the initiative's reach now extends across the entire city. (Los Angeles Conservancy, n.d.)

The main benefits of the ordinance from a sufficiency perspective include the potential for converting buildings outside the city center and removing minimum unit size requirements offering greater flexibility and a wider variety of housing options. Additionally, carbon emissions are minimized through the reuse of existing structures. (Los Angeles City Planning, 2024)

Legislation for construction and conversion of existing buildings into co-living units in Seattle

In 2024, Seattle approved a new legislation permitting the construction and conversion of existing buildings into co-living units. The removal of some design standards for common areas and parking units (in buildings located at a certain distance from metros) were also included to provide more flexibility.

Incorporation of shared spaces in co-living arrangements, combined with the elimination of car parking, helps reduce the 'per-capita footprint' of the living space, while the more flexible design regulations facilitate more adaptable floorplans to meet diverse requirements. The legislation was created to address the city's housing shortage by offering alternative and affordable living options in all areas where zoning regulations allow for multifamily housing. (Office of the Mayor, City of Seattle, 2024; Seattle City Council, 2024)

4.3 Mobility

In comparison to the housing sufficiency measures presented, the mobility sufficiency measures identified in research might seem more familiar to many cities.

The benefit of adapting the sufficiency lens in local mobility planning could be that it so clearly puts re-distribution of mobility resources in the centre, which often implies shifting from prioritising private car owners to balancing their needs with needs of other groups. In many cities, this means reducing and limiting private car use and decreasing the space reserved for private vehicles, and investing in shared mobility and non-motorised modes of transportation. Looking at mobility policy through the sufficiency lens also leads to highlighting co-benefits of measures, for instance how green spaces can be preserved if less new land is needed for road infrastructure.

4.3.1 Approaches to mobility sufficiency

Based on quantifications of the most impactful measures to reach the goal, the Hot or Cool Institutes report emphasises the following as high impact measures: switching to public or active commuting, reshaping urban planning to enable living closer to work and study, and switching to alternative fuels - all with support from policies and infrastructures. (Hot or Cool Institute, 2025)

Taking a re-distributive lens to transport planning would emphasise reallocating road space that is currently used by private cars to buses, pedestrians and cyclists, or setting up goals for longest distances to public transport to satisfy mobility needs (Xue & Eräranta, 2025). A sufficiency lens would further imply an overall approach of rethinking how basic mobility needs can be met with fewer resources, for instance by replacing private cars with shared mobility and public transport (Xue & Eräranta, 2025).

4.3.2 Examples of sufficiency policy measures in mobility

A comprehensive mapping of sufficiency policies by Iten, Seidl & Pütz (2024) notes that currently, most existing local policies that are aligned with sufficiency principles are found in the mobility sector. As noted in previous chapters, municipal level mandates vary between countries, but the table below can provide some examples of policy measures for different levels. After the examples, a case example from

the City of Ghent is presented.

Objective	Examples of suggested local measures	Examples of suggested national measures
Limiting urban space reserved for cars and re-allocating space to pedestrians and cyclist and other uses	Reducing parking spots Decreasing the number of new parking spots required per new apartments in new developments Creating car-free areas and low emission zone Congestion charges or road tolls Lowering speed limits Zero land-take goal for roads Communication of co-benefits of limited private car use and increased active mobility	Revising legislation, for instance to ensure that spatial planning regulation enables establishment of low emission zones and congestion charges
Improved access to public transport	Investment in public transport Setting up goals for longest acceptable distances to public transport Free of charge public transport (to all or to certain groups in need) or free school transport	National level investments Supporting regulatory frameworks
Support to active walking and cycling	Prioritise walking and biking in infrastructure and urban planning, and improve public space for walking and cycling Good winter-maintenance to enable walking and cycling (prioritising walking and cycling in snow removal) Campaigns to promote bicycle commuting Ensuring safe and secure bicycle storages, for instance in connection to mobility hubs Enable and promote environmentally-friendly local cycling tourism Setting up requirements for good bicycle storage and/or provision of mobility services in new developments	Subsidies to individuals for electric bicycles Tax allowances that support bike commute National subsidies to municipalities investing in bicycle infrastructure

Increased shared mobility	Promoting car sharing (e.g., by providing municipal car fleet to be shared by citizens when not in use) Provide platform for private car-sharing City-wide bike sharing schemes, including cargo bikes	
Urban planning that decreases individual everyday transport needs	Adapting 15-minutes city principles in urban planning Support local and decentralised services	Setting national goals for accessibility of e.g., services and green spaces

Table 2: Examples of suggested sufficiency policies in mobility (Source: Iden, Seidl & Pütz, 2024; Breucker and Defard, 2023; Xue & Eräranta, 2025)

4.3.3 Local case example

Ghent Circulation Plan as mobility solution for sufficiency
In 2017 the city of Ghent implemented an ambitious plan in the city center: an existing area with restricted traffic was expanded by 128%, substantially reducing the space reserved for private car traffic and freeing up space for other uses. This initiative stemmed from a city administration assessment revealing that approximately 40% of vehicles crossing the city center were merely passing through, not destined for any location within it. (Chartered Institution of Highways & Transportation, 2018) To tackle this issue, the city was divided in six sections surrounding the restricted traffic area. These sections are connected through a ring road allowing the distribution of traffic in the outer part of the city. The strategy prioritizes space for pedestrians, cyclists and frees up space for traffic that really needs to pass through the city: buses, trams, emergency services, waste collection services, taxis and healthcare providers with permits. Additionally, five important commercial streets were converted to strictly pedestrian use from 11am to 6pm. (City of Ghent, 2017)

4.4 Food

Research by Breucker and Defard (2023) on Germany and Danmark shows that national solutions for more plant-based diets can be more difficult to implement compared to local initiatives, which emphasises the central role that local governments can play in promoting more healthy and sustainable diets.

4.4.1 Approaches to food sufficiency

Sufficiency policy suggestions in research focus on reducing food-waste and on shifting diets towards more regional, seasonal, plant-based and organic food (see Iten, Seidl & Pütz (2024). At local level, this in practice often means introducing principles and implementing a shift to more vegetarian and climate-friendly meals in municipal institutions, such as public canteens and schools. A research overview by

Merk et al. (2024) shows that the calculated GHG emission reductions from meat-free days in schools range from 31% to 74%.

At the national level, there are examples such as abolishing VAT on healthy and climate-friendly foods. VAT reduction can also make healthy and environmentally friendly food available for all groups. (Breucker & Defard, 2023). Information campaigns are also a common measure. Examples include, for instance information campaigns on food waste reduction or on the value and availability of locally produced food. (Iten, Seidl & Pütz, 2024).

Breucker & Defard (2023) show that education and communication of science based on independent expertise has been identified as a key driver for local sufficiency policies related to food, as authorities are afraid of introducing food options that lack essential vitamins, fats or proteins.

Local governments can also promote local food production, for instance by supporting community agriculture and by ensuring availability of land for food production. Urban food production can be supported in various ways, e.g., by preserving and allocating suitable areas for urban gardening within the urban structure.

4.4.2 Examples of sufficiency policies in food

Objective	Examples of suggested local measures	Examples of suggested national measures
Increased consumption of climate-friendly food	Only providing vegetarian lunches to children in day-care and primary schools Including environmental considerations of school meals in city monitoring reports Dietary guidelines for public canteens based on independent expertise	Abolished or reduced VAT on healthy and climate-friendly food
Increased local food production	Local strategies for edible plants in public municipal green spaces Supporting local urban farming (for example providing soil for growing vegetables to interested citizens) and include local urban farming in local spatial plans Preserving and strengthening the role of urban allotment gardens for local food production Local regulations on shares of private gardens to be used for food production	Ensuring that national planning regulations allow for local planning solutions in favour of urban farming

Increased knowledge on benefits of climate-friendly nutrition and sustainable and/or local food production	School-based teaching garden to teach students about food production Local independent consulting boards for nutrition recommendations Provide information on local food production and processing to increase the interest in and consumption of regional products, e.g. with a 'From the region for the region' campaign Information campaigns for food waste reduction	Climate impacts included in science-based national dietary recommendations

Table 3: Examples of suggested sufficiency policies in nutrition (Source: Iden, Seidl & Pütz, 2024; Breucker and Defard, 2023)

4.6.1. 4.4.3 Local case example

The City of Almere's regulations on food production in Oosterwold
The City of Almere has established an independent governance scheme for its Oosterwold district, promoting self-governance, but setting requirements on food production. In the district, each housing plot must have a dedicated area to food production. (Docter-Loeb, 2024) In practice, the food production requirements differ based on four categories of plots. Owners of plots assigned as "agricultural plots" need to dedicate up to 88% of the land area to agriculture when the plot is bought (reduced to 80% later). Owners of "business plots" and "standard" plots are expected to dedicate 50% to farming, whereas for "landscape plots", no agricultural use is required. Development control of the land is conducted by a system of 'parcel passports' that is a type of contract which states the rules of the specific plot bought (Münderlein & Jansma, 2025). The city of Almere has become a role model in the Netherlands and worldwide for its approach to food production. In addition to the planning regulations, the city has been focusing on improving urban agriculture skills in the population and promoting food related businesses in the city. In 2017, a knowledge institute focused on food-related challenges was also established in Almere. van Houten, van Engelshoven and van Ark (2023) note that these types of "agro-cities" offer a model for mitigating food-chain emissions associated with transportation. Additionally, food waste within these systems can be extensively repurposed for agricultural applications.

4.5 Cross-cutting local strategies

An overview of existing research shows that few cities have yet adapted consistent and overall sufficiency frameworks at strategic levels. Local approaches currently focus on individual policies instead of strategic pathways towards societal transformations, but the mapping by Iten, Seidl & Pütz (2024) provide some examples of cross-cutting strategies, such as:

- Include sufficiency goals in local sustainability strategies, e.g., by adding goals on reducing consumption volumes and goals for reducing consumption-based emissions

- Including sufficiency as a guiding principle in local energy strategy
- Establishing new welfare indicators to monitor local developments
- Supporting local sufficiency-oriented initiatives by providing advisory and e.g., communications support
- Establishing pilot projects on voluntary personal carbon budgets
- Integrating sufficiency in public procurement, e.g., by setting requirements for repairability and durability, by prioritising co-operatives, and only procuring when it is really necessary and something needs to be replaced

It is important to note, that many cities might be working along the principles of sufficiency and promoting reduced resource demand while promoting wellbeing for all, even if the concept of sufficiency is not used. One example of an overarching approach where the principles may align with the sufficiency principles is the doughnut economic model developed by Kate Raworth that focuses on how to ensure that basic human needs for all are met within planetary boundaries. City examples and practical tools for operationalising the doughnut economics model are shared online and implementation support to cities is provided by the non-profit organisation Doughnut Economics Action Lab.

4.5.1 Cross-cutting strategy examples

Below, we will shortly describe the information available on two European cities (Zürich and Grenoble) that explicitly state that they have adapted the concept of sufficiency as a guiding strategic principle.

The City of Zürich net zero strategy explicitly integrates energy efficiency with sufficiency, and concrete sufficiency measures are designed in regular stakeholder workshops as well as in inter-departmental cooperation (Guyon, 2023). The city renewed its municipal energy policy in 2016 to include the priorities of sufficiency (reducing the demand for energy-relevant goods and services), efficiency (in buildings, processes and devices, and related to mobility), and energy sources (Rovira & Borsi, 2022). The priorities were selected to support the sufficiency-aligned goal of becoming a “2000-Watt Society” which referred to each resident having two kilowatt hours (kWh) per hour at their disposal for all their energy requirements (including e.g., housing, mobility and food). (Rovira & Borsi, 2022)

An Energy Master Plan was developed in order to quantify the objectives of the 2000-Watt Society goal, and to design concrete measures for its implementation. The Energy Master plan includes targets and implementation measures in settlement development, energy supply, buildings, mobility and consumption. Example goals include work-related travels following the principles of sufficiency, efficiency and consistency, and conducting work-related travel by public transport, bicycle on foot. When air travel is unavoidable, the CO2 emissions are offset and all airline travel needs to be reported.

It has been key to the Master Plan implementation, and the inclusion of sufficiency approaches to the city’s overall work, that the plan is annually harmonised with the different municipal departments’ other strategies and objectives, and adjustments and corrections are made to align plans. (Rovira & Borsi, 2022).

In Grenoble, the concept of sufficiency was first introduced in local energy policy in 2015. Sufficiency then entered into its overall vision in a process for “Grenoble 2040” that started in 2021 and mapped a vision for a desirable and sufficient city. The process applied the Doughnut economics model. (EU Covenant of Mayors, 2024; City of Grenoble, 2024).

The design and implementation process of the doughnut economics model to integrate sufficiency and the doughnut economy principles in local policy and governance included:

- Developing a comprehensive model for a holistic approach to environmental and social responsibility,

- Integrating the doughnut model as an analysis framework into local decision making and prioritisation processes,
- Developing a method for rating suggested projects based on the model (City of Grenoble, 2024)

Cooperation with stakeholders was at the core of the process. For instance, a randomly selected group of citizens was invited to "ecological re-direction workshops" that resulted in a roadmap on what to "abandon, retain and modify" in the fields of transportation, green spaces and consumption. (EU Covenant of Mayors, 2024)

In Grenoble, the doughnut model has become a shared and cross-cutting framework for linking social and environmental topics and is continuously used to pre-evaluate projects and inform decision-making. (EU Covenant of Mayors, 2024; City of Grenoble, 2024). Practical measures implemented as a result include, for instance, better utilisation of school spaces for community activities, applying sufficiency in the local land use strategy, and appointing two municipal staff members dedicated to saving energy and raising awareness among municipal building users. (EU Covenant of Mayors, 2024)

Well-aligned with the principles of sufficiency, the Mayor of the City of Grenoble Éric Piolle sees the doughnut model as an approach to "questioning our lifestyles and strengthening existing policies" while bringing all stakeholders together to build a future together (City of Grenoble, 2024, p. 2). In late 2024, the city published a report in English aiming at providing inspiration and learning to other cities.

This chapter has outlined sufficiency-oriented policy options in the main urban sectors and through cross-cutting measures. These examples illustrate the range of approaches available to municipalities, while their effectiveness depends on various factors such as local contexts, governance capacities, political will and societal acceptance. The following chapter will explore various local and national enabling conditions and challenges in sufficiency policy design and implementation.

5 Challenges, opportunities and enabling conditions for local sufficiency policy

The chapter consists of two main parts. The first part discusses overall challenges and drivers in policy and strategy, while the second focuses on citizen engagement, stakeholder cooperation and communication of co-benefits as key drivers and enablers behind developing and implementing policies with high acceptability.

5.1 Moving from individual policies to strategic and holistic policy mixes

Strategy, or lack of it, is a major enabling condition, or a barrier, to the possibility to promote norms, practices, infrastructures and regulations in line with the sufficiency principles.

As noted, few cities have yet to approach their local strategy with this lens, but some examples exist, as highlighted by the examples presented from Zürich and Grenoble. In particular, the doughnut economics model is applied as a strategy framework in a growing network of cities in Europe and beyond. As noted by Hot or Cool Institute (2025), high emission reduction impact strategies also address and question dominant norms on, for instance,meat-focused diets, private car use or oversized housing.

5.1.1 Integration of policy areas and building a coherent policy mix

In practice, implementing a holistic strategy approach requires integration of various policy areas. This could, for instance, mean integrating social policy into the technical considerations typical to introducing

low emission zones. It further means that policies need to take a holistic approach to the phenomena that is being addressed. For instance, when addressing sufficiency in housing, it is necessary to also consider the residents' mobility practices. As an example, increasing use of home offices leads to changes not only in resource use in homes, but also in transport patterns and the demand for near-by services (Lorek et al., 2019).

A holistic approach also means understanding that demand-reduction strategies cannot only address individual behaviours, but need to address things like social norms, understandings of what brings social status, and the infrastructures of everyday life.

A holistic policy approach would also imply not only adding new policies that diversify consumption options, but also revising hindering policies, combined with policies that phase-out high pollution and high material footprint options. An example from Danish cycling policies is the need to phase out tax incentives for cars and re-balancing investments from roads for cars to cycling infrastructure (Breucker & Defard, 2023). Also, both push and pull measures, or carrots and sticks, are needed to be included in an effective and complimentary policy mix.

5.1.2 Multi-level governance and local agency

Depending on the division of power between local and national governments, the political will of national governments can be an important enabler or a hindering factor for local sufficiency strategies, and it needs to be considered when building local sufficiency strategies.

For instance in Denmark, cities' investments in improving cycling infrastructure are limited by national rules and national budgetary decisions, despite the fact that the investments follow the directions set in national goals. (Breucker & Defard, 2023) National regulations can also influence how and where congestion charges can be introduced and for what the income can be used for (for instance, if the city can regulate that the income will be used to develop public transport).

In situations where cities' room for manoeuvre is limited, it is important that cities identify, on one hand, areas where they can take concrete local policy action, and on the other hand, areas where their strategy might be to advocate for national policy and regulatory change, and making sure that cities' voices and needs are heard at the national level.

5.1.3 Experiments and evaluations as key strategy elements

Many of the policy proposals in research still remain suggestions, and there is still limited evidence available on the conditions that support or hinder successful implementation. Systematic policy experimentation and pilots are needed, also as evidence shows that policy support often increases once a policy is in place (Breucker & Defard, 2023).

Cities need to evaluate policies and experiments on their social and environmental impacts, as well as the success factors and barriers in implementation (Breucker & Defard, 2023). Further, learnings from these evaluations need to be properly applied in revising and improving policies, but are also helpful if shared with other cities, for instance within the EU Mission Cities network.

5.1.4 Adapting to local conditions

It is important to note that the feasibility of the different policy approaches presented in Chapter four varies greatly between countries but also between cities. No overall recommendations can be given on which policy responses to prioritise, and the reviewed research does not include comprehensive analyses on the contextual needs for implementing different types of sufficiency policies.

Various local conditions such as infrastructure, social norms, demographic and socioeconomic structures, as well as policy and regulatory frameworks and path-dependencies need to be taken into consideration when designing policy mixes that are both effective and have high acceptability. As an

example of how existing infrastructure enables sufficiency policy implementations in contextual settings, the well-developed national railway infrastructure with high-speed trains has been a major enabler behind policies to reduce short-distance flights in France. Continued investment in railways is a major precondition for continued public support for the policy. (Breucker & Defard, 2023)

The need to meaningfully engage citizens and other local stakeholders in design and implementation of policies and strategies is important from a local democracy point of view, but also to ensure that all relevant knowledge on local conditions and needs are included. The next chapter will discuss the central role of cooperation between municipalities, citizens and other stakeholders in the context of sufficiency strategy and policy.

5.2 Cooperating meaningfully and ensuring influence from citizens and other stakeholders

Sufficiency measures in fields such as housing, mobility and food touch upon areas that are considered to belong to the private sphere and where acceptability of interventions may be limited. Even if it is clear that, for instance, the current allocation of land between private cars and cyclists and pedestrians is a result of politics and earlier policy choices, it is often considered political to suggest changes, while continuing with business-as-usual is more often seen as un-political and un-controversial.

Although what is seen as acceptable highly varies between contexts, cooperation with citizens and other stakeholders is highlighted in research as key to ensure acceptability and increase the public support of sufficiency policies (see e.g. Xue & Eräranta, 2025; Koch et al. 2024).

At the same time, cooperation and enabling of citizen influence is not to be done in order to increase acceptability of top-down decided policies. As sufficiency policy in essence aims at ensuring well-being for all, democratic approaches are at its core to ensure fair policies that contribute to a just distribution of the remaining carbon budgets in order to stay within the planetary boundaries (e.g. Breucker and Defard, 2023).

Instead of top-down approaches, local governments, planners and other officials can adopt transformative roles in helping other actors to “broaden their horizons” by proposing and informing, as well as by encouraging local debate and exploration of new norms for how to reach a high quality of life for all within planetary boundaries.(Xue & Eräranta, 2025)

This could mean, for instance, engaging citizens in discussing the relationship between well-being and private car use, or large individual homes, or about what constitutes a good everyday life, and in what different avenues could be built to reach it (Xue & Eräranta, 2025)

5.2.1 Deliberative citizen processes as a key method

Deliberative citizen processes are highlighted as a particularly important method in formulating and implementing sufficiency policy in the reviewed sufficiency policy research. In many countries, the panels have made decisions that are more aligned with sufficiency and more ambitious than their governments’ views (see e.g. Breucker & Defard, 2023; Lage et al. 2023). For instance in France, the deliberative forum Citizen Convention on Climate suggested and reached consensus on suggesting a ban for short-distance flights (Breuker & Defard, 2023).

Deliberative forums combine expert knowledge from researchers with the everyday practical knowledge of citizens and stakeholders to jointly define what a good life in their specific social and cultural contexts and environmental limits means, and what goods and services are needed for satisfying core needs (e.g., Koch et al. 2024)

Research evidence shows that deliberative citizen panels have helped to review policy goals, behaviours, needs satisfiers and infrastructures, and have contributed to transforming long-term policy in line with the sufficiency principles (Koch et al., 2024).

5.2.2 Ensuring just distribution of costs and benefits

The impacts of planned measures need to be considered and policies designed from the perspective of vulnerable groups in order to avoid causing, for instance, mobility poverty. Vulnerable groups need to be involved in policy design processes to make sure their knowledge and perspectives can influence outcomes.

A study by Guilbert (2024) shows that current sufficiency measures do not always show enough consideration to justice aspects or acknowledge vulnerabilities and different groups' different possibilities to act and make choices. The study highlights the need for inclusive democratic processes and giving power and visibility to vulnerable groups (Guilbert, 2024).

Exemplified with mobility policies, this means that cities need to take a granular approach in understanding mobility needs of different groups. As an example, cities need to ensure that measures limiting private car-use do not, for instance, burden socio-economically disadvantaged car-dependent groups outside city-centres with irregular working hours during which no public transport options are available (Hult et al., 2021). An example from the housing sector is the need to ensure that retrofits in the housing stock do not lead to increased rents and forced displacement of groups who are no longer able to live in their homes.

5.2.3 Cooperating with civil society and companies

In addition to ensuring the involvement of citizens, cities can also build coalitions with other actors from the civil society and the private sector.

Social demand from the civil society has been a driving force behind many sufficiency policies, with examples such as the Danish Cycling Federation that had a key role in ensuring an increased national budget for cycling infrastructure (Breucker & Defard, 2023). Another example here is the European citizen initiative House Europe! that is collecting one million signatures for their "right to re-use" initiative that calls for stopping demolition of buildings and establishing policy and regulatory tools such as VAT reductions for building renovations (House Europe!, 2025).

Cities can cooperate with citizen-led sufficiency initiatives, and examples exist of, for instance, cities working together with housing initiatives to address legal and regulatory issues. Cities can also have a key role in providing financial and other support to local sufficiency-aligned initiatives and social innovations.

Working together with local industries and labor organisations to jointly address risks of loss of jobs or economic activity is also central to just and acceptable transitions (Buschka et al., 2024). Companies, such as developers and architecture companies willing to experiment with new space-sharing solutions, can also be important co-operation partners to cities in various sufficiency-related initiatives.

5.2.4 Communicating co-benefits

Sufficiency policies by nature address both social and environmental factors, but also come with other co-benefits. Identifying, communicating and considering those is highlighted in research as a key lever for new regulations in favour of sufficiency (Breucker & Defard, 2023).

As housing sufficiency measures aim at decreasing the demand for floor space, and thereby the need for land used for housing, they enable co-benefits in, for instance, preserving green space. Green spaces provide several co-benefits for health and they are essential in a warming climate with increasing heat stress for city-dwellers, while preserving green space can also alleviate the biodiversity crisis

especially when areas of high biodiversity values are kept.

Stopping the increase in land used for transport infrastructure networks can also keep land available for greenery, while other mobility sufficiency co-benefits include health and lifestyle improvements by less time spent in traffic, less air and noise pollution and improved quality of urban spaces.

In relation to food, it has shown to be useful to rely on positive communication on non-environmental co-benefits (such as health), while local resilience and crisis preparedness are further arguments for supporting increased local food production.

6 Key takeaways for cities

Sufficiency is increasingly recognised as a vital complement to efficiency and technological innovation. While efficiency improves *how* we use resources, sufficiency helps cities define *how much is enough* - ensuring that local prosperity, climate goals and social wellbeing are achieved within planetary limits. Evidence has shown that efficiency measures on their own cannot deliver the deep reductions needed at city and national level to meet emission goals. For EU Mission Cities and others who are serious about climate neutrality, shifting focus from efficiency-only to also include sufficiency ensures a practical and fair approach to closing the gap between current trajectories and climate targets and reducing the demand for resources.

Sufficiency reframes climate action as an opportunity to enhance wellbeing. It highlights that living within planetary limits does not mean sacrifice but smarter, fairer and more meaningful use of resources, for example, affordable and accessible housing, healthy diets, and liveable, walkable cities. When designed carefully, sufficiency measures can simultaneously reduce emissions, lower the housing costs for households, and strengthen community resilience.

This report has shown that cities already have significant agency in advancing sustainability transitions towards just societies within planetary boundaries. Many are implementing sufficiency-aligned actions, for instance by promoting shared housing, improving cycling infrastructure, or supporting urban agriculture, usually without explicitly labelling them as such. Experience from cities like Zürich and Grenoble, demonstrate how sufficiency can be embedded across municipal strategies and broader city visions and planning processes, aligning environmental, social and economic objectives, and strengthening public support for net zero transformation.

As sufficiency brings different objectives together, it also necessitates and facilitates breaking intern-departmental silos and engaging new voices. Because sufficiency challenges existing norms of what a “good life” looks like, cities need to facilitate open conversations about wellbeing within planetary boundaries. Research consistently highlights deliberative citizen panels as an effective tool for such dialogue.

While cities can achieve the greatest long-term impact by redefining climate strategies to include planetary wellbeing for all, many are more likely to start with smaller, practical steps of testing and co-developing sufficiency approaches with citizens and local actors. Small, well-designed steps can serve as building blocks of deeper transformation.

Below are some suggestions of concrete actions:

- Bring sufficiency into discussions and decision-making within the municipal organisation: Encourage municipal teams to ask new questions on what is truly needed and how existing resources can be used better. Highlight co-benefits such as health, affordability, and quality of life, rather than focusing solely on emissions.
- Apply the sufficiency lens in governance processes: Consider how strategies, public procurement, or land-use policies might change if guided by sufficiency principles. How might, for instance, strategy framings change if a strategy revision process was complemented with

one workshop asking questions on what is enough, or how needs can be met in different ways?

- Engage residents through dialogue and co-operation: If launching a full deliberative forum is not feasible, organise smaller workshops, neighbourhood discussions, or participatory budgeting sessions to explore what a “good life within limits” could mean locally. One important step could be to add sufficiency-related topics to already planned other citizen dialogues, helping citizens to come up with new ideas by asking new types of questions.
- Support local initiatives: Cooperate and support citizen-led projects (such as shared housing or community gardens) and provide them with regulatory, advisory or financial support. Resources such as the open access book Social Innovation Projects for Climate Neutral Cities Making Municipalities Sustainable with People-Based Solutions (Bresciani, 2025) from the NetZeroCities project can provide useful guidance on how to promote citizen-led social innovations.
- Pilot, experiment and evaluate: Work together with citizens and other actors to identify and implement initiatives that could be tested in your city. Experiment and evaluate concrete and small scale measures first, such as temporary car-free zones. Be sure to evaluate both environmental and social impacts of the experiments. Continuously consider who benefits and who might be negatively affected, and ensure that the policies improve wellbeing especially for vulnerable groups.
- Reach out to the NetZeroCities consortium if you are an EU Mission City who wishes to start applying sufficiency principles and would like to receive expert support in doing that, or wishes to be connected to other cities for peer-learning and exchange.

Sufficiency helps cities connect two urgent policy agendas: achieving net-zero emissions and ensuring a good life for all. It offers a unifying framework for social justice, resilience, and climate ambition—empowering cities to lead Europe’s transition toward a sustainable and liveable future. Cities do not need to wait for national-level regulation to act. By testing new ideas, rethinking resource use, and embedding sufficiency as a guiding principle, local governments can accelerate their transition toward climate neutrality and greater collective wellbeing.

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Annex 5 – From Neighbours to Networks: How Communities Fund Their Own Future (Democratic Society)

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Democratic Society, October 2025

Summary

This deep dive examines how community-owned enterprises mobilise resources and design financing models to advance a just climate transition across housing, mobility, energy, and food systems. Through four European cases—Mietshäuser Syndikat (Germany), SomMobilitat (Spain), Energy Island Samsø (Denmark), and Community Grocery Shop (UK)—it identifies two dominant early-stage pathways: solidarity finance rooted in community contributions and government-backed support such as grants, subsidies, and feed-in tarifs. Political partnerships, locally anchored networks, and trusted intermediaries emerge as critical enablers, helping initiatives secure legitimacy, unlock bank finance, and scale without losing their community character.

The deep dive also surfaces structural risks that can stall or skew impact: uneven legal recognition of cooperative forms, exposure to grant volatility and shifting policy priorities, and competitive pressures from larger market actors once a niche proves viable. It highlights sector-specific designs—from Mietshäuser Syndikat's internal solidarity fund to Samsø's feed-in tariff—that broaden participation and share benefits over time. Finally, it underscores that broader social and environmental value is still undervalued in conventional assessments, suggesting cities should pair accessible finance with supportive regulation, public partnership, and better valuation of social outcomes to sustain resilient, equitable community finance.

Keywords

Community-owned enterprises; cooperative finance; just transition; social innovation; municipal governance; solidarity economy; community finance; local resilience; public-private partnerships; sustainability transitions; urban policy.

1. Introduction and Objectives

Community-owned enterprises (COEs) are increasingly recognized as critical actors in building fair, sustainable, and resilient local economies. They emerge in response to unmet needs—whether affordable housing, green mobility, renewable energy, or dignified food access—and pioneer financing strategies that combine solidarity, creativity, and public support. Yet, these models operate within broader political, economic, and legal systems that often privilege conventional market actors. By examining four diverse cases - housing projects within Mietshäuser Syndikat (Germany), SomMobilitat (Spain), Energy Island Samsø (Denmark), and Community Grocery Shop (UK) - this study explores how communities mobilize resources, secure legitimacy, and navigate risks. By explicitly identifying emerging trends, opportunities, and structural risks, the paper aims to provide foresight-oriented insights that can inform both policy and practice in shaping future community-led finance.

2. Context

Many discussions on sustainability transitions emphasize the critical role of economic organizations, which are often seen as more influential than governments and implicated in the declining legitimacy of democratic systems (Battilana et al. 2022; Cumbers 2020; Ferreras, Battilana, and Méda 2022). Current economic systems remain oriented toward continuous GDP growth, prioritizing expansion over sustainability and well-being (Kubiszewski et al., 2013). Scholars argue for a shift toward models that respect ecological limits and prioritize community well-being, supported by more inclusive and democratic governance structures to ensure fair distribution of economic benefits (Asara, Profumi, and Kallis 2013; Eckersley 2021). In this context, there has been a renewed interest in community-owned models, seen as vehicles for reimagining and reconfiguring the economy and introducing alternative forms of governance (Birchall, 2013; Cheney et al., 2014). Community-owned enterprises (COEs) embody these principles in practice: they redistribute power and resources, embed social and environmental objectives into governance and financing, and create locally rooted alternatives to extractive economic models. COEs are owned and run by those they directly benefit—the community—enhancing participation and empowerment in local planning and development. In doing so, they play a pivotal role in a just transition by linking economic activity with social equity and ecological sustainability. They take various forms, including cooperatives, credit unions, land trusts, and limited stock ownership enterprises (Participedia 2019).

Even with this potential, COEs face significant challenges within the current economic and financial system. Many struggle to move beyond the start-up phase toward maturity and financial stability. This deep dive therefore seeks to explore what lessons can be drawn from existing community-owned organizations that have successfully overcome initial financing hurdles in key sectors of a just climate transition, and how these insights can inform future systemic financing strategies for similar initiatives.

3. Methodology

The aim was to explore how community-led initiatives overcome early financing hurdles. This is an exploratory study aimed at generating insights, making a case study approach particularly suitable (Gerring 2017; Yin 2018). Our design follows a most-different, same outcome logic (Gerring 2017): selecting diverse cases that share the outcome of successfully mobilizing early-stage finance. In our study, a case is an enterprise that falls into the following definition:

> *A community-owned enterprise is a business or organization that is owned, controlled, and managed by the community it serves, with a primary purpose of generating benefits for that community rather than for private profit (Participedia 2019).*

In addition, we are looking at the ones that are considered financially sustainable, which we define as a COE that has achieved financial viability for at least three years. To capture variation, we chose four cases across different sectors (housing, mobility, energy, food systems) and ensured geographical

spread with a focus on European countries (Germany, Spain, Denmark, UK). All cases represent community-owned or community-driven models that achieved initial financial viability.

The primary data source was semi-structured interviews with individuals directly involved in the cases. Interviews were guided by a protocol structured around the PESTEL framework (Political, Economic, Social, Technological, Environmental, Legal).

We applied Framework Analysis (Spencer et al. 2003) using the PESTEL framework as our coding structure. A coding sheet was developed based on these themes. Each case was coded individually, then analysed collectively to identify similarities, differences, and systemic patterns.

4. Cases

4.1. Mietshäuser Syndikat (Germany)

Mietshäuser Syndikat is a network of housing projects in Germany that are collectively organized and self-managed. The Syndikat grew out of the squat movement of the late 1980s and early 1990s and was formally established around 30 years ago. Its goal is to create affordable, community-based housing that is permanently removed from the real estate market and protected against privatization or speculation. Decision-making is structured without official representatives or hierarchies, following a grassroots democratic approach.

To finance new projects, housing projects within Mietshäuser Syndikat rely on support from their community. Bank loans and direct loans from friends, family, acquaintances, and foundations constitute the two main pillars of financing for new housing projects. Direct loans are often recognised by banks as equity replacements, enabling access to traditional bank financing.

4.2. SomMobilitat (Spain)

SomMobilitat is a non-profit cooperative in Catalunya that provides shared electric mobility services. Founded in 2016 by activists linked to the SomEnergia network, the cooperative adapts energy sector cooperative principles to the mobility field. Its purpose is to reduce private car ownership and contribute to greener cities through locally rooted, member-based initiatives. The cooperative collaborates with municipalities and participates in broader cooperative networks across Spain and Europe.

In its early stages, SomMobilitat was financed through volunteer work, pre-financing from its founders, and visibility and support from SomEnergia. Start-up prizes and members loans with fixed terms allowed the cooperative to expand its fleet and operations while remaining community-driven. Today, the cooperative is also financed via ethical bank loans and a charge for the service

4.3. Energy-Island Samsø (Denmark)

Samsø is a Danish island that became internationally known as “Energy Island” after transitioning to 100% renewable energy. The project began in 1997 when Samsø won a national government competition launched in response to Denmark’s Kyoto Protocol commitments. The winning proposal was drafted by local business leaders, including the chair of the Samsø Business Association, with support from external engineering expertise. Once selected, it grew into a large-scale, long-term community project involving residents, farmers, and local institutions. The competition provided a starting grant of 200,000 DKK for the detailed plan, and public campaigns and subsidies were instrumental, offering up to 20% support for house insulation, efficient windows, and heat pump installations. Over the following decade, Samsø residents and local businesses co-invested alongside government funds to carry out the transition, combining public support with strong local ownership.

4.4. Community Grocery Shop (UK)

The Community Grocery initiative in Manchester was launched in 2020 during the first COVID-19 lockdown by The Message Trust. It began as a church-based response to local food poverty, initially providing hot meals and deliveries to households in need. As demand grew, the model developed into a permanent grocery shop where people could access affordable surplus food in a dignified way. Alongside food provision, the initiative also offers support programs such as cooking classes, financial advice, and wellbeing activities. Funding for the first shop came from church resources and donations from local organizations. This early support provided the infrastructure needed to set up the grocery and make it sustainable beyond emergency food provision. The model combines food access with broader community support, creating a space where people come not only for groceries but also for connection and guidance.

Category	Mietshäuser Syndikat	SomMobilitat	Energy-Island Samsø	Community Grocery Shop
Mission	Community-led housing projects to create affordable homes protected from speculation	Cooperative for shared electric vehicles to reduce car ownership and build greener cities	Community energy island aiming for 100% renewable energy and local sustainability	Community food project to reduce food waste, fight poverty, and build dignity
Country / Location	Germany	Catalunya, Spain	Samsø Island, Denmark	Manchester, UK
Year of Foundation	1993	2016	1997	2020
Size / Members	Over 180 housing projects	~2200 members	~3700 residents	68000 members since start
Sector(s)	Housing	Mobility	Energy	Food
Legal Form	of housing projects: limited liability company (GmbH) co-owned by residents and Syndikat	Non-profit cooperative	Cooperative ownership	Charity/Initiative started by The Message Trust
Early-Stage Financing	Direct loans from the Community; solidarity from the squat movement	Backed by SomEnergia network; volunteer and pre-financing from founders	Won a national government competition; subsidies for insulation and renewables	Church-led effort support during COVID-19; donations and volunteers to start up
Current Financial Sustainability	Direct loans from network, internal solidarity fund, bank loans, foundation funds, individual donors	Service charge, members loans (2.5% interest), government grants, start up prizes	Government grants/subsidies, bank loans and national feed-in tariff, cooperative ownership shares	Donations, Local grant programs, food donations, annual membership fee
Key Outcomes	Creates and protects collectively organized, solidarity-based housing projects long-term from speculation and private exploitation	Provides shared electric mobility solutions to support greener cities and reduce car ownership	Achieved 100% renewable energy transition; global model for local energy transitions. Inclusive financial model enabled all residents to co-invest and benefit economically	Saves over +5,250 tonnes of food from landfill, contributing to the explicit mission to reduce food waste. Combats food poverty by providing affordable surplus food

Fig 1. Comparative Case Study Overview

5. Findings: Opportunities & Risks

This chapter explores how external factors shape innovative financial models of community-owned enterprises in sectors key to a just climate transition. Drawing from the four case studies - housing projects within Mietshäuser Syndikat, SomMobilitat, the Energy Island Samsø, and the Community Grocery Shop UK - the analysis identifies signals that point to both enabling opportunities and potential risks for future community-led finance models. These cases collectively highlight emerging trends that could inspire new forms of resilient, inclusive community finance.

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5.1. Opportunities

5.1.1. Early Financing Pathways: Divergent Models

The cases suggest two distinct pathways for early financing: solidarity-based models rooted in direct community contributions and government-backed programmes. Housing projects within Mietshäuser Syndikat, for example, rely on direct loans from friends, family, and supporters. Early projects often began with as little as €500 from a member of the network, pooled to purchase land and buildings. Similarly, the Community Grocery Shop launched using local donations from a church and community supporters, proving that small-scale contributions can seed meaningful initiatives. On the other hand, Samsø and SomMobilitat benefitted from structured government support. Samsø received a 200,000 DKK grant to develop its renewable energy plan and subsidies for home insulation and heat pumps, while SomMobilitat leveraged joint grant applications with SomEnergia and regional government support to scale their electric mobility services. These examples suggest that blending grassroots funding with institutional support could be a strategic pathway for resilient community finance, and could inform future hybrid financing strategies for emerging initiatives.

5.1.2. Political Factors: Grants and Partnerships as Enablers

Political support and partnerships were central to early success across all cases. SomMobilitat's credibility with local government, for instance, hinged on SomEnergia's backing and shared grant applications. The fact that SomEnergia is locally rooted in Catalunya was especially important. In a political context marked by the Catalan independence movement—when some international firms relocated their headquarters—SomEnergia stayed. This demonstrated a long-term commitment to the region, making political actors more willing to recognize the initiative as trustworthy and embedded in the local context. Samsø's national feed-in tariff enabled residents to finance wind turbines without upfront capital, demonstrating the catalytic role of public institutions. These stories show that cultivating partnerships and navigating local political landscapes is not just bureaucratic - it can actively unlock resources and accelerate community impact. This underscores that strategic partnerships may continue to be a critical lever for emerging community finance models in politically complex contexts.

SomMobilitat – Leveraging Networks

When SomMobilitat was just starting, ethical investors weren't interested - they were "not big enough" to matter. The cooperative turned this around by leveraging SomEnergia, the energy cooperative network they were part of. SomEnergia promoted them in newsletters, offered direct service contracts, and helped with joint grant applications. This credibility with the regional government enabled SomMobilitat to secure start-up prizes and public funding, demonstrating how existing networks can act as a springboard for new community-led initiatives.

5.1.3. Economic Models: Multiple Pathways to Sustainability

The financial designs of the four cases reflect sectoral needs. Housing projects within Mietshäuser Syndikat use an Internal Solidarity Fund, which functions as a collective funding mechanism, redistributing resources across the network to protect projects from speculative market pressures. Samsø employed a different approach: residents could buy shares in wind turbines without upfront capital, as banks financed the shares and held the ownership documents until revenue from electricity sales repaid the loans over 6–7 years, with a national feed-in tariff providing security. SomMobilitat raised €1.6 million through member loans of €2,000 each at low interest, while Community Grocery Shop sustains itself via a £5 annual membership fee and recurring donations.

Mietshäuser Syndikat - Internal Solidarity Fund

Internal Solidarity Fund, which functions as a collective funding mechanism: each new project contributes €12,400 for GmbH shares, generating roughly €124,000 annually from about ten new projects. These funds are pooled to co-finance other projects within the network, enabling a cycle of solidarity-based financing. This mechanism allows projects to access larger bank loans, as small private loans from network members are recognized as quasi-equity, while also redistributing resources across the network to protect projects from speculative market pressures.

These examples highlight three broad approaches to financial sustainability: one-time investments with gradual payback (Samsø, Mietshäuser Syndikat), cooperative membership-based contributions (SomMobilitat, Community Grocery), and pooled solidarity mechanisms (Mietshäuser Syndikat). They also show how combining community contributions with institutional support can leverage both trust and scale. Looking forward, hybrid models that mix these approaches may offer adaptable, resilient pathways for future community finance projects.

5.1.4. Social Justice and Inclusion

Equity considerations varied across cases. In Samsø, a significant achievement was the mechanism that allowed all residents, regardless of income, to become owners in wind power projects. The Community Grocery Shop similarly embedded social justice in practice: stores were located in low-income areas, serving those affected by poverty, addiction, or domestic abuse. The shop offered wraparound support - financial advice, cookery classes, mental well-being programs - ensuring that community needs beyond food access were met.

Samsø - national feed-in tariff

A particularly innovative mechanism was the use of a national feed-in tariff, which guaranteed a minimum price for 10 years. Residents could purchase shares in wind turbines without having to provide upfront capital, as banks could safely lend money to shareholders based on the tariff guarantee. This reduced individual financial risk and encouraged participation across income levels. The feed-in tariff effectively catalysed the energy transition by enabling broad-based community ownership, transforming a potentially exclusive investment opportunity into one accessible to all residents. Loans were repaid using revenue from electricity sales, and after 6–7 years, individuals received full ownership and annual dividends - ensuring long-term economic benefits even for low-income participants. This mechanism not only facilitated capital accumulation but also strengthened the social legitimacy of the project, as everyone in the community could participate and benefit from the energy transition, pointing to the potential of national feed-in tariff guarantees as a replicable tool for equitable green transitions elsewhere.

By contrast, SomMobilitat's mission is primarily ecological, with social inclusion emerging as a secondary effect of cooperative participation rather than as a core objective. In the case of Mietshäuser Syndikat projects, self-organization is time-intensive and often requires much time, which can be a social privilege largely available to middle-class groups. While some projects deliberately partner with NGOs to include marginalized groups, the structural challenge of who has the capacity to organize remains. Future community finance initiatives may need to explicitly design inclusion mechanisms to avoid reproducing social inequities.

5.1.5. Social Factors: Who is the Community?

Community definitions differ across contexts. Housing projects within Mietshäuser Syndikat and the Community Grocery Shop emerged organically, responding to local housing shortages or food insecurity. For example, in Wythenshawe, Manchester, volunteers first delivered hot meals during the COVID-19 lockdown before formalising a community grocery that served over 5,000 tonnes of surplus food.

Community Grocery Shop – Building Community

Early on in the Manchester Community Grocery, a local family came in struggling with food insecurity. After receiving support and participating in cookery classes, they began volunteering and sharing their story on Instagram. Their post was picked up by local media, inspiring other families and attracting new volunteers and donations. This small act of visibility illustrates how tangible, immediate impact can mobilize community support and sustain early-stage projects.

In contrast, Samsø required mobilising the entire island of 3,700 residents. Søren, the first staff member, recalls hosting extensive workshops with farmers, business owners, and residents to build a joint vision for the energy transition. Similarly, SomMobilitat had to translate the energy-sector cooperative model from SomEnergia into a new mobility context, creating trust among local municipalities and users. These differences suggest that projects must calibrate their approach: in some contexts, visible individual stories can catalyse momentum, while in others, only collective buy-in across stakeholders ensures legitimacy and durability. Developing foresight about these dynamics is therefore key to anticipating the kind of mobilisation a project will require.

5.1.6. Environmental Commitments: Leverage for Funding and Legitimacy

For Samsø and SomMobilitat, environmental objectives were central. However, rather than acting primarily to attract funding, these initiatives were enabled by policy frameworks prioritizing climate action. Government programs such as subsidies for energy-efficient installations, feed-in tariffs, and sustainability-focused start-up prizes created conditions under which these community-driven projects could thrive. Community interest aligned with these priorities: residents and cooperative members were motivated by shared environmental goals, and policies helped remove financial or institutional barriers. By contrast, environmental factors played a minor role in housing projects within Mietshäuser Syndikat and Community Grocery, which were primarily driven by social or solidarity motives. However, in the Community Grocery, regulations requiring supermarkets to reduce food waste effectively enabled access to surplus food, indirectly supporting environmental impact. Looking ahead, aligning environmental priorities with community finance strategies could create additional legitimacy and funding opportunities.

5.1.7. Local Anchors and Changemakers: Sustaining Engagement

The presence of motivated leaders - changemakers - was decisive across all cases. For instance, early SomMobilitat founders pre-financed the first cars, while in housing projects within Mietshäuser Syndikat, network members provided essential small loans. In Samsø, Søren's facilitation of workshops and the Energy Academy created trust across the entire island. These cases signal that supporting and cultivating changemakers can sustain engagement, mobilize resources, and accelerate adoption, highlighting an often-overlooked factor in anticipating future successes.

5.2. Risks

5.2.1. Unequal Legal Landscapes

Legal frameworks can enable or constrain. Denmark's cooperative-friendly laws supported Samsø's transition, while housing projects within Mietshäuser Syndikat and SomMobilitat faced challenges being recognized under traditional company law. Legal constraints affected their ability to access bank loans and establish cooperative ownership structures.

If legal recognition remains fragmented, community-led finance may struggle to scale or be systematically excluded from mainstream funding, signaling a need for harmonisation or new cooperative legal forms. For future community finance models, advocating for harmonized cooperative-friendly legal frameworks could be critical to scaling and sustainability.

5.2.2. Market Competition: Risk of Being Crowded Out

Scaling community-led initiatives can expose them to competitive pressures. Samsø faced a market shift when larger energy companies entered, offering bigger projects and more streamlined financing. The initial community-led momentum made the transition feasible in the 1990s, but in today's market-driven context, similar community energy projects would struggle to compete with established corporations. This illustrates a structural risk: as small-scale initiatives prove successful, they may attract competition from larger actors, potentially undermining local control, community engagement, or equitable access.

For other cases, such as SomMobilitat, competition is less immediate but emerging; legal frameworks currently treat them like standard private companies, which could disadvantage community-oriented cooperatives when scaling. Similarly, housing projects within Mietshäuser Syndikat rely on legal mechanisms and solidarity funds to protect themselves from speculative pressures, demonstrating the importance of proactive measures to maintain autonomy as market pressures grow. Community Grocery faces limited market risk due to its social mission, but dependency on grants and donations could leave them vulnerable if larger charitable or commercial actors enter the space.

5.2.3. Limited Recognition of Broader Impact

The broader social and environmental impact of projects is often undervalued. Community Grocery Shop provides wraparound services - such as cooking classes, financial advice, and mental health support - that address root causes of poverty and exclusion, yet these are not systematically recognized in funding systems. Similarly, Mietshäuser Syndikat projects contribute to social solidarity by keeping housing permanently outside speculative markets, but this long-term societal benefit is rarely accounted for in financial assessments. Without mechanisms to value these wider contributions, initiatives risk being treated as small-scale charitable or niche efforts, which may hinder their sustainability and ability to grow. Future community finance strategies could integrate measurement tools to capture social and environmental value, strengthening funding and policy support.

5.2.4. Dependence on Grants and External Funding

Reliance on external grants exposes initiatives to vulnerabilities beyond their control. Community Grocery Shop depended on local donations and grant programs, SomMobilitat relied heavily on regional government funding and start-up prizes, and Samsø initially drew on significant government subsidies for insulation and renewable installations. While these external supports enabled early success, they also created exposure to shifting political priorities and policy changes. For example, in Samsø, the entrance of larger corporate players into renewable energy markets highlighted the fragility of relying too much on top-down subsidy structures. These cases underscore the importance of developing

diversified, resilient financing models - such as community loans, membership fees, or solidarity funds - that can provide stability when external support fluctuates. Emerging trends suggest that future community-led initiatives should prioritize financial diversification to enhance resilience against shifting political or market conditions.

6. Recommendations for Cities

Community-led initiatives across housing, mobility, energy, and food systems demonstrate how cities can act as enablers for bottom-up action. Based on the case studies, key takeaways for municipal policymakers focus on creating enabling conditions, supporting local resource mobilization, and aligning legal, financial, and policy frameworks with community priorities.

6.1. Provide Accessible and Flexible Funding Programs

Cities can design grant programs and subsidies that are easy to access and adaptable to the diverse needs of community-led projects:

- Allow funding to be flexible across legal forms, recognizing that cooperatives, associations, and other community structures may not fit standard corporate templates.
- Offer clear, accessible criteria focused on social, ecological, or community impact rather than organizational size.
- Include multi-year or staged funding, enabling early-stage projects to prove viability and scale sustainably

Example: Transparent and open municipal or regional funding programs were especially critical for Samsø and SomMobilitat, enabling them to establish ambitious energy and mobility projects. Samsø leveraged a government competition and subsidies, while SomMobilitat benefited from joint applications with SomEnergia and start-up prizes, demonstrating how accessible public funding can catalyse local action.

6.2. Leverage Legal and Regulatory Support

Legal frameworks can either enable or constrain community-led initiatives. Cities should recognize community-led organizations as key stakeholders in the development of regulations that affect them:

- Consult community initiatives when designing or reforming legal frameworks, especially those that impact financing, land use, or cooperative structures.
- Recognize alternative organizational forms such as cooperatives, associations, and community-owned entities within local regulations.
- Provide guidance and advocacy to help navigate national or regional policies that unintentionally disadvantage local initiatives.

Example: In Germany and Spain, housing and mobility cooperatives face legal ambiguities around their form and governance. In contrast, Denmark's cooperative-friendly framework allowed Samsø to implement a highly inclusive energy model. Consulting community-led organizations in local regulatory design could replicate this supportive environment elsewhere.

6.3. Support Local Economies Against Market Pressures

Community-led initiatives are often vulnerable to competition from large, established actors. Cities can mitigate this by:

- Prioritizing local actors in funding, procurement, and public space allocation.
- Encouraging national feed-in tariffs or co-financing schemes to reduce barriers for low-capital community participation.
- Providing platforms to showcase community-led solutions, raising visibility and credibility with private funders, banks, and the wider public.

Example: The national feed-in tariff in Samsø enabled residents to invest in wind turbines without upfront capital, democratizing access and protecting the project from exclusionary market pressures.

6.4. Enable Local Resource Mobilization

Cities can actively support community-led initiatives by creating opportunities for local resource mobilization:

- Provide infrastructure or space access, such as buildings for community grocery initiatives or mobility hubs, to reduce initial financial and logistical hurdles.
- Explore the possibility of making public land or spaces available under low-cost leasehold agreements, supporting long-term security for housing projects, urban gardens, or mobility hubs.
- Support local procurement processes that favour community-driven initiatives rather than purely market-driven actors.
- Facilitate community fundraising and investment mechanisms, such as feed-in tariffs or co-financing schemes, which reduce barriers for residents or members to participate without upfront capital.
- Promote collaboration and networks between local organizations, funders, and other stakeholders to share knowledge, resources, and visibility.

Example: In Mietshäuser Syndikat housing projects, internal solidarity funds and direct loans from community members are essential to finance projects. Municipal support in making land available or facilitating low-cost lease agreements can significantly amplify these internal resources.

6.5. Encourage Leadership and Changemakers

While in the case studies, no effort from cities to promote skills from individuals was observed, the ambition and ability of individuals to motivate others was a key to success. Thus, cities should recognize the human and social dynamics that drive community-led initiatives:

- Support local leaders and early adopters (“firesouls”) who demonstrate commitment, vision, and ability to mobilize others.
- Include initiatives in public communications to showcase successes and inspire replication.

7. Conclusion

The cases demonstrate that community-led financing is not marginal improvisation but a vital arena of experimentation with implications far beyond local contexts. Early financing pathways—whether direct community loans, church donations, or feed-in tariffs - signal the importance of embedding trust and solidarity into financial design. At the same time, systemic risks such as market competition, grant dependency, and legal ambiguities reveal the fragility of these initiatives without supportive political and institutional frameworks. For cities, the lesson is clear: enabling community-led initiatives requires more

than ad-hoc funding. It calls for a deliberate strategy that combines accessible finance, supportive regulation, municipal partnerships, and recognition of the broader social and environmental value generated. By highlighting emerging trends and potential future challenges, this study provides a foresight perspective that can guide cities and communities in designing resilient, scalable, and equitable financing strategies. By nurturing these conditions, cities can help transform isolated experiments into resilient building blocks of a just climate transition.

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Annex 6 – Climate, Security and Preparedness: Pathways for urban climate neutrality, resilience and preparedness in a new geopolitical landscape (Viable Cities)

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Summary

This deliverable **deep dive** provides an exploration of the integration of climate change mitigation, climate adaptation and security strategies in urban contexts, with particular attention to pathways for resilience and preparedness in European cities. It is situated within the broader framework of the NetZeroCities (NZC) programme, which supports the transition towards climate-neutral, sustainable, and inclusive urban futures.

Europe faces a rapidly intensifying landscape of interconnected risks in which climate change acts as a profound **risk multiplier**, exacerbating environmental degradation, geopolitical instability, economic pressures, and societal vulnerabilities. In this context, **cities emerge as critical arenas for action**, both because they are uniquely exposed to these converging threats and because they possess the capacity to mobilise innovation, partnerships, and societal engagement at scale. As hubs of population, infrastructure, governance, and economic activity, cities sit at the nexus of climate mitigation, climate adaptation, and security preparedness, making them indispensable actors in ensuring Europe's long-term resilience.

The document highlights that while mitigation has historically dominated the climate agenda, accelerating climate impacts and geopolitical shifts now make **adaptation and security considerations equally urgent**. Extreme weather events, biodiversity loss, water scarcity, food system vulnerabilities, and infrastructure failures already impose severe strain on urban systems. These hazards coincide with escalating geopolitical tensions, hybrid warfare, disrupted supply chains and information manipulation, calling for mounting defence demands—forces that reduce fiscal space for climate action and amplify the importance of robust societal resilience.

Against this backdrop, the report stresses the need for **integrated strategies** that break down traditional silos between mitigation, adaptation, and security. Treating these challenges as competing priorities leads to ineffective spending, missed opportunities, and increased long-term risk. By contrast, an integrated approach enables cities to design actions that deliver **multiple co-benefits**, strengthen preparedness, and ensure more **efficient and effective use of public spending and investment**. Examples include:

- **Nature-based solutions**, which simultaneously reduce emissions, cool urban environments, manage stormwater, strengthen ecosystems, enhance public health, and build social cohesion.
- **Resilient and energy-efficient infrastructure**, which protects critical services, reduces disaster recovery costs, lowers operational emissions, and enhances defence-readiness.
- **Localised, climate-resilient food systems**, which mitigate emissions, improve soil carbon, enhance biodiversity, and bolster food sovereignty against geopolitical shocks.
- **Collaborative governance and community-based resilience**, which support social stability, trust in institutions, and the capacity to respond collectively in times of crisis.

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Cities' role must therefore be expanded—not only as implementers of climate policies but as **key pillars of societal security**. Their ability to orchestrate multi-stakeholder alliances, apply adaptive governance, harness local knowledge, and integrate participatory processes positions them at the forefront of Europe's response to systemic risks. The document calls for cities to adopt comprehensive climate-security strategies, enhance scenario planning, strengthen early-warning and data systems, and build robust networks that connect local, national, and international actors.

Ultimately, the report argues that **aligning climate mitigation, adaptation, and security is not simply beneficial—it is essential**. Integrated action can reduce total risk exposure, generate significant cost savings, safeguard critical infrastructures, and strengthen the resilience and wellbeing of communities. By investing in solutions that deliver across domains, Europe's cities can protect their populations from emerging threats, reduce long-term expenditure, and accelerate the transition toward climate-neutral, secure, and thriving urban futures.

Keywords

Security; preparedness; Climate mitigation; climate adaptation; climate mitigation; urban governance; NetZeroCities; nature-based solutions;

1. Introduction & Objective

1.1. Climate Security Nexus - and Cities Vital Role

We live in a world of interconnected and cascading risks with potential environmental, economic and social impacts. We are facing the ripple effects of trespassing multiple planetary boundaries, causing irreversible tipping points. From a security and resilience point of view climate change has become a risk multiplier—and recognised as such by the EU in the New Outlook on the Climate and Security Nexus: Addressing the impact of climate change and environmental degradation on peace, security and defence (European Commission, 2023), and by NATO in its Climate Change and Security Action Plan (NATO, 2024). The more than 1.5C overshoot creates climate induced disasters that impact food security, energy security and access to fresh water, and livelihood loss, which in turn could add to migration and inflationary pressures and impact the cost of living and global competition for resources. Additionally, there are increasing geopolitical fractures and conflict, and aggressive measures with long term impact, including armed conflicts, sabotage to critical infrastructures and digital disinformation, are deployed by global competitors in critical areas.

For European nations, especially in the Nordics and Eastern Europe, defence and national resilience have become paramount as the spectre of Russian aggression in Ukraine has loomed large. Russia has also been intensifying hybrid warfare in the "legal gray zone below the threshold of armed conflict", challenging the rules of engagement and sense of safety and security. At the same time, Russia's expansionism is impacting the Nordic and Baltic states (Carnegie & Ålander, 2024), including the pursuit of aggressive commercial and shipping interests in a thawing Arctic. Whilst Norway may be most impacted by trade routes, Sweden is vulnerable by virtue of the strategic location of Gotland Island in the Baltic Sea (Politico & Martin, 2024). Finland – a country that has historically shared Sweden's approach to security—borders Russia. Both countries went from neutral and non-aligned to joining NATO, with Finland in April 2023 and Sweden in March 2024.

Further uncertainty has been created for European security in the wake of Donald Trump's election as US President; in terms of the American commitment to both NATO and Ukraine, to safeguarding international trade agreements and critical raw materials supply, as well as to threatening new

territories' sovereignty, such as Greenland and Denmark (Antsygina, 2025). European partners are faced with the stark reality of needing to assume greater responsibility for and intensify investment in their own collective security, even “developing a nuclear deterrent strategy independent of the US” (European Leadership Network, 2024). However, with economic difficulties and declining public support for Ukraine across the EU, it may not be easy to increase defence spending. This may trigger further division and even political turmoil within and between European partners. As wars are also raging in other parts of the world, and as the traditional power balances are shifting, it is important that Europe rethinks its position, as well as its ambitions, on climate, energy, resources, and defence.

National security and defence strategies have always prioritised critical national infrastructure (CNI) i.e. national (hard) assets that are essential for the functioning of society (National Cyber Security Centre, 2025). However, an increasing number of events and suspected events of sabotage e.g. of submarine cable systems or intrusion into security assets such as water plants (Sveriges Radio, 2024), have highlighted civil societal vulnerabilities of external interference. In recent years, the theatre of war has purposefully addressed vital societal areas that are closely interconnected with climate change risks such as energy and food security.

Moreover, given today’s fast moving society, short political turnaround times, polarisation and digital disinformation campaigns, policy makers and governments are having to grapple with social pressures at home.

Cities are critical settings and actors, not only because they house CNI, but also because they are holders of civic resilience including culture and identity. Throughout history, cities have been managing complexity, constantly reinventing themselves as living ecosystems. Even more so since WWII and the Cold War, cities have been key targets in global warfare but also of propaganda and disinformation to harm people's sense of security and will to resist. Given that future warfare is moving from traditional sea-land-air force to hybrid forms of warfare focussing perhaps more on small scale, targeted technology, data, biological warfare, chaos, and attrition, our approach to defence may need to be redesigned.

The role of cities needs to be amplified, not only as centres of capital, expertise, innovation, and production, but also of hope, resistance, preparedness, communal support and resilience. One question that may be posed is whether, after decades of relative peace in Europe, is Europe still fit, as a population, to support national security and defence strategies which do not fully rely on technology and military equipment, but also rely on people being able to come together as supporting communities?

In this Deep Dive, we wish to explore the critical role of cities and how cities may need to adapt to the security/climate interface, and increasing threats, but also where cities have the opportunity to contribute to security, preparedness and civil defence.

2. Context

2.1. Different narratives, same context

There are clearly multiple narratives that can be played out about the climate transition agenda on the one hand, and the interplay between security, defence and competitiveness on the other hand. In many ways, the opposite ends of this debate are nothing new. But as the stakes are higher than ever, the tone of the debate certainly has become sharper.

On one extreme end, there is a narrative in which the climate agenda risks losing out in a world where war and defense spending, economic competition, cost of living concerns and the need for growth simply eclipse or trump environmental concerns, further fuelled by issues such as a reluctance to

holistically address lifestyle and consumption changes in prosperous global North societies. In such a discourse, driven by expansionism and/or fear of falling behind, climate action becomes a political football and risks getting structurally losing out in a zero-sum game vis-á-vis desirable goals like faster security, economic growth, affordability, maintaining ways of life and the consumption standards that go with them. The UK is a telling example of where an incoming Labour Government is trying to, but struggling to overcome this 'zero-sum' thinking (The Guardian & Adu, 2025), and this argument is playing out across the world.

On the other hand, there is the argument that the consequences of not addressing climate change will drive much greater systemic insecurity and forced lifestyle changes and that widely attractive concepts like resilience, safety, stability, insurability, affordability, good health, shared prosperity and social cohesion can only be maintained - let alone improved - by making smart, integrated investments and actions.

Bending the narrative from the former to the latter is not straightforward - and in a rapidly changing global discourse, it will require ever more concerted efforts by a range of engaged actors.

2.2. EU Strategies addressing the Climate and Security Nexus

The European Union (EU) addresses climate threats within its security framework through a comprehensive strategy that recognises climate change as a "threat multiplier" to global peace and security. This approach is primarily guided by the 2023 Joint Communication on the Climate-Security Nexus, which sets out the EU's plan to anticipate and respond to these intertwined challenges (European Commission, 2025).

The EU strategy on climate threats in a security context is built on four main priorities:

Strengthening Evidence-Based Analysis: The EU develops enhanced foresight and analysis of climate-related security risks to inform better planning and early warning systems. This includes the annual "Climate and Security Trend Analysis" report, which identifies critical pathways through which climate change exacerbates security challenges (e.g., resource scarcity, livelihood disruption, and political instability).

Operationalising the Response: The EU integrates climate and security considerations into its external action, including regional conflict analyses and crisis management missions under the Common Security and Defence Policy (CSDP). CSDP missions now include environmental advisers to address local environmental and climate-related security challenges, such as protecting natural resources and tackling environmental crime.

Enhancing Civilian and Military Capabilities: The strategy focuses on adapting Member States (European Commission, 2025) civilian and military capabilities, infrastructure, and operations to the changing climate conditions, with the goal of improving efficiency and reducing carbon footprints without compromising effectiveness. This includes specific guidance for defence leaders on climate risk management.

Reinforcing International Partnerships: The EU works with multilateral fora and partners like the UN and NATO to align its approach to climate and security. The EU also engages in peace mediation and dialogue initiatives in vulnerable regions (e.g., in West and Central Africa to mediate conflicts over natural resources).

3. Key issues

3.1. Climate Change in Europe: Risks, Consequences, and the Need for Adaptation

Climate change is already having a profound impact across Europe, manifesting through rising temperatures, altered precipitation patterns, and an increasing frequency of extreme weather events. Since the 1980s, Europe has warmed twice as fast as the global average, making it the fastest-warming continent on Earth (European Commission, 2025). Projections indicate that by the end of the 21st century, annual temperatures across Europe could rise by 2 to 6°C compared to historical baselines, depending on future green gas emissions.

This rapid warming is not just an environmental issue—it is a systemic challenge that touches every aspect of life, from the food we rely on to the infrastructure we depend on and the health of our populations. These impacts are already posing significant risks to European cities, amplifying challenges such as food security, infrastructure resilience, and public health. Recent analyses by the OECD and Eurocities (Euro Cities, 2024) underscore the urgent need for cities to adopt climate adaptive strategies for climate risks (OECD, 2023).

But these risks don't exist in isolation. Geopolitical shifts, such as political instability and conflicts, are exacerbating these challenges by influencing how resources are allocated and how cities prioritise their responses. Cities are at the intersection of these compounded risks, as they not only face the direct impacts of climate change but also play a critical role in managing these risks. Urban areas provide access to core human needs and are hubs of economic activity, critical infrastructure and dense populations. However, to effectively address these complex challenges, cities must be equipped with the right governance and adaptation strategies.

As cities confront these interconnected challenges, it is clear that their role as central actors in Europe's climate and security strategies has never been more important. Understanding the specific direct risks they face—along with the external forces of geopolitical and security factors shaping those risks—is key to ensuring cities are adequately prepared for the future.

3.1.1. Direct Risks

3.1.2. Risk to Biodiversity, Land and Water

Climate change poses significant risks to land, water, and biodiversity across Europe, already experiencing notable impacts. The European Environment Agency (EEA) emphasises the interconnectedness of these environmental challenges and advocates for integrated solutions to address them. Biodiversity faces multiple threats from climate change, including habitat loss, altered species interactions, and phenological changes.

3.1.2.1. *Impacts on Biodiversity*

Rising temperatures and altered precipitation patterns are affecting land ecosystems across Europe. For example, many mountain and alpine species are shifting their ranges northward or upwards in elevation, while more generalist species thrive. This trend has been particularly damaging to specialist species, which rely on specific environmental conditions that are becoming less stable (Simma et al., 2025, 2088-2099). Similarly, the migration of species such as the red fox in northern Europe has led to the decline of native populations, including the Arctic fox

(Länsstyrelsen, 2025). These shifts highlight the need for adaptive land management strategies that preserve biodiversity and support the resilience of ecosystems.

3.1.2.2. Impacts on Land

Coastal ecosystems are also at significant risk due to sea-level rise and increased coastal erosion. Across Europe, low-lying coastal areas are already experiencing damage from rising seas. For instance, salt meadows and wetlands in the Mediterranean and Atlantic regions are increasingly threatened (WWF, 2025). Efforts to enable inland migration of these habitats are crucial for preserving their ecological functions, particularly their role in carbon storage and supporting coastal biodiversity.

3.1.2.3. Impacts on Water

Climate change is intensifying water-related challenges across Europe, including water scarcity, quality deterioration, and increased flooding. The EEA reports that nearly two-thirds of Europe's water bodies are in poor condition, with agriculture and coal-fired power plants contributing significantly to pollution (European Environment Agency, 2024). Increased precipitation and extreme weather events have led to flooding and nutrient runoff, exacerbating eutrophication in water bodies.

To address these challenges, many European countries are adopting nature-based solutions. For instance, initiatives across the Danube River Dasin are working to restore wetlands and reconnect floodplains to reduce flood risks and restore biodiversity (Horizon Europe, 2022) . These projects involve cross-border collaboration among several EU countries, demonstrating the effectiveness of integrated, regional approaches to water management. Similarly, the EU Water Framework Directive (WFD) promotes cooperation among member states (European Commission, 2025), urging them to implement integrated river basin management strategies that enhance the resilience of water systems to climate change while improving water quality and availability.

3.1.3. Risk to food security

Urban food security is emerging as a key area of focus for cities, expressing the nexus of climate mitigation, climate adaptation, and security. Europe's current food production system presents both significant risks and potential solutions. The prevailing agricultural practices contribute to unsustainable land and water use, biodiversity loss, and carbon emissions (European Commission, 2020). However, with effective policies that encourage sustainable practices and adapt to local needs, there is considerable potential to reduce emissions from agriculture more rapidly while also enhancing carbon sequestration in the land sector, soils, and forests (European Commission, 2025).

Food and farming are vital to Europe's people, economy, and society. The European Commission's Farm to Fork Strategy (European Commission, 2020), as part of the European Green Deal, aims to make the food system fair, healthy, and environmentally-friendly. The strategy focuses on sustainable food production, reducing food waste, and ensuring food sovereignty across the continent. As European Commissioner for Agriculture and Rural Development, Janusz Wojciechowski states:

> *"We need a resilient agri-food sector that can withstand crises and shocks while continuing to contribute to the EU's efforts to combat climate change"*
> *(European Commission, 2025)*

Recent global events, such as the Russian invasion of Ukraine, have highlighted the vulnerability of

Europe's food systems. These shocks, along with extreme weather events and market disturbances, are increasing food price volatility and challenging the security of the food supply. For example, food price inflation has surged in many European countries, exacerbating food insecurity for vulnerable populations. Additionally, rising energy costs, limited availability of agricultural machinery, and increasing demand for fertilisers are putting further strain on agricultural production.

Farmers are at the forefront of many of these challenges, and they must make significant adaptations to reduce their vulnerability to climate risks. Agroecological practices, carbon-sequestering farming, and improved soil health can help reduce agricultural emissions while increasing the resilience of farming systems. Cities can play a pivotal role in this transition, supporting transitioning farmers through for example food procurement, as land owners/ land leasers, as providers of vocational training for the next generation of farmers and investing in carbon credits.

Across Europe, agriculture remains essential for food security and economic stability. While Denmark is a net exporter of agricultural products, other EU countries face challenges in ensuring sufficient local food production. The EU's focus on food sovereignty aims to reduce reliance on external food sources, enhance local production, and promote sustainable practices.

To support this transition, cities are encouraged to develop regional food systems that integrate sustainable practices, promote urban agriculture, and ensure that climate-resilient food systems are in place. By supporting farmers' adaptation to climate change and fostering collaboration between local governments, food producers, and consumers, cities can play a crucial role in ensuring Europe's food security while simultaneously driving climate adaptation efforts.

3.1.4. Risk to Built Environment and Infrastructures

The increasing frequency and intensity of extreme weather events, driven by climate change, poses significant risks to the built environment and infrastructure across Europe. Phenomena such as landslides, floods and extreme weather events cause severe damage to roads, bridges, and other critical structures, disrupting daily life and threatening lives and livelihoods. These events already lead to substantial economic losses for private property owners, local, and national governments, with profound implications for insurance and financing sectors.

For example, in Örnsköldsvik, northern Europe, heavy rainfall in 2025 undermined critical infrastructure, with an estimated 40 roads closed, and multiple trains derailed as a direct result of the heavy rainfall (Krisinformation, 2025), highlighting the vulnerability of infrastructure to extreme weather. Similar to other European cities, extreme weather events have exacerbated issues such as flooding, erosion, and landslides. In this case, human interventions, such as poorly managed construction sites and deforestation, contributed to the severity of the damage. These events underscore the need for adaptive infrastructure planning that accounts for the changing climate and rising risks.

In southern Europe, cities are also experiencing severe infrastructure risks due to extreme weather events. Coastal flooding, heatwaves, and water shortages have increasingly put pressure on urban infrastructure. In Valencia, heavy rainfall in recent years has led to severe flooding, particularly in low-lying areas, with the most severe example being the catastrophic flooding in 2024 resulting in 232 deaths, 100.000 destroyed cars and estimated damage costs of 10,7 billion EUR. Prior to that, the city has been forced to upgrade its drainage systems and flood defenses to cope with more intense storms and rising sea levels. These examples underscore the urgency of addressing the infrastructure vulnerabilities faced by cities across Europe, particularly as extreme weather events become more frequent and intense.

The growing frequency of such events also highlights the need for comprehensive insurance coverage and proactive financial strategies. The disparity between economic losses from climate-related events and insured losses, known as the insurance protection gap, is widening across Europe. leaving a significant portion of climate-related damages uninsured.

"In Europe, only about 25 % of economic losses from extreme weather events are insured, leaving a 75 % insurance protection gap." (Bassetti, 2025)

To address this issue, there is an urgent need for better risk assessments, innovative insurance models, and policies that make coverage more accessible while encouraging cities and regions to adapt to climate risks.

For example, in the UK, a recent report indicated that nearly 2 million people and a third of England's critical infrastructure are at risk of flooding (Public First et al., 2025). The report underscores the urgent need for investment in flood defenses to mitigate these risks. Similarly, in Italy, starting in April 2025, businesses will be required to secure natural disaster insurance to help alleviate the state's financial burden in compensating for climate-related damages (Norton Rose Fulbright et al., 2025). While this policy shift aims to foster prevention and infrastructure improvements, businesses have raised concerns about the cost and complexity of the requirements.

3.1.5. Health risks

Ongoing climate change is significantly affecting health and the conditions for good living across Europe. Increased temperatures, extreme weather events and changes in ecosystems are contributing to growing health risks. These risks include heat-related illnesses, respiratory diseases, and the spread of vector-born diseases, which are becoming more prevalent as the climate shifts.

The European Environment Agency (EEA) and other health organisations across Europe have highlighted the key threats to public health associated with climate change (European Environment Agency, 2022). These include extreme heatwaves, changing precipitation patterns, and air quality deterioration. The combination of an aging population, urbanisation, and rising temperatures is exacerbating health risks across the continent, particularly for vulnerable groups, such as the elderly, children, and those with pre-existing conditions.

The frequency of heatwaves has increased across Europe, which is particularly problematic for regions that are not traditionally exposed to extreme heat. For example, during the 2018 heatwave, many European countries experienced unprecedented temperatures, overwhelming health systems that were ill-prepared for such events. In response, cities across the EU have started to implement heatwave emergency plans, create cooling centers, and develop strategies to reduce heat island effects through more green spaces and shading infrastructure.

Another significant health risk is the changing precipitation patterns across Europe. Climate models suggest that annual rainfall will increase by 10 to 40 percent in many northern and central European regions, increasing the likelihood of flooding, landslides, and erosion. Conversely, southern regions may experience reduced summer rainfall, leading to droughts and water scarcity, exacerbating health risks related to dehydration, malnutrition, and poor sanitation.

Air quality is also projected to worsen as warmer temperatures and altered precipitation patterns lead to longer pollen seasons and higher pollution levels. This will exacerbate respiratory conditions and increase the incidence of allergies and asthma. In addition, vector-borne diseases such as Lyme disease and tick-borne encephalitis are expected to spread as warmer temperatures expand the habitats of disease-carrying insects.

3.1.6. External Forces

3.1.7. Geopolitical & Security Risks

The direct risks of climate change—such as food insecurity, infrastructure vulnerability, and health risks are already challenging cities across Europe. However, these risks are compounded by geopolitical and security dynamics, which affect how cities can respond to and manage these growing challenges. Geopolitical shifts such as political instability, resource conflicts, and international tensions influence the allocation of resources and priorities, ultimately determining how well prepared cities are to handle both climate impacts and security threats.

3.1.7.1. Changing Geopolitical Landscape in Europe

In recent years, Europe's geopolitical landscape has shifted dramatically. Russia's war of aggression against Ukraine, for example, has not only created humanitarian crises but has also disrupted energy markets, food supplies, and trade routes, further exposing Europe's vulnerabilities. The Russian threat to the Baltics and Nordic countries, combined with growing NATO/US uncertainty, has raised concerns about the regional security environment, influencing how resources are allocated for national defense and climate resilience.

In this context, military defense spending across Europe is on the rise, with countries redirecting funds to strengthen national security, coming from record low levels during 2010-2019. This shift places additional pressure on the public purse, as governments must balance the increasing demands of defense readiness with the ongoing need for climate mitigation and adaptation investments. The competing priorities between security needs and climate goals are creating tension, particularly at the municipal level, where cities are responsible for both public safety and climate resilience.

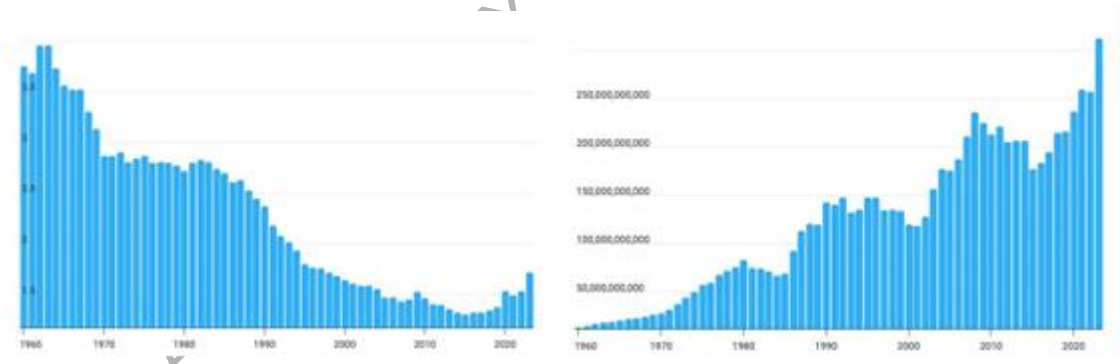

Figure 1: European Military Spending/Defense Budget 1960-2025: % of GDP and spending in EUR. For an interactive link, see here. See also EU Defense for more information.

1.1. Impact on the Stability of Cities and the Sense of Security for Citizens

Cities, positioned at the intersection of these compounding risks, are particularly vulnerable. They are economic hubs, cultural centers, and infrastructure lifelines, which makes them highly sensitive to the effects of geopolitical instability. When geopolitical tensions disrupt global supply chains, cities can

face resource shortages, economic downturns, and social unrest, all of which make it even harder for them to address climate-related challenges.

Future forms of warfare might move from traditional sea-land-air force to hybrid forms of warfare targeting cities more directly. An increasing number of events and suspected events of sabotage e.g. of submarine cable systems or intrusion into security assets such as water and energy plants, have highlighted civil societal vulnerabilities of external interference. Citizens and cities have been key targets of propaganda and disinformation campaigns to create distrust to public institutions, harm people´s sense of security and will to resist.

The impact of geopolitical instability is also reflected in migration pressures. Conflicts, political instability, and resource scarcity can trigger large-scale movements of people, placing additional strain on urban infrastructures, social services, and housing systems, further complicating cities' ability to implement effective climate mitigation and adaptation measures.

1.2. The Urgency of Addressing Geopolitical and Security Risks

In this rapidly changing environment, EU and national governments focus on urgent ramp up of investments and mobilisation for security and preparedness. However, climate mitigation, climate adaptation and security risks are not separate issues that should be placed in competition with each other. Preparedness for geopolitical risks must be integrated with urban climate strategies. Without considering the interconnected nature of security and climate change, cities risk missing crucial opportunities for coordinated responses and long-term resilience.

In addition, there is a need to start grappling with how the risks influence and exacerbate each other. The table below also lists financial risks which are crucial in this context, both regarding impact without necessary actions, and as possible barrier to taking necessary actions. Financing is however not the focus in this document.

Type of risk	Impact
Environmental and Physical Risks	• **Food Security Risks** Vulnerability of food systems to extreme weather, affecting production, distribution, and pricing, leading to food shortages and insecurity. • **Infrastructure Vulnerability** Increased flooding, heatwaves, and extreme weather damage urban infrastructure (roads, bridges, water systems), disrupting daily life and economic activities. • **Health Risks** Rising heatwaves and deteriorating air quality lead to increased heat-related illnesses, respiratory issues, and the spread of vector-borne diseases (e.g., Lyme disease, tick-borne encephalitis).
Geopolitical and Security Risks	• **Political Instability** Aggressive events and threats such as sabotage and misinformation may harm citizens' sense of security, their trust in politicians and public institutions, and social resilience. This can feed polarisation, creating further instability in cities. • **Resource Conflicts** Geopolitical tensions (e.g., war, political conflict, sabotage,

	misinformation) exacerbate competition for critical resources (water, food, energy) in crisis • **Migration Pressures** Climate-induced migration, driven by extreme weather events and resource scarcity, increases pressure on cities' social services, housing, and public health systems, creating potential political and social challenges. • **Shifts in Defense Priorities** The shift of resources to national defense and military spending reduces investment in climate resilience, creating a tension between climate mitigation, climate adaptation and preparedness for security needs.
Financial Risks	• **Underinvestment in Vulnerable Regions** Insufficient funding directed towards cities most affected by climate change exacerbates inequalities, leading to uneven adaptation efforts across regions. • **High Economic Costs** Increased costs of climate change impacts (e.g. damage to infrastructure, public health crises) divert funds from resilience building to repair and damage control, leading to long-term financial strain. • **Insurance Gaps** The widening gap between economic losses from climate events and insured losses (the protection gap) leaves cities and citizens financially exposed to climate-related disasters. • **Barriers to Funding Access** Administrative hurdles, limited resources, lack of adaptation-focused financing opportunities and shifting political priorities prevent cities from accessing necessary climate adaptation funds.

Table 1. Risks on Cities Relating to Climate Change Impacts and Security

4. Gaps & Opportunities

4.1. Addressing Gaps in Risk Mitigation and Adaptation Strategies

Climate change is already having a profound impact across Europe, manifesting through rising temperatures, altered precipitation patterns, and an increasing frequency of extreme weather events. Since the 1980s, Europe has warmed twice as fast as the global average, making it the fastest-warming continent on Earth. Projections indicate that by the end of the 21st century, annual temperatures across Europe could rise by 2 to 6°C compared to historical baselines (European Commission, 2025), depending on future green gas emissions.

Climate change presents multifaceted risks to land, water, and biodiversity. Integrated, ecosystem-based strategies are essential to mitigate these impacts and promote environmental resilience. To enhance resilience, proactive adaptation strategies are essential. This first and foremost means mapping, and understanding risk and its direct and indirect consequences, with regard to unexpected shocks as well as long term stresses, and subsequently also preparing for plausible scenarios. This is key to know how to apply modifications in processes, practices, and structures aimed at reducing potential harm or capitalizing on opportunities linked to climate change. As conditions are different for every country, city and community, there is no one size fits all approach. Therefore adaptation in this context, can benefit from the multi-perspective, multi-actor, and multi-level government approach

explored in climate and mitigation strategies, but should even more explore how future impacts need to help orient current decisions, investments, and partnership and collaboration models.

For example, a study by the World Bank emphasizes that adequate road maintenance is the most efficient way to reduce the impact of climate change on road systems. Investing in pavement improvements to withstand higher temperatures and considering the broader impact of road disruptions can yield significant long-term benefits.

Addressing these challenges necessitates a multifaceted approach involving increased investment in resilient infrastructure, comprehensive insurance coverage, and proactive adaptation strategies to mitigate the adverse effects on societies and economies worldwide.

Emerging practices are starting to address how cities can ensure how these, already multi-faceted, approaches can be combined and aligned with the efforts of climate mitigation (i.e. emission reduction).

4.1.1. Opportunities for multiple benefits

To mitigate the adverse effects of climate change, several adaptation strategies that inform cities of prioritised measures have been outlined. Many of these measures still rely heavily on grey infrastructures or still follow an approach geared towards planning and control, enhancing the resilience of infrastructure to withstand extreme weather events. This includes reinforcing buildings, roads, and bridges to cope with increased flooding and temperature fluctuations.

When combining the perspectives of climate mitigation, climate adaptation and security, the benefit of initiatives that can address several risks becomes evident. We would like to stress the multiple benefits of nature based solutions in this context, since besides preventing damage to physical infrastructure, it can also supply us with a broad range of benefits to both human and ecological systems.

4.1.1.1. Nature Based Solutions

Nature-based solutions offer a powerful pathway to address the escalating risks of climate change while simultaneously improving human health, wellbeing, and community resilience. By restoring and working with natural systems, societies can build environments that are more adaptable, more sustainable, and more supportive of everyday life.

In urban settings, greening initiatives can dramatically transform the quality and resilience of cities. Trees, parks, green roofs, and restored wetlands provide shade and cooling during extreme heat, reducing urban heat-island effects and lowering health risks and energy demand for cooling. Vegetation helps capture carbon, improves air quality, and supports natural water management, reducing the likelihood and severity of flooding. Green spaces also create habitats for biodiversity, can support small-scale food production, and offer places for recreation, relaxation, and social interaction—strengthening community bonds and enhancing overall wellbeing.

In and beyond cities, restored wetlands and retention ponds with additional detention capacity provide especially valuable multifunctional benefits (Jarsjö, 2023). These systems help manage water by storing excess rainfall during storms and gradually releasing it, reducing flood risk while also increasing water availability during droughts. Wetlands naturally sequester carbon, filter pollutants, safeguard water quality, and create rich habitats that support diverse plant and animal species. At the same time, these blue-green spaces offer opportunities for recreation, education, and community gathering, turning climate adaptation infrastructure into shared social assets.

Further into the rural landscape, transitioning from traditional industrial agriculture to regenerative farming methods represents another crucial nature-based approach. Regenerative practices rebuild soil health, increase organic matter, improve water retention, and restore ecosystem functions. These methods sequester carbon, reduce nutrient runoff and eutrophication, and minimize reliance on harmful agrochemicals. By producing healthier, more nutrient-dense crops and fostering more diverse

landscapes, regenerative agriculture supports a food system that is better able to withstand climate shocks.

Importantly, regenerative approaches also strengthen food sovereignty—a critical concern in a time of increasing geopolitical instability. As global supply chains face disruptions from conflict, economic turmoil, or climate-related disasters, dependence on imported fertilizers, feed, and staple crops exposes communities to significant risk. By enhancing local soil fertility, diversifying crop production, and reducing reliance on external inputs, regenerative agriculture empowers regions to produce more of their own food sustainably. This bolsters resilience not only to climatic extremes but also to geopolitical pressures that threaten food security.

Together, these nature-based strategies—urban greening, wetland restoration, and regenerative farming—demonstrate how working with nature can yield multiple co-benefits. They strengthen climate resilience while improving public health, restoring ecosystems, protecting biodiversity, safeguarding water quality, and fostering more secure, self-reliant communities in an increasingly uncertain world.

4.2. Emerging Trade-Offs or Win-Win Opportunities

To some, security and climate present rather different policy areas, assumptions and value sets. Others would argue that they are opposite sides of the same coin. The challenge is not so much what these terms represent, but how adherents to each term might see demarcated lines when in fact there are multiple crossovers and, to borrow a military term, 'skirmishes'. 'To be secure' is not only referring to the harder military aspects but also for a society to be secure and for the population to feel secure. Both climate change and disinformation sparking increasing polarization in day to day politics can be a direct threat to this. Moreover, the nexus between sustainable development and peace and security is made explicit in the UN SDGs 2030 Agenda with "each incapable of being achieved without the other". In the words of Ulrika Modéer, UN Assistant Secretary-General and Director of the Bureau of External Relations and Advocacy, UNDP, "The connection between climate change and security does not need to be a trade-off in policy priorities but an opportunity to address some of the defining issues of our time through integrated action".

In daily reality, this ideal of synergy and integration may not always feel achievable: it may rather feel like painful trade-offs are being made. For example, a security-first approach might make some people feel that, by deprioritising other issues like social and climate spending in budget allocations, preventative spending across domains may be at risk and vulnerability reducing policies and measures falling through the cracks. However, the opposite can also be true: what might be different is the frame that is applied. A holistic resilience approach with dual security lenses could be focussed on tackling systematic nodes of vulnerability and could lean on foresight and scenario planning including and across climate, security and social priorities, aiming for holistic security and preparedness. In this logic, a range of systemic vulnerabilities need to be addressed as nodes in a system, and so e.g. climate adaptation, vulnerable groups and social inequities need to be addressed to avoid systemic fractures (e.g. social breakdown) given their interconnectedness. Therefore, a societal notion of security has the potential to be more inclusive of co-benefits e.g. river flood protection as 'expanding natural landscapes versus higher concrete levees', or indeed 'ensuring resilient food access for all is in everyone's interest.'

To avoid trade-offs and instead find synergies among security, climate mitigation and climate adaptation actions requires long term thinking but also participatory approaches that enable the translation of common interests and goals to each others' agendas, processes and initiatives. But also to understand costs, investments, benefits, co-benefits, and co-impacts and to demonstrate added value at operational level. This also requires a rethinking of roles and responsibilities within the larger security scope so that more actors could navigate and leverage their respective fields of action to larger mutual benefit. Hereunder we list a number of potential trade-offs that might open up to further pathways for research, exploration and conversation. It is not intended to be a full overview of all possible trade-offs but one that shows the scope and wide diversity of different types of trade-offs we have to consider.

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Risk Type	Win-Win Opportunities with an Integrated Approach to the risk
Environmental and Physical Risks	• **Transition of Food System** Strengthening and diversifying local food systems through regenerative agriculture and urban farming can reduce emissions and sequester carbon, improve biodiversity and ecosystem services, increase food sovereignty and reduce dependence on vulnerable global supply chains. • **Infrastructure Resilience** Climate-adaptive infrastructure, including green-blue systems and heat-resilient materials, improves water management, reduces flood and heat risks, and protects essential transport and water networks. This supports economic stability, lowers long-term maintenance costs and ensures societal preparedness if/when faced with accidents, sabotage, or aggression. • **Health and Wellbeing** More green spaces provide cleaner air, reduce heat-related and respiratory illnesses while enhancing physical activity, social interaction, and overall mental wellbeing.
Political Instability	• **Political Stability** Increasing local self-sufficiency in food, water, and energy reduces vulnerability to global crises and supports stability during geopolitical disruptions. Local systems maintain essential services and build trust in governance. • **Access to Resource** Collaborative management of water, food, and energy resources strengthens social cohesion and reduces conflict. Shared stewardship enhances fairness and collective preparedness for crises • **Realigning Defense Priorities Toward Resilience** Integrating climate resilience and nature-based solutions into security planning protects key infrastructure and improves readiness for environmental and geopolitical threats, while using public funds more efficiently.
Financial risk	• By addressing climate mitigation, climate adaptation and security risks with an integrated approach, and by prioritising actions with multiple benefits, the total impact and costs of risk events can be reduced, hence enabling more effective and efficient use of public spending and more stable, future-proof economies and societies.

Table 2. Opportunities relating to an integrated approach in climate mitigation, adaptation and security strategies

5. Recommendations

5.1. Emerging Trade-Offs or Win-Win Opportunities

To some, security and climate present rather different policy areas and assumptions and value sets. Others would argue that they are opposite sides of the same coin. The challenge is not so much what these terms represent, but how adherents to each term might see demarcated lines when in fact there are multiple crossovers and, to borrow a military term, ‘skirmishes’. ‘To be secure’ is not only the harder military aspects but also for a society to be resilient and able to function and provide for its citizens´ independent of strains and events.

From a whole-system, integrated point of view, cities already today play a critical role as places where a multitude of risks and opportunities come together, alongside significant innovation capacity and networks of committed stakeholders. In this context, cities are both liability holders, weathered curators of complexity and key to the mobilisation of society. NetZeroCities and national networks and platforms for climate transition in cities can play a critical role here by leaning into its collaborative networks and programming within its cities network, learning and innovation structures.

It is crucial to adopt a comprehensive approach that integrates the perspectives of security, climate action and adaptation, and identify synergies between them. This may require adaptive governance models that bridge environmental and security concerns, while addressing systemic impacts within cities, doing what is needed on a large scale to shift norms, manage a transition together while being prepared for threats and crises. Stockholm Resilience Centre, SRC, among others, have addressed the issue of adaptive governance of socio-ecological systems in an uncertain world in several papers, concluding that adaptability in a resilience (security) framework implies the capacity not only to respond according to the preferences of important stakeholders but also to respond to, and shape ecosystem dynamics and change in an informed manner. In this regard 'informed' leans into the notion of acknowledging our dependence on the biosphere. It is noted that:

> *Trust building and knowledge generation in local social-ecological systems (SES) are important in periods of slow change* ***in order to be prepared for adaptation in periods of fast change****. Although management practices of ecosystem services play out in local contexts, adaptive governance systems tend to be multilevel, connecting the local with the national and international (Olsson et al., 2007, 28).*

5.2. Strengthening the Urban Dimension of Civil Preparedness

NetZeroCities is well placed to build on its climate work with municipalities and collaborate with partners on specific and strategic innovations to adopt a more security-aware lens in climate programming, and vice versa, and thus enable cooperation between cities as well as the civil and military security and defence ecosystem on national and EU level. NetZeroCities could enable the sharing of actionable knowledge in a multi-level governance perspective with the purpose of helping cities in their daily work to enable them to be more resilient in their climate approach, from narrative to tactical action to longer term investments, including:

- Positioning cities' leadership on integrating climate adaptation, security and preparedness as relevant to urban climate neutral transitions thinking
- Within Europe, leading the research and stakeholder engagement on expanding the notion of security to include climate /resilience and other transition challenges, and key elements for preparedness and resilience.
- Growing shared awareness, language and skills around this intersection across cities´ and stakeholder landscapes, making the significant work already pioneered by cities working with quadruple helix transition arenas and mission driven task forces available and actionable. It is important to note that this is about mobilisation of society, focused on doing what is needed on a large scale to shift norms, manage a transition together while being prepared for threats and crises.
- Development and roll out of active sensemaking, communications and engagement tools and programmatic toolkits to engage stakeholders at all levels, foster trust and collaboration.

5.3. Innovating financial models and governance structures

Develop and establish dynamic financing tools and frameworks for fostering integrated climate mitigation, adaptation and crisis readiness to strengthen municipalities' capacity to address climate/security challenges, and ensure ongoing innovation and rapid implementation of necessary actions and strategies.

5.4. Key Recommendations for Cities

Cities are in urgent need of but also well placed to develop comprehensive strategies and action plans for climate mitigation, climate adaptation, security and preparedness that combine hard infrastructure improvements with nature-based and community-led initiatives. There is also a significant opportunity to harness multiple benefits by combining these aspects when selecting and prioritising initiatives and actions. Developing strategies and implementing action plans not only protect lives and livelihoods but also fortify urban security and resilience against both immediate hazards and long-term risks and threats across multiple domains, reducing total risk exposure, lower future economic losses, and enhance societal wellbeing.

Addressing the eminent challenges necessitates a multifaceted approach:

5.4.1. Protection of Lives and Infrastructure

Take a holistic stance on built environment and infrastructure interventions for energy efficiency, circularity, climate adaptation and security. This includes a structural acknowledgement that investing in sustainable and resilient community infrastructures (physical and social), is desirable both from a just climate transition, an adaptation and a security and preparedness perspective.

- Risk Reduction: Identify and implement necessary adaptation measures—ranging from flood defenses and stormwater management systems to heat mitigation through urban greening—to reduce the risk of catastrophic events. This is crucial for ensuring the safety of residents and continuity of essential services.
- Economic Stability: By investing in adaptive infrastructure, cities can prevent the high economic costs associated with disaster recovery and reconstruction, thus protecting local economies and public finances.
- Resilient Critical Infrastructure: Modern cities depend on a robust network of utilities, transportation, and communication systems. Adaptation ensures these systems are fortified against climate-induced disruptions, reducing vulnerabilities that could compromise urban security.
- Social Cohesion and Public Trust: Proactive adaptation policies can build public confidence by demonstrating that governments are prepared to protect communities. This enhances social stability and mitigates potential conflicts arising from resource scarcity or disaster-related disruptions.

5.4.2. Build Strong Alliances and Communities

- Strong Alliances: Fostering, reinforcing and building new collaborative partnerships and alliances between public and private sectors around e.g. the role of urban transitions in integrated security/resilience, alongside national and international partners. There is also a big

potential in strengthening city-to-city collaboration (Bai, 2024) to enhance resilience and preparedness.

- Strong Local Communities: Fostering and supporting local communities as a vital part of working with security and preparedness. Promoting multi-stakeholder communities, action and governance where the cities take on a role of orchestrating cooperation and joint action of many different actors to solve complex problems and change societal systems together. This puts cities in a strong position to create resilient local communities that care for and take care of their neighbours and neighbourhoods. Recognise that communities can also represent a vulnerable node within a city's ecosystem, given increased migration into cities, growing inequalities and poverty, generational differences, growing social isolation and loss of public trust in power. The challenge is to not only fix vulnerabilities (e.g. ensure that disinformation campaigns do not target vulnerable groups and drive up societal division) but also to strengthen such nodes so that the community regain trust and support societal resilience.

5.4.3. Governance Integration and Collaborative Scenario Planning

- Holistic Urban Planning: Integrating climate (mitigation and adaptation) and preparedness into every layer of urban policy ensures that resilience is built into the fabric of the city. Risk and scenario analysis can be applied as an approach for developing strategic plans that are adaptable and resilient to various potential future conditions. It enables the assessment of a range of plausible climate-related risks and opportunities, ensuring preparedness for different outcomes.

- Multi-Level and Cross-Sector Collaboration: Effective climate mitigation and adaptation requires coordinated efforts among local, regional, and national governments, as well as private stakeholders and communities. Collaborative governance leads to innovative, scalable, and sustainable adaptation strategies and civil preparedness.

- Fostering regional and international cooperation: Cities can draw upon the sharing of best practices, technical expertise, and resources to scale successful mitigation, adaptation and resilience initiatives across cities, regions and nations.

- Leverage Data for Risk Analysis, Monitoring and Scenario Building in Policies and Strategies: Adopting a data-driven approach to climate mitigation, climate adaptation, and security initiatives can help identify and mitigate risks, adapt to shocks and stresses and find synergies. Using digital twins and installing regular monitoring, feedback loops, and learning environments help to keep scenarios and strategies up to date and to also use them as learning and training opportunities
  Data gathering would also benefit from enhanced community engagement: involving local communities in planning and decision-making processes would facilitate adaptation strategies that address local needs and build collective resilience.

5.4.4. Leveraging Nature-Based Solutions (NbS)

- Multiple Co-Benefits: NBS, such as green roofs, urban forests, and restored wetlands, not only help manage urban microclimates but also improve air quality and enhance community well-being. These solutions provide a cost-effective and sustainable way to address multiple urban challenges simultaneously, and gain multiple synergistic benefits.

- Ecosystem Services: Beyond mitigating climate impacts, NBS enhance biodiversity and provide ecosystem services that are essential for long-term urban resilience, including water regulation and carbon sequestration.

5.4.5. Training, skilling, reskilling

- Enhancing crosskilling expertise by expanding professional development programs, attracting, retaining and advancing those that work across borders and silos as well as specialized personnel.
- Recognising that innovation and relationship capabilities are crucial for enhancing the implementation of climate, security and preparedness agendas.

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Annex 7 – Blog post: Preparation vs prevention?
How cities can find a balance as they face challenges of climate change (DML)

Author: Dark Matter Labs (based on partners' outputs)

Will we run out of the materials we need for clean energy generation? How do we balance adapting to a changing climate with mitigating and preventing its worst effects? And what role could AI play in achieving climate neutrality? These are some of the key questions facing cities and, in three upcoming papers introduced in this post, NetZeroCities partners Dark Matter Labs, Demos Helsinki and Polimi take a deeper look.

Anticipating future problems and opportunities should be a priority for organisation's risk management and to inform their decision making – and cities are no exception.

Yet to what extent can cities invest their energy in thinking about things that don't fit neatly in action plans and municipal budget lines just yet?

These reports, produced by partners in NetZeroCities, summarise the thinking on a series of topics that will affect cities in the next three to five years and set out trends, risks and opportunities that cities will need to know, including:

- Electrification risks https://netzerocities.app/resource-4870
- AI and carbon neutrality https://netzerocities.app/resource-4871
- Adaptation and mitigation https://netzerocities.app/resource-4872

Full electrification risks

Transitioning to clean energy technologies will undoubtedly be a driving force in the transition to a low-carbon economy. It is, however, crucial to have a holistic perspective and account for the potential negative side effects that could come with it.

Much of the minerals needed for clean energy transitions are highly geographically concentrated for both the extraction and production stages. This high geographical concentration could give rise to social distress and geopolitical risks that in turn creates vulnerable supply chains. Alongside this too is the limited capacity for mining and refining in a sustainable way and at the speed required.

There might be enough raw material for a European green transition, but Europe has no circularity capacity for long-term electrification maintenance, and sourcing is currently deeply problematic in terms of carbon emissions, timescales, working conditions and labour force, corruption and geopolitical risks.

Apart from transitioning towards renewables, we need to rapidly develop technology and circularity in their production and material sourcing, and even more importantly reduce the energy demands by redefining our needs and standards.

Adaptation and mitigation

As global temperatures continue to rise, evidence indicates that mitigation efforts alone are insufficient to prevent the negative impacts of climate change. Cities must not only persist in cutting emissions but also work toward strengthening their adaptation strategies, building the necessary resilience to manage inevitable consequences.

There is an urgent need for mitigation-adaptation integration. The success of implementing and evaluating integrated mitigation and adaptation actions greatly depend on the availability of financial resources.

But the ways cities respond can result in potential maladaptation – this paper argues that mitigation and adaptation should be viewed as interdependent strategies to reduce the risk of maladaptation.

Currently, however, mitigation is prevailing over adaptation. The prevalence of mitigation is attributed to several factors, including from cities' lack of governance capacities for implementing both policies, and international networks and agreements that inadvertently promote mitigation over adaptation.

Adaptation's challenging implementation can be down to its lack of evaluation methods and, to date, there are no clearly transferable methods or universal metrics to monitor the effectiveness and progress of adaptation measures and strategies are often transferred from one city's best practices to others, or applied uniformly, assuming the same conditions across different areas of the same city.

AI and carbon neutrality

AI offers potential solutions for cities to:

- mitigate carbon emission impacts through advanced technologies in energy, mobility, agriculture, and water and waste management. However, the adoption of AI must be approached carefully, considering both its advantages and risks.
- optimise energy consumption of buildings, energy distribution and energy storage thus contributing to energy savings – but it also demands significant energy to function itself, highlighting the need for greener AI solutions.
- radically improve the efficiency of urban mobility by reducing congestions and lowering emissions, but this requires overcoming financial barriers as well as regulatory, technological and commercial hurdles.
- to useAI in urban farming for future food production, however, this comes with costs to access the technology and the digital literacy of end users.
- overhaul waste management by improving efficiency and promoting recycling, but attention needs to be given to implementing new paradigms linked to the circular economy.
- improve water usage and management, but there are the costs associated with AI's own water consumption.

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Annex 8 – Blog post: Scenarios for Sustainable Cities Future (DML)

Author: Dark Matter Labs (based on partners' outputs)

Introduction

A series of new Futures Scenarios imagine what could happen in 4 fictional cities from different regions in Europe as they respond to a variety of challenges and opportunities that catalyse change.

This exercise in strategic foresight drew on insights from a series of futures deep dives,horizon scanning interviews with experts as well as scenario making collaborative workshops to inform 'what if' thinking, and respective tactics and actions.

The resulting scenarios deliberately focus on providing strategic moves that led to the positive city futures to shed light on the possible pathways NZC cities may undertake already now. The pathways draw from existing glimmers of systemic change and seed innovations set out how each city overcomes the ensuing structural, institutional and cultural barriers and crisis management they will face in order to achieve climate neutrality by 2030.

Scenarios

- *Read Full Scenarios Here*
- *Explore MIRO Board with the Scenarios and Tactics or Download a PDF*

Scenario 1: Radical policy shifts impacting on construction

In 2025, a European-wide policy shift imposed carbon ceilings on cities, particularly targeting the construction sector. The policy threatened to stifle growth, particularly in housing, and initially faced strong resistance from stakeholders. However, Veldon's leadership recognized the opportunity for transformative change. Rather than viewing the restrictions as obstacles, the city embraced them as a catalyst for a new approach to urban living.

Within Veldon's scenario at one point Veldon is envisaged as revolutionizing its approach to energy by implementing radical new ways of generating and storing energy. The city transitioned to renewable energy sources, including solar panels on all retrofitted buildings and wind farms around the city. Additionally, energy storage systems allowed the city to maximize its green energy use, even during periods of low generation. The associated case study in Pecs on converting existing plants and the associated challenges mirrors the experience of many cities at this point as they too navigate implementing future facing infrastructure within present day constraints.

Scenario 2: Degrowth futures and a radical approach to cumulative crisis'

In 2025 Tondende was worn down by competing demands of tourism, draught management and deindustrialisation. A series of small crises escalated into a political crisis and Tondende's municipal government and citizens found themselves at a point of needing radical change. Adapting together was demanding socially but small positive impacts immediately reassured Tondende residents that the recalibration was positive.

Degrowth can seem a very detached and hard to implement future strategy, but the principles of deliberation and representation, allocation and distribution are already being explored in many places. In Braga, Portugal You Decide [Tu Decides] is a innovative participatory budget that demonstrates the potential. (https://netzerocities.app/resource-casestudy-2851)

Scenario 3: The opportunity and challenges of AI for carbon neutrality

The catalyst for Heilding's transformation came in the form of an escalating climate crisis. Like many cities, Heilding faced rising energy consumption, inefficient transportation systems, waste management inefficiencies, and the adverse impacts of climate change. In response, the city committed to the EU's Mission for Climate-Neutral and Smart Cities by 2030, aiming to integrate AI technologies into climate action strategies for energy efficiency, waste management, and transportation.

However, the use of AI was not a straightforward solution. The city faced significant challenges that needed to be addressed for AI to effectively contribute to its climate goals.This is an example of where technology and the idea of its potential often moves faster that the digital reality on the ground, and we can learn from the contemporary experience of Rivne when they launched the development of the Municipal Energy Passport (MEP), a digital platform for monitoring, managing, and analysing energy consumption across municipal infrastructure.(https://netzerocities.app/resource-casestudy-4770)

Scenario 4: Adaption, critical response and mitigation to climate based vulnerabilities

In 2025, Solvstadt was hit by a series of extreme weather events that highlighted the city's vulnerabilities to climate change. After severe flooding caused by record rainfall, the city's leadership recognized that climate action could no longer be approached in silos—mitigation alone was insufficient to prepare for the future. The city needed to integrate both mitigation and adaptation strategies to build a truly climate-resilient city. While there are obvious connection we can make to cities that have faced the brutal reality of climate change driven weather events there are also learnings that are far more planning and forecasting based investments in governance changes.

Like in Umeå building capacity for transition leadership (https://netzerocities.app/resource-casestudy-4740) or in Malmo, where Green Bonds form a crucial part of financing integrated transition solutions and infrastructure. (https://netzerocities.app/resource-casestudy-4327)

Outro

By using fictional cities and catalysts the team was able to extract learnings from multiple cities experience and allow themselves to engage in world building and the creation of scenarios that "project into a conceivable future and its contingencies ". These are rooted in learning from across the NetZeroCities ecosystem, and in the scenarios there are links to case studies or examples we can learn from too.

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Annex 9 – Blog post: When efficiency isn't enough: How can sufficiency policies help cities to reduce resource demand while ensuring a good life for all (Demos)

Author: Demos Helsinki

Introduction

Research increasingly shows that energy and resource efficiency and technological innovation alone cannot solve our climate and environmental crises. Major actors like the IPCC and the EU Horizon Programme are therefore turning their eyes towards how resource demand can be reduced, while ensuring that everyone's needs are met. A new NetZeroCities report by partner Demos Helsinki takes a deeper look at what sufficiency policy could mean for cities, especially when it comes to housing, mobility and food.

'Sufficiency' has gained attention in recent years as a way of decreasing emissions and reducing environmental footprints while securing sustainable wellbeing for all.

A key takeaway of our report is that sufficiency offers cities a necessary complement to efficiency and technological innovation. Adopting sufficiency principles can guide cities to design fair and effective policies that reduce emissions while improving social equity. We recommend that municipalities begin by embedding sufficiency thinking into their governance to start asking new questions about necessity, need satisfaction, and equitable resource use.

Read the full version here (Comms team should paste the link).

What is sufficiency?

The Intergovernmental Panel on Climate Change (IPCC) considers sufficiency "a set of measures and daily practices that avoid demand for energy, materials, land, and water while delivering human well-being for all within planetary boundaries." The UN Environment Programme adds a just transition perspective and notes that sufficiency is about the need to increase resource use in low-development contexts to enable dignified living while reducing consumption of populations whose consumption is well above the planetary capacity.

Sufficiency focuses on meeting people's needs while staying within ecological limits, and on wellbeing and preconditions for a good life. As illustrated by the UNEP definition mentioned above, sufficiency also underscores the need for a fairer distribution of resources.

How can sufficiency principles help EU Mission Cities?

The emergence of sufficiency as a hot topic is particularly timely for the EU Cities Mission. Mission Cities and their climate mitigation efforts could benefit from sufficiency-oriented approaches to tackle consumption-based emissions, strengthen social justice, and close the gap between current trajectories and climate goals.

As cities carry responsibilities for both the environment and social wellbeing, embedding sufficiency as a guiding principle can be a way of integrating local environmental and social equality efforts and finding co-benefits and synergies between them. While the concept brings together these different

fields, it also has the potential to unite sectors and bring more municipal departments and new stakeholders on board to create visions and measures for the future.

What are sufficiency policies?

Sufficiency policies address production and/or consumption and go beyond technological improvements to redefine and explore how human needs can be met in more sustainable ways.

Successful sufficiency policy relies on both phasing in more sustainable practices and phasing out unsustainable ones. The French ban on short flights, for example, both phases out unsustainable options (air travel) and supports sustainable options by investing in train infrastructure. It is important to integrate both approaches, instead of focusing on individual, siloed policies.

Policy and planning approaches to promote sufficiency could include:

- Land lease regulations (e.g., favouring developments that include shared spaces or co-housing solutions)
- Practical and financial support for elderly looking to downsize within their local neighbourhood
- Council tax surcharge for un-used or under-used apartments
- Progressive property taxes based on per capita living area
- Prioritising walking and biking in infrastructure and urban planning
- Setting up a zero new land-take goal for roads
- Communication of co-benefits (for instance health benefits of active mobility)
- Supporting local community initiatives
- Integrating sufficiency principles in public procurement (e.g. setting requirements on repairability and durability, and only procuring when critical or something needs to be replaced)

Please see our ***report f***or more examples of sufficiency policies and governance.

Where can cities start?

The report emphasises that while many municipalities already implement measures aligned with sufficiency (e.g. Zürich and Grenoble), few have yet developed comprehensive strategies guided by sufficiency principles. Moving from isolated actions to integrated policy mixes is a central challenge. Successful implementation requires coordination across departments, alignment between policies, and a combination of both 'pull' measures that enable sustainable practices and 'push' measures that limit unsustainable ones. Experimentation, evaluation and adaptation to local conditions are also crucial to understanding what works.

Citizen participation and cooperation with stakeholders are also identified as essential elements of sufficiency-oriented policies. Deliberative citizen panels are highlighted in research as particularly suitable tools. The new report highlights the importance of ensuring that costs and benefits are distributed in a just manner. Further, it notes that local governments need to collaborate with civil society, companies and social movements, and support bottom-up initiatives aligned with sufficiency.

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Annex 10 – From Neighbors to Networks - How Communities Fund Their Own Future (DemSoc)

Author: Democratic Society

Introduction

Imagine an island powered entirely by its residents, a grocery store fighting food waste while building community, or a network of affordable homes shielded from market speculation. These aren't utopian dreams - they're real examples of communities taking control of their own resources and rewriting the rules of local finance. Across Europe, community-owned enterprises are showing that collective action can fund sustainable, inclusive, and resilient local economies in ways traditional markets often cannot.

Within the framework of **NetZeroCities**, we conducted an anticipation and foresight activity taking a closer look at community-owned enterprises. Unlike conventional businesses, these initiatives are owned and run by the very communities they serve, ensuring that value circulates locally. They take many forms - such as housing cooperatives, mobility initiatives, renewable energy projects, and community food programs - and their financial models are as creative as their missions.

By examining four cases across Europe, we explored how communities overcome the challenge of early-stage financing, turn risk into opportunity, and ensure broad participation. We also looked at how cities can create the right conditions for community-owned organizations to flourish.

Four Inspiring Cases

1. **Mietshäuser Syndikat (Germany) -** A network of over 180 housing projects, Mietshäuser Syndikat protects affordable homes from speculation. Emerging from Germany's squat movement in the 1990s, these projects are self-managed through grassroots democracy. Bank loans and direct loans from friends, family, acquaintances, and foundations form the two main pillars of financing for new housing projects. An Internal Solidarity Fund redistributes resources across projects, helping new initiatives get started and remain independent of market pressures.
2. **SomMobilitat (Spain) -** Founded in 2016 in Catalunya, SomMobilitat provides shared electric vehicles to reduce private car use and build greener cities. It was created by activists linked to the SomEnergia network, who adapted cooperative energy principles to the mobility field. In its early stages, SomMobilitat was financed through volunteer work, pre-financing from its founders, and visibility and support from SomEnergia. Start-up prizes and member loans with fixed terms allowed the cooperative to expand its fleet and operations while remaining community-driven.
3. **Energy Island Samsø (Denmark) -** Samsø became internationally known as "Energy Island" after transitioning to 100% renewable energy. The project began in 1997 with a national competition that sparked local collaboration between residents, farmers, and institutions. Innovative financing - such as allowing residents to buy wind turbine shares without upfront capital and repay loans via electricity sales under a national feed-in tariff enabled broad participation and long-term community ownership. Today, Samsø stands as a global model for local energy transitions.
4. **Community Grocery Shop (UK) -** Launched in Manchester during the first COVID-19 lockdown, this initiative provides affordable surplus food while tackling food poverty and social isolation. Initially funded by church donations and local support, it now offers grocery services

alongside cooking classes, financial advice, and wellbeing programs. By saving over 5,250 tonnes of food from landfill, it combines environmental impact with human dignity.

How Community Owned Enterprises Make It Work

Across the cases, several pathways to early-stage financing emerged:

- **Solidarity-Based Funding:** Small direct contributions from community members can seed powerful initiatives. In Mietshäuser Syndikat, housing collectives pool small loans from friends, family, acquaintances - sometimes as little as €500 - to buy land and build homes. Banks often recognize these direct loans as equity replacements, unlocking access to traditional financing.
- **Membership-Based Contributions:** Regular member fees or small loans create stable, recurring income and strengthen local ownership. SomMobilitat, for example, is sustained by thousands of members who each contribute annual fees and small investments, providing both working capital and long-term commitment.
- **Government Support:** Structured subsidies, competitions, and grants can provide the financial backbone needed to scale, as seen in Samsø and SomMobilitat. Samsø's energy transition began with a government grant and ongoing subsidies, while SomMobilitat grew through start-up prizes and its cooperative network.

Community-owned enterprises are also **rewriting financial design itself**. Mietshäuser Syndikat's Internal Solidarity Fund allows new projects to co-finance others within the network, strengthening collective resilience. Samsø's feed-in tariff guaranteed a minimum energy price, enabling residents to invest without upfront capital and repay loans through energy revenues - a mechanism that democratized ownership of the island's renewable future.

Financial creativity alone isn't enough, however. The **social dimension** is central. The Feed-in tariff in Samsø, allowed everyone - regardless of income - to participate in wind projects, turning the green transition into shared economic benefit. Manchester's Community Grocery Shop offers not only affordable food but also community connection and practical support, ensuring no one is left behind.

Risks to Watch

Despite their successes, community-owned enterprises face structural challenges. Unequal legal recognition can make it difficult to scale or access loans, while market competition threatens local control - successful models can attract larger players, risking displacement or reduced influence. Heavy reliance on grants or donations also leaves initiatives vulnerable to shifting political priorities.

At the same time, the broader social and environmental impacts of these initiatives are often undervalued in funding and policy systems. Without recognition of these wider benefits, community-led projects risk being treated as niche or charitable efforts, which can hinder their sustainability and impact.

What Cities Can Do

These stories aren't just inspiring - they offer concrete lessons for urban policy. Cities can help community-owned enterprises thrive by:

1. **Providing Accessible Funding:** Design grant programs and subsidies that are easy to access and adaptable to diverse community-led projects. A key ingredient is to create flexible grants that recognize different organizational forms.

2. **Creating Supportive Legal Structures:** Legal frameworks can either enable or constrain community-led initiatives. Cities should recognize community organizations as key stakeholders in shaping regulations that affect them.
3. **Protecting Local Economies:** Community-led initiatives are often vulnerable to competition from large, established actors. Cities can mitigate this by prioritizing local actors in funding, procurement, and public space allocation - and by providing platforms to showcase community-led solutions, raising visibility and credibility.
4. **Mobilizing Local Resources:** Cities can actively support community-led initiatives by providing space, infrastructure, and networking opportunities.
5. **Encouraging Leadership:** Recognizing and supporting local changemakers accelerates impact and sustains momentum.

A Glimpse into the Future

Community-owned enterprises are more than local experiments - they're **laboratories for building a fairer, greener, and more resilient economy**. By blending solidarity, innovation, and strategic partnerships, they show how communities can anticipate challenges, create opportunities, and lead change. For cities willing to nurture them, these initiatives can become the building blocks of a just climate transition - turning local action into global inspiration.

Annex 11 – Learnings from the process

There were several learning opportunities within this task, and we have some reflections on the process, expectations and future resourcing for similar activities. There were also deviations that were circumstantial and unexpected that should be articulated. While anticipation and foresight task partners met fortnightly to align on tasks and synthesis associated with the deliverables. This was consistent between months 4 and 18 then paused as the task lead experienced serious health problems. A decision was made to pursue the completion of existing work separately while pursuing an extension to reflect the position of the task delivery.

Fundamentally we see a disconnect in the aspirations of the task and the structure of the resource and positioning. In a contemporary understanding of foresight and anticipation this is an activity that is most powerful and can inform strategic actions when it is done with those it seeks to influence. In this instance that would be either Mission Cities themselves or those actors within NetZeroCities that directly influence program design. In being located as a collaboration of task partners without the city facing remit and minus the positioning and agency to work directly with those it seeks to impact it instead becomes a form of remote content generation and depends more heavily on knowledge alienated from the sources.

The structural set up and aspiration of horizon scanning briefings as written in the grant agreement assumed a level of involvement and responsiveness whereas the reality was that the voice of the early horizon scanning briefings became just another bit of short form content in a very saturated environment. It wasn't long enough or targeted enough for the newsletter nor appropriate for the portal. In the end the mode of communication to committees was instead tailored on request and generally took the form of a slide deck.

There was disjointed communication aspirations versus the reality of communication architectures and constraints. For example, the initial formatting and intention of deep dives was going to be distinct, but the brand guidelines and constraints put them into a standardised format with no room for differing information hierarchies. Conversely the aspirations for radically different scenarios the task partners brought to scenario generation assumed a level of resourcing and collaboration with WP 9.2 on editorial content that didn't manifest. Scenario articulation and visualisation relied instead on more universal formats like PDFs, as opposed to being rich and standalone content types as the hosting of them was tied to established platforms and conventions. This alongside under resourcing left little room for the team to sustain creative energy and inspiration.

The resourcing of the task overall and the differing PMs per partner organisation rendered many partners unable to contribute beyond the fortnightly meetings and deep dive production. Aspects like the involvement of experts in horizon scanning had no distinct resource, travel budget or clear value proposition to the contributing expert. This put a strain on the delivery of these and momentum for them became challenging. It is worth highlighting that the ambition of the task did not align with the allocated WPs and aspects like engaging external experts lacked any associated budget to compensate or acknowledge their contribution. Additionally working collaboratively was 100% remote which doesn't always enable strong alignment.

An additional challenge that was circumstantial was the unexpected illness of the task lead and the ensuing decisions on whether to postpone significant production, invest in future work or pause. This uncertainty and the need to bring in additional capacity for the transition period impacted both the need for an extension and became a stressor that magnified existing differences of opinion and intent for the task.

Fundamentally the aspiration to provide a function for futures literacy and awareness is a good idea, and the needs outlined in the grant agreement in many cases were validated, but the structural constraints and context added complexity and there is a mismatch between aspiration and impact. This misalignment can be better resolved in future activities by responding to the reflections above,

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The purpose of Task 4.8 is to provide an anticipation and foresight function for NetZeroCities, allowing capacity for agile responses and innovation through future programme & service (re)-design. This was based on a number of assumptions about influencing strategies and communication which had variable realities and constraints.

Coordination with WP2, 3, 6 was mediated by the work package lead and we found it most efficient to mainly used deliverables and research produced by WP 2 and 3 to incorporate into our processes. Deeper collaboration was envisaged with CRS temporarily around scenario articulation, but the mechanics of how to collaborate and align our differing responsibilities and approaches proved challenging. There were clear alignments and a desire late on in the task to align with 6.5 and the policy labs and use 4.8 content to seed richer conversations with cities from the policy lab participants. However, the required adaptations and dedicated time were not available to customize it in a way where the value proposition for cities was clear and easy to communicate. We have instead put together a forward-looking integration of 4.8 assets with the groundwork and intent outlined that sits better within a city support facing budgeting.

Triangulating emerging signals from cities (WP2), integrating knowledge from various research activities (Tasks T4.3 and T4.6), and scanning the horizon for risks and opportunities in global trends and events is a task that could easily become a full-time role or department. In our experience of initially producing the Horizon scanning briefings for the strategic committee, we had to refine what our request and expectations were of the participants. When a new committee was suggested as a more natural home, the delivery of these evolved, but the stalling of the production rhythm never really recovered. By coordinating with multiple work packages, T4.8 aimed to provide cities, the consortium, and the Mission with the tools and insights needed to anticipate the barriers, bottlenecks, and opportunities associated with medium to long term trends and Overton window shifting events or crises. However, with the resourcing being so light in terms of capacity, this could not be done effectively.

One question that we returned to consistently was a lack of clarity about the audience for the work and the mechanics of influencing them. The initial focus was on producing the foundational work that the rest of the task aspired to build upon but as the pace of production was staggered and forecast linearly and knowledge was expected to cascade accumulatively this proved out of step with both the deliverables schedule and how information moves through NetZeroCities.