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From Crisis to Growth: Pre-Disaster Planning as a Catalyst for Sustainable Innovation and Circular Economy in European Cities

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1 ABSTRACT

The proposed contribution analyses how short- and long-term strategies in urban planning can foster urban resilience and a circular economy by comparing technological measures, nature-based solutions and integrative communication processes. In examining how authorities engage the public to address emerging hazards, this study demonstrates the role of pre-disaster planning in catalysing sustainable innovation. We highlight communication as the key driver for inclusive, resilient long-term policy.

Our case studies include Graz (AT) and Ljubljana (SLO). Though confronted with similar ecological and socio-demographic challenges, the two cities address these challenges in markedly different ways, reflecting culturally biased divergent policy priorities and communication strategies. Using Graf et al.'s 2026 introduced Aware–Prepare–Act (APA) lens as a heuristic, the paper conducts a comparative policy analysis of two contrasting urban governance models. The paper tests the thesis that technological upgrades (e.g., expanding tram networks, cycling infrastructure, digital tools and AI) only produce urban resilience when anchored in sustained communication and participatory processes, a relationship made visible through an overarching APA lens on prevailing practices. In addition, inclusive, participatory formats are crucial for the achievement of a Social Licence to Operate, needed for boosting involved stakeholders' acceptance to redesign cities for enhanced biodiversity, integrate green infrastructure, and organizational learning on all levels.

Keywords: Urban resilience, Participatory Urban Planning, Communication Strategies, Circular Economy, Nature-Based and Technological Solutions

2 INTRODUCTION

European cities are increasingly exposed to compound and cascading risks arising from climate change, demographic shifts, and infrastructural ageing. Heatwaves, flooding, biodiversity loss, and energy insecurity challenge established urban development models and strain institutional capacities. In this context, disasters are no longer isolated events but manifestations of long-term structural vulnerabilities. Urban governance has often been characterized by a predominant focus on response and recovery. Recent research increasingly emphasizes anticipatory and preventive approaches to disaster risk management, highlighting the need to reduce vulnerability before hazardous events occur (Botzen & van den Bergh, 2009). These approaches embed disaster risk reduction within broader sustainability objectives, as articulated in the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015). Analyses of the Sendai Framework further interpret this shift as a move toward risk-informed and preventive governance that extends beyond reactive disaster management (Kelman & Glantz, 2015). Beyond climate-related hazards, urban mobility systems constitute a persistent and underestimated risk domain in European cities. According to the DEKRA Road Safety Report 2025, road traffic remains one of the leading sources of preventable fatalities in urban environments, with vulnerable road users accounting for a growing share of deaths, particularly in cities undergoing rapid mobility transitions. The report emphasizes that technological upgrades alone (such as digital traffic management or vehicle automation) do not reduce systemic risk unless accompanied by behavioural change, governance coordination, and sustained public communication (DEKRA Verkehrssicherheitsreport 2025).

Pre-disaster planning has emerged as a governance arena where risk anticipation, infrastructural investment, and institutional learning intersect. This paper builds on this premise, thus asks: How does pre-disaster planning shape the relationship between risk communication, circular economy strategies, and urban

resilience? To address this question, the paper compares Graz (Austria) and Ljubljana (Slovenia), two medium-sized European cities facing comparable ecological and socio-demographic challenges but pursuing markedly different governance and communication strategies. The analysis draws on the Aware–Prepare–Act (APA) lens as a supportive conceptual heuristic, which supports the comparative interpretation to how communicative purposes (awareness-building, preparedness-oriented communication, and action-oriented signals) and temporal orientations are articulated across policy domains (Graf et al., forthcoming). By focusing on communication and participation, the paper advances the argument that technological and infrastructural innovation only becomes transformative when socially embedded and publicly legitimised.

Demographic comparison of Graz and Ljubljana			
Indicator	Graz	Ljubljana	
Country	Austria	Slovenia	
Settlement type	regional city (mid-sized)	capital city (mid-sized)	
Area (total)	127.58 km²	163.8 km²	
Population (most recent value stated)	345.391	301.268	45,983 (total Ljubljana)
of which EU citizens	52.563	5.686 (Osrednjeslovenska region)	
of which non-EU citizens	50.092	no data	
Population density	2. 707,25/km²	1. 839,24/km²	

Table 1. While 15.3% of Ljubljana's inhabitants are foreign nationals, the specific breakdown for EU citizens is only designated at the regional level for Osrednjeslovenska (SiStat 2026a, 2026b). Numbers are considered most recent (01.01.2026 for Austria, Second Half Year 2025 for Slovenia).

The demographic profile of Graz consists of 50.55% female and 49.45% male residents, with the 25–30 age bracket representing the most prominent cohort across both genders. In contrast, Ljubljana's demographic structure is older, with the 40–44 age group being the most populous, while the 25–30 bracket ranks fourth, accounting for approximately 13% of the total population (SiStat 2026). These demographic characteristics are relevant insofar as they shape participation potentials and legitimacy structures in urban mobility governance. Statistically, members of Gen Z and Millennials are more inclined to adopt digital and shared mobility solutions, which generally fosters more sustainable urban transport systems (Arsovski et al. 2025; Little 2024). Demographic change further amplifies the relevance of inclusive mobility planning. OECD analyses show that ageing societies require adaptive transport systems that integrate accessibility, safety, and participation, reinforcing the need for anticipatory governance in urban mobility transitions (OECD, 2001).

Despite these demographic potentials, a critical disparity arises regarding political agency. In Graz, 29.7% of inhabitants lack Austrian citizenship, and only 15.2% of this group (those holding EU citizenship) possess municipal voting rights (Stadt Graz 2026). This exclusionary framework significantly impacts local governance and social cohesion (Statistik Austria 2025). The restrictive nature of the Austrian franchise becomes particularly evident when compared to the Slovenian model. While Graz excludes third-country nationals from local elections, Slovenia grants municipal voting rights to all foreign residents with permanent residency, regardless of their country of origin. Furthermore, Slovenia's National Council facilitates "functional representation", allowing foreign workers to participate in interest-based elections (Waldrauch 2022).

Finally, urban safety remains a critical metric for both cities. In 2024, Graz recorded 1,655 traffic accidents involving personal injury, resulting in 2,003 casualties and 7 fatalities (Statistik Austria 2026). Though there are no final numbers for Ljubljana 2025, it had zero road fatalities in 2024 (DEKRA Verkehrssicherheitsreport 2025).

3 THEORETICAL FRAMEWORK

3.1 Urban Resilience and Circular Economy

Urban resilience has evolved from a predominantly technical concept concerned with robustness and recovery toward a socio-ecological framework that integrates governance, participation, and learning. Contemporary resilience research emphasizes adaptability, transformability, and the capacity of urban systems to reorganise in response to long-term stressors. Parallel to this development, the circular economy paradigm has gained prominence as a sustainability framework aiming to decouple economic activity from resource consumption through reuse, regeneration, and closed material loops.

Resilience and circular economy approaches both challenge linear planning models and highlight the need for cross-sectoral coordination. In urban contexts, circular economy strategies often materialise through

mobility transitions, green infrastructure, energy systems, and waste management. Their success, however, depends not only on technological feasibility but also on governance arrangements and public acceptance. Recent research highlights that transitions toward circular urban systems critically depend on everyday practices and lifestyles. Studies focusing on urban communities demonstrate that circular economy strategies are only effective when infrastructural change is accompanied by shifts in consumption patterns, mobility behavior, and social norms, reinforcing the role of communication and participation in enabling systemic transformation (Szabó et al. 2024).

Recent mobility research further demonstrates that circular economy strategies in transport systems simultaneously reduce environmental pressure and systemic risk exposure. A large-scale review of urban mobility transitions shows that cities integrating reuse-oriented mobility services, shared infrastructure, and demand-management instruments experience lower rebound effects and higher system robustness than cities focusing exclusively on electrification or digital optimisation (Zhang et al., 2023). A systematic synthesis of circular economy strategies in the transport sector shows that interventions focusing on reuse-oriented services, shared infrastructure, and lifecycle optimization tend to produce broader environmental and operational benefits than narrow electrification or digital optimisation strategies (He et al. 2023). Recent scoping reviews of urban mobility literature highlight that integrated planning for sustainability and resilience, especially through multimodal systems and redundancy, enhances both environmental outcomes and systemic robustness in the face of disruptions (Sassaron et al. 2025).

3.2 Pre-Disaster Planning as a Transformative Bridge – from Participation to Social Licence to Operate

Pre-disaster planning has evolved from reactive emergency management into a transformative governance space that reshapes development trajectories before disasters impose urgent constraints. It functions as a temporal bridge, aligning short-term risk awareness – defined by the interaction of hazard, exposure, and vulnerability (UNDRR 2017) – with long-term infrastructure cycles. The ETSC PIN Annual Report (2025) validates this by showing that sustained safety gains result from institutionalised preventive governance and public engagement rather than isolated technical investments. Thus, anticipatory planning serves as a risk governance mechanism that synchronizes safety, sustainability, and behavioral adaptation (ETSC 2025).

Securing an SLO is critical for sustainable transformation, requiring both capable institutions and active stakeholder involvement to develop legitimate solutions (Borrás et al. 2025, Wenander 2024). Within the spectrum of participation, cities must move beyond a one-sided transfer of information (where experts define goals) towards the co-production of knowledge based on joint problem definitions (Schneider et al. 2018). This shift is essential for implementing the demand-side measures and lifestyle changes that the IPCC (2022) identifies as central leverage points for mitigating climate risks in urban mobility and infrastructure systems.

3.2 The Aware-Prepare-Act Lens

The conceptual foundations of the APA lens build on empirical insights from a systematic scoping review of risk and crisis communication research, which identified persistent fragmentation between short-term warning-oriented communication and long-term adaptation-oriented approaches (Graf et al. 2026).

Building on these empirical findings, the APA lens was subsequently developed as a conceptual heuristic through iterative analytical synthesis and interdisciplinary expert consultation (Graf et al. forthcoming). It distinguishes three interrelated communicative purposes: awareness-building, preparedness, and action.

Awareness refers to the communication of risks, uncertainties, and long-term challenges to diverse publics. Preparedness encompasses planning instruments, institutional capacities, and resource allocation.Action refers to communication related to concrete measures and infrastructure interventions as they are presented in policy documents, without implying an assessment of their implementation or effectiveness. s. The analytical value of the APA lens lies in its capacity to make patterns of emphasis and potential communicative gaps analytically visible, particularly situations in which technical planning advances without corresponding social engagement, as well as configurations where participatory communication reinforces policy coherence and legitimacy.

3.3 Social Licence to Operate in urban transformation

Originally developed in the context of extractive industries, the concept of Social Licence to Operate (SLO) has gained relevance in urban governance. Large-scale transformations, such as mobility transitions or the

reallocation of public space, often generate social conflict and resistance. Formal legal approval alone is insufficient to ensure long-term legitimacy. In urban contexts, SLO refers to the ongoing acceptance of policies and projects by affected communities. It is generated through trust, transparency, and meaningful participation. This paper adopts SLO as an analytical bridge between risk communication and pre-disaster planning, arguing that anticipatory governance can strengthen legitimacy by involving publics before crises escalate.

4 METHODOLOGY

The paper follows a qualitative comparative case study design. Graz and Ljubljana were selected due to their comparable size, regional context, and exposure to climate-related risks, combined with divergent governance and communication approaches. Primary sources include urban development strategies, sustainable urban mobility plans as issued by the respective cities, environmental indicators, and institutional publications. In order to achieve comparability the selected document are mobility plans and strategies of the respective cities that aimed for a vision 2020 and 2040, respectively. This choice allows the APA lens to render long-term goals set in the earlier document in context of the later (Graf et al. 2026). Due to the separated publication of the Graz documents, the mobility plan as well as connected documents such as the plan's measures and goals are added. This is true for both Styrian policy documents. The following table provides a overview of the used sources. Document analysis was complemented by a qualitative content analysis. A coding manual was developed based on a semi-deductive, semi-inductive approach. The deductive perspective was structured using the theoretical Aware-Prepare-Act lens. Furthermore, coding focused on three analytical dimensions: (1) technological measures and infrastructural interventions, (2) nature-based solutions (NBS) and circular economy (CE) elements, and (3) communication strategies and participatory formats.

In a first step, the main coding categories were derived deductively from the research questions and relevant literature on urban governance, risk and crisis communication, disaster risk reduction, and sustainability planning (Fereday & Muir-Cochrane, 2006; Mayring, 2014, Ellen MacArthur Foundation 2017; CE Center | Circular Economy Policy Research Center 2019).

This initial framework was subsequently discussed and critically reflected in an interdisciplinary expert round involving four researchers with backgrounds in trauma studies, sociology, linguistics, environmental systems sciences, psychology, and history. The purpose of this exchange was to assess conceptual clarity, identify overlaps or gaps, and ensure the analytical applicability of the coding categories across disciplinary perspectives. In a second step, the coding scheme was iteratively refined through inductive engagement with the empirical material during pilot coding of selected policy documents, resulting in the specification of category definitions, inclusion and exclusion criteria, and illustrative examples.

The APA lens was subsequently applied as a comparative analytical framework to examine how awareness-building, preparedness, and action are aligned or decoupled across the coded policy domains. The comparative approach allows for identifying patterns of alignment and misalignment between planning, communication, and implementation. This study remains mindful of the potential for verification bias. Following Popper's principle of falsification (1963), the framework is employed not merely to confirm the necessity of participatory communication, but as a diagnostic tool to identify where these assumptions might fail or where technological excellence, as seen in the Graz case, partially compensates for communicative gaps. The comparative design specifically looks for 'disconfirming evidence' – instances where resilient outcomes occur despite a lack of integrated participation.

5 CASE STUDY: GRAZ

5.1 Governance context

Graz positions itself as a regional innovation hub with a strategic emphasis on climate mitigation and sustainable mobility. However, the city's governance landscape is characterized by structural fragmentation, with policy responsibilities dispersed across multiple municipal departments. While high-level strategic documents articulate ambitious sustainability targets, the lack of cross-sectoral coordination often hinders the translation of these goals into a cohesive urban vision.

5.2 Technological measures and circularity

Technological interventions in Graz are robust, focusing on the expansion of the tramway network, significant investments in cycling infrastructure, and the deployment of digital traffic management systems. These measures are effective in driving a modal shift and reducing emissions. Nevertheless, circular economy principles remain weakly institutionalized, surfacing primarily as isolated, sector-specific initiatives rather than as an integrated pillar of urban resilience.

5.3 Communication and participation

The analysis of the Graz Mobility Plan underscores the systematic, dialogue-oriented integration of the Climate Advisory Council into action planning, aiming to incorporate long-term climate-related considerations. In the so-called district dialogues, held over three evenings, there was a clear match between what people wanted and the action plan presented. The mobility dialogue, attended by 300 participants, was rated as uncritical and positive, suggesting approval of the existing concept. At the same time, there is a high level of interest in participation on the part of the population, who want to have a say and be actively informed. However, the selection of target groups and stakeholders is not described transparently in the plan. It also remains unclear how the results of the online mobility survey, which had around 3000 participants, will be integrated into the further development of the concepts. Although the survey provides valuable information on preferences and needs, it does not explain how these findings will be incorporated into concrete measures.

Compared to earlier concepts such as the Graz Mobility Concept 2020, there has been clear progress: these predecessors contain virtually no references to citizen participation or stakeholder involvement. Only the city of Graz's mobility strategy mentions the need to raise awareness, but it does not specify how this should be achieved. For the city of Graz, it also remains essential to coordinate transport policy objectives and planning measures with higher-level planning authorities (the province of Styria, the federal government, ÖBB, and the EU). This serves to protect urban interests and requires targeted lobbying to address overarching problems in the transport sector. Overall, the Mobility Plan 2040 shows a significant increase in consultation elements, especially in the integration of stakeholders and expert committees, but there is still room for improvement in systematically integrating survey results and in the transparent selection of stakeholders.

A primary example for bridging academic research and municipal practice is the city’s involvement in the FLOODPREP project (a pre-disaster planning instrument), which targets extreme weather and heavy rainfall management through the development of advanced planning tools and high-resolution hazard simulations (Stadtportal der Landeshauptstadt Graz, 2025).

5.4 Circular Economy Measures in Mobility Assessment

Austria's Mobility sector has decreasing GHG emissions by 17% in comparing the years 2022 and 2023 considering the whole of the sector. In detail the reduction is due to the decrease in heavy commercial vehicles (WKÖ 2024). The UBA reports the same trend for 2024 with a reduction of 2,7% of emissions in the mobility sector, mainly due to decline in diesel sales, particularly in freight transport). In personal mobility the numbers of use have risen. In 2024 still 19,5 Mio. tons of CO2-eq are attributed to the mobility sector (Environment Agency Austria 2026). 12.3% more cars newly registered than in 2024, leading to 5.29 million passenger cars registered in Austria closing 2025 (Statistik Austria 2026). In Slovenia, the number of newly registered cars rose to 6% compared to the previous year. (Statistics Slovenia 2025). In 2023 Slovenia’s emissions linked to the mobility sector comprised the biggest share (37%, 5,4 CO2-eq) of the countries emissions, which totalled at 14,6 CO2-eq. (European Commission 2024).

To sum, the mobility sector has reduced emissions but not in personal mobility. Mobility services consume resources as well as energy, which need to be reduced in a climate friendly mobility system Based on the principles of circular economy (CE). The VCÖ has put forward a version of the 9Rs circular economy to better mobility's environmental balance (VCÖ 2022). Within the scope of this paper the version has been tailored to the CE measures that apply to cities and their governmental scope. As stated by the Ellen MacArthur foundation cities can plan a major role in implementing CE measures in the fields of urban planning, the design of mobility offers as well as infrastructure (Ellen MacArthur Foundation 2017).

To assess how the selected urban mobility plans incorporated an innovative circular economy perspective literature research concerning mobility measures was conducted. From these categories of CE measures

suitable for urban policies was derived. Subsequently, the documents were screened for the defined categories. Studying the VCÖ report it becomes apparent that the cites leverage in CE application in urban mobility is among the first Rs, focusing on intelligent use and production of infrastructure

Prominence is given to measures within the scope of urban policies. Measures targeting R4 (reuse) and higher were not observed as cities do not have high leverage to influence these factors. Instead, a focus was given to R1 refuse, R2 rethink, and R3 reuse (see fig. 1).

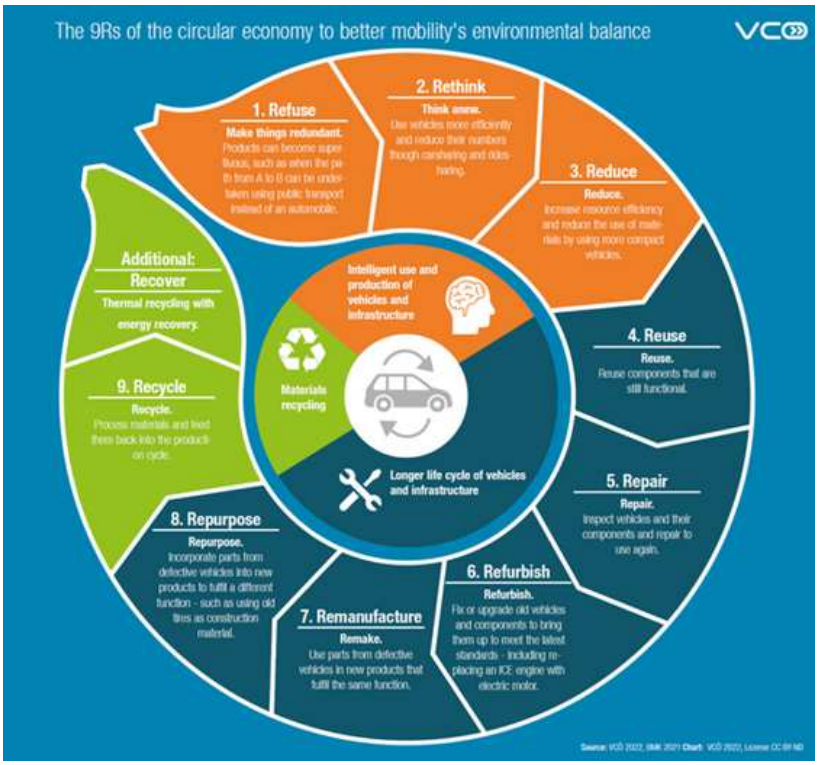

Figure 1: Measures targeting R4 (reuse) and higher were not observed as cities do not have high leverage to influence these factors. Instead, a focus was given to R1 refuse, R2 rethink, and R3 reuse. Illustration from VCÖ.

A non-exhaustive list of mobility measures implementing a circular economy follows and is used as criteria for the assessment of the selected policy documents:

- Cars (car-sharing, rental, carpooling park and ride, etc)
- Cycling (rental, storage, etc.)
- Public transport (micro-public transport / small buses /on-demand buses etc.)
- Walking (pavements, connection of mobility services, pedestrian etc.
- Monitoring (of traditional public transport, walking measures such are.

(Ellen MacArthur Foundation 2017; CE Center | Circular Economy Policy Research Center 2019)

These measures will serve as categories for the Table of Circular Economy Measures (in the Appendix). The results of the policy document assessment and a comparison is found

5.5 APA assessment

The Graz mobility governance portfolios are dominantly structured by preparedness and implementation logics. Awareness-building is present, but its integration varies across instruments. Analytically, the case comprises two policy strands: The Mobility Strategy 2020 is an integrated package (GZ-MOB-2ABC: guideline, targets, and measures), while the Mobilitätsplan Graz 2040 (GZ-MOB-01) is a consolidated long-term strategy document.

The APA profile shows that the dominant purposes for the GZ-MOB-1ABC package are to Prepare and Act. Preparedness is established through planning standards, measurable targets, and steering logics. Action is embedded in a structured implementation measures program. Awareness remains supportive and focuses on the upstream guideline component through normative framing and behavior-oriented messaging. The

package is clearly long-term focused, using hybrid implementation pathways, including phased roll-out of measures. Communication occurs mainly through information and consultation, with little explicit evidence of feedback loops covering the whole portfolio.

GZ-MOB-01 outlines a scenario-based approach, long-term targets, and institutionalized evaluation cycles as the path forward. Awareness serves as legitimizing framing, presenting mobility transition as a shared societal challenge. Action is carried out through implementation pathways and downstream measures programs. Participation formats, such as consultation, workshops, and co-creation, are more explicitly documented than in the 2020 package. This supports the interpretation that participatory elements in the planning cycle are gradually strengthening. Both Graz policy papers show the focus is on Prepare and Act. Awareness-building is included, but not always in every public relations activity. Initiatives such as FLOODPREP illustrate Graz's high institutional preparedness capacity: hazard knowledge is systematically translated into planning instruments through expert-driven collaboration, reinforcing a strong 'Prepare' logic within the APA profile, while post-event social recovery and circular innovation remain weakly addressed.

6 CASE STUDY: LJUBLJANA

6.1 Governance context

Ljubljana follows an integrative governance model that treats sustainability as an inseparable component of its long-term urban identity. Environmental objectives are strategically framed as quality-of-life improvements, a narrative shift that facilitates political continuity and seamless cross-sectoral coordination. Ljubljana's integrative governance approach is reflected in its long-term socio-demographic and mobility indicators. Official municipal statistics show comparatively lower population density pressures and a stable modal shift towards public transport and active mobility, which the city explicitly links to quality-of-life narratives rather than risk avoidance alone (City of Ljubljana, Ljubljana v številkah 2025).

6.2 Technological and nature-based solutions

The city views sustainable mobility, green corridors, and biodiversity-sensitive design as interconnected facets of a singular urban metabolism. In Ljubljana, technological upgrades are intentionally paired with NBS, creating a redundant and adaptive infrastructure that enhances systemic resilience.

6.3 Communication and participation

While the mobility plans of the City of Ljubljana include consultative elements, these remain largely expert- and institution-driven. The plans refer to workshops involving more than 300 experts and other stakeholders, as well as coordination processes with municipalities, ministries, and specialised institutions. Alignment with parallel planning instruments, such as the regional spatial development plan, is also highlighted. The resulting dialogue partnerships are therefore primarily oriented toward formal actors and expert communities. The role of the general public is largely confined to receiving information and fostering acceptance. Participation primarily serves to gather expert knowledge, provide feedback on predefined concepts, and build consensus within institutional frameworks. There is no evidence of joint problem definition with the population, nor of shared decision-making power. Long-term co-governance structures involving users, or forms of equitable knowledge co-production, are not established.

Problem framing, scenario development, and modelling logics remain consistently expert-defined. Public input is advisory rather than binding. Although the documents normatively emphasise the need for active participation of the general public, they do not specify concrete mechanisms for joint decision-making, such as co-design processes, citizens' panels, or participatory decision formats. Consequently, participation in practice ranges from passive information provision to consultation: input is collected, but decision-making authority remains with institutional actors. Co-creation is conceived exclusively within the circle of professional stakeholders, while citizens and the wider public are not actively involved in shaping outcomes. Recent sustainability research further indicates that participatory urban governance enhances policy coherence and long-term system resilience, particularly when mobility and environmental strategies are framed as shared societal projects rather than sector-specific interventions (Abujder Ochoa et al. 2025).

6.4 APA assessment

The mobility governance portfolios of Ljubljana are dominated by preparedness logics. It is evident that awareness-building and action are embedded as supportive elements across the policy instruments. The case is clear: there are two policy strands. The first is the regional guideline and project brochure Public Transport in the Ljubljana Urban Region (LJ-MOB-01). The second is the Sustainable Urban Mobility Plan of the Ljubljana Urban Region (SUMP) (LJ-MOB-02). This is a long-term strategic planning document (anticipatory/pre-disaster logic).

The primary purpose of the Policy guideline "Public Transport in the Ljubljana Urban Region" is to prepare, primarily through expert guidance, long-term regional planning instruments and to institutionalise coordination and harmonisation across governance structures (e.g. ticketing systems, timetables and regulations). Awareness-building is a key part of the solution to the structural problem framing of unsustainable mobility (traffic congestion, air pollution, CO2 emissions, noise, and quality-of-life impacts). This legitimises coordinated regional action. Action is included through concrete public transport improvements and infrastructure modernisation measures. These are described as planned and phased steps that depend on institutional and financial conditions. LJ-MOB-01 is long-term oriented, combining long-term governance coordination with hybrid implementation trajectories.

LJ-MOB-02 clearly shows a more balanced configuration. Preparedness remains dominant through its strong emphasis on regional coordination mechanisms, institutional capacity-building across municipalities, and integration of climate and mobility objectives into long-term planning frameworks. Awareness-building is explicitly documented and functions as a guiding narrative by framing sustainability and mobility transition as a shared regional responsibility linked to quality of life. Action is operationalised mainly through strategic priority initiatives and implementation pathways. These are delegated to follow-up programmes and stepwise realisation. Participation formats, including workshops, interviews, online surveys and GIS-based input formats, are explicitly integrated and accompanied by iterative monitoring and evaluation elements. This indicates a comparatively strong learning- and feedback-oriented governance logic.

7 COMPARATIVE ANALYSIS: GOVERNANCE CULTURES AND CE-INTEGRATION

The comparison of mobility policies in Graz and Ljubljana demonstrates that technological capacity alone is insufficient for resilience. Instead, the governance culture determines how pre-disaster planning translates into sustainable innovation. While both cities share a multimodal technical baseline, their strategic execution reveals distinct approaches to the APA-Lens:

- Ljubljana: Risk-Aware Integration. Ljubljana's strategy (LJ-MOB-01) is unique in its explicit consideration of failure. By including scenarios for unsuccessful measures, the city demonstrates a high level of Awareness regarding implementation risks. This transparency, combined with radical measures like city-center access restrictions, suggests an integrative communication style that prioritizes long-term legitimacy over quick technical wins.
- Graz: Developer-Led Preparedness. Graz focuses heavily on the Prepare phase by institutionalizing the "City of Short Distances" and contracting private developers to provide decentralized mobility hubs (car-sharing, bike services). While technically advanced, this decentralized "action" lacks the centralized, high-visibility communication seen in Ljubljana, potentially leading to a fragmented perception of resilience.

The CE is silent: A key finding is the total absence of Circular Economy as a term, despite the systematic use of CE-strategies (R1-Refuse through access restrictions; R2-Rethink through short distances). Both cities fail to leverage the CE-paradigm as a marketing or narrative tool to secure an SLO. This indicates that while the technical Action is circular, the Awareness phase remains disconnected from the broader sustainability discourse, leaving a significant potential for public engagement untapped.

7.1 APA

This section compares the governance logics underlying urban mobility planning in Graz and Ljubljana. It summarises the results of the qualitative content analysis conducted using the APA lens (see Chapter 4). The comparison matrix summarises the APA-based coding results by aggregating the communication purposes and their temporal orientations.

As shown in Figure 2, the analysed Ljubljana policy documents (LJ-MOB-01, 2010; LJ-MOB-02, 2019) are characterised by a dominance of preparedness-oriented communication in the long-term temporal horizon. In both documents, awareness-raising is coded as present and supportive, accompanying preparedness-oriented communication across long-term planning horizons. Action-oriented communication is coded as supportive and predominantly hybrid, indicating the co-existence of short-term measures and long-term infrastructure development as articulated in the documents. Across both Ljubljana documents, awareness-raising and preparedness-oriented communication precede and accompany action-oriented communication in terms of temporal positioning.

The Graz documents display a different distribution of communicative purposes (Figure 2). In the aggregated policy package GZ-MOB-01-ABC (2010/2012), preparedness-oriented and action-oriented communication are coded as dominant in the long-term horizon, while awareness-raising is coded as supportive and is primarily located within the strategic guideline component. In the later document GZ-MOB-02 (2025), awareness-raising is coded with increased prominence in the long-term horizon, reflected in explicit narrative framing within the policy text. Preparedness-oriented communication remains dominant, structured through scenario-based planning instruments and evaluation cycles. Action-oriented communication in GZ-MOB-02 is coded as hybrid, combining references to immediate measures with long-term infrastructure development.

To summarize, the documents differ in the distribution and temporal positioning of awareness-raising, preparedness-oriented communication, and action-oriented communication across the analysed policy documents. These differences reflect document-level patterns of communicative purpose and temporal orientation within pre-disaster urban mobility planning.

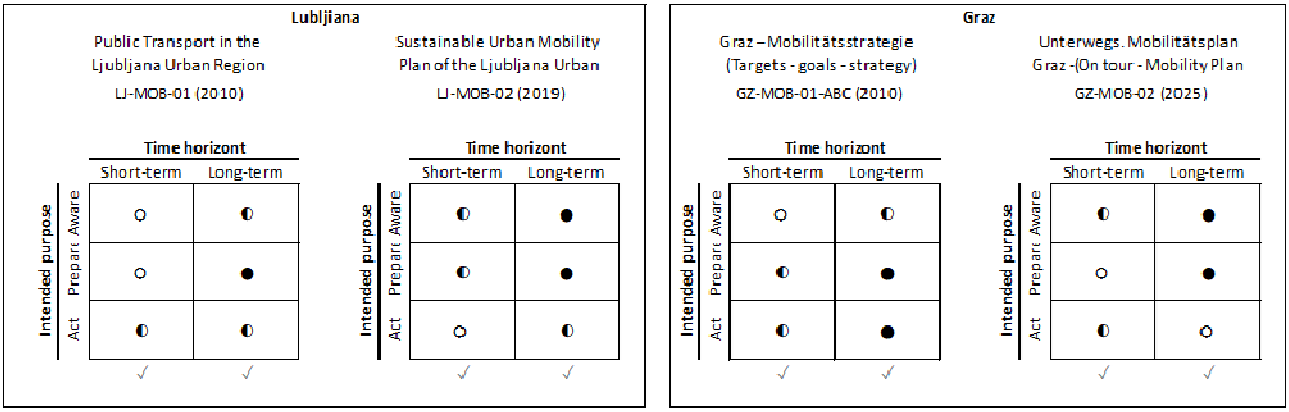

Figure 2 Comparative APA-based matrix of communicative purposes and temporal orientations in urban mobility policy documents for Ljubljana and Graz.

The matrix summarises the results of the qualitative content analysis by mapping the dominance of awareness-raising, preparedness-oriented communication, and action-oriented communication across short-term, long-term, and hybrid time horizons for each analysed policy document.

8 DISCUSSION: PRE-DISASTER PLANNING BEYOND URBAN POLICY

The findings underscore that pre-disaster planning operates as a cross-sectoral logic rather than a localized, city-specific practice. In comparing Graz and Ljubljana, it becomes evident that the efficacy of anticipatory governance depends on whether communication is treated as a technical add-on or a foundational infrastructure. Their instruments function as pre-disaster planning mechanisms, embedding long-term risk anticipation into everyday urban governance rather than treating disasters as exceptional events.

In Graz, the policy documents from the Abteilung für Verkehrsplanung and the city's Klima- und Umweltstrategien demonstrate a high level of technical proficiency in areas such as emissions reduction and digital traffic management. However, the discussion points to a communicative rupture. While the Graz Museum project Becoming Urban: Stadtentwicklung sehen und verstehen attempts to bridge the gap by making urban development visible and understandable, the participation model remains largely consultative. This top-down approach, focused on informing rather than co-creating, often fails to secure the SLO necessary for radical shifts, such as the reallocation of public space for green infrastructure. From a future-oriented perspective, global mobility foresight studies caution against a purely technology-centric transition

pathway. The Arthur D. Little Future of Mobility 5.0 Report stresses that without strong social acceptance, governance legitimacy, and behavioural alignment, digitalisation and electrification may even amplify systemic vulnerabilities by increasing complexity and dependency. This reinforces the paper's core argument that Social Licence to Operate constitutes a critical precondition for resilient and circular urban mobility systems (Little 2025).

Conversely, Ljubljana exemplifies a balanced APA configuration where communication is an enabling infrastructure. The Regionalni razvojni program (Regional Development Programme) and the Strategija prostorskega razvoja (Spatial Development Strategy) of the City of Ljubljana do not treat risk as an isolated hazard but embed it within a broader narrative of urban metabolism. As evidenced in the Ljubljana public transport – Brochure, environmental objectives are strategically framed as quality-of-life issues, fostering trust and collective learning. This integrative approach reinforces the argument that anticipatory governance is most effective when it transcends sector-specific silos.

Furthermore, these parallels are not confined to city governance alone. Comparable anticipatory strategies are observable in broader European research, such as the Interreg Europe Good Practices initiatives, which emphasize that technological infrastructure must be paired with inclusive public discourse to succeed. As highlighted by Graf et al. (2026), the transition from short-term hazard warnings to long-term adaptation requires a fundamental shift in how institutional knowledge is shared with the public.

Ultimately, this discussion reinforces that anticipatory governance, transparent communication, and resource efficiency constitute a broader transformation paradigm. SLO is not a static permit but an ongoing process of social learning and trust-building. These findings suggest that for European cities to move from crisis management to sustainable growth, they must align their technical Action with deeply embedded Awareness and Preparedness strategies. While the results largely support the APA-logic, a Popperian perspective invites us to consider potential falsifications. One might ask: Could a city like Graz achieve sufficient resilience through purely technical and institutional 'Preparedness' (e.g., FLOODPREP) without broad public co-creation? Our findings suggests that while technical 'Action' provides immediate protection, the long-term SLO, essential for the CE, remains the point where purely technical models are most likely to be falsified in practice. The implementation of CE in both cities primarily targets the higher levels of the 9R hierarchy, specifically R1 (Refuse), R2 (Rethink), and R3 (Reduce).

- R1 & R2 : Graz's City of Short Distances model and Ljubljana's access restrictions in the city center effectively encourage citizens to refuse private car use in favor of shared or active mobility.
- R3: Both cities emphasize a reduction in GHG emissions through modal shifts, though personal mobility remains a challenge as car registrations continue to rise in both Austria and Slovenia.
- Gaps in R4-R9: Strategies for higher-order R-measures, such as R4 or R9, are largely absent from urban policy documents as municipal authorities have less leverage over the industrial lifecycles of vehicles.

The analysis reveals a critical disconnect between technical implementation and strategic communication. While both Graz and Ljubljana are successfully operationalizing the higher-order 9R strategies (specifically R2 through modal shifts and R3 through optimized infrastructure) these are often framed as isolated transport projects rather than a systemic transition toward a CE. The analysis of Graz reveals a critical tension: although technical excellence in projects like FLOODPREP and tram expansions provides high-performance Action within the APA framework, it functions as a fragile buffer rather than a sustainable foundation. Without integrated Awareness and co-creation, a communicative rupture emerges that threatens the SLO. Consequently, technical success becomes a systemic risk: It secures immediate hazard mitigation but fails to foster the public trust and behavioral alignment essential for radical CE transformations. As demonstrated by Ljubljana's more integrative approach, true resilience requires that technical measures be harmonized with, or even secondary to, foundational communicative processes.

9 CONCLUSION

This paper has shown that pre-disaster planning can catalyse CE transitions and urban resilience when technological measures are embedded in participatory governance and effective risk communication. By anchoring the comparative analysis in externally documented safety, mobility, and governance risks, the study confirms that pre-disaster planning is not merely a preparatory instrument but a decisive leverage point

for preventing cumulative socio-technical failures in urban systems. Using the APA lens, the study demonstrates that communication is a critical infrastructure of transformation rather than a supplementary activity. The comparative analysis of Graz and Ljubljana highlights the importance of securing an SLO for anticipatory urban policies. For European cities facing increasing climate risks, integrating pre-disaster planning with circular innovation and inclusive communication offers a viable pathway from crisis management to sustainable growth. Future research could test the APA lens across additional urban contexts to further explore its applicability beyond mobility governance.

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11 APPENDIX

Circular economy mobility concepts						
CODE	Title	Car (Car-sharing, car-pooling, etc.)	Cycling (Sharing, rental, etc.)	Public Transport	Walking	Monitoring
GZ-MOB-01	Unterwegs. Mobilitätsplan Graz 2040	carsharing since 2016, by 2023 31 stations in the city; carpooling not centralised but with corporate mobility management of regional employers	rental not in place, middle to long term perspective to install; new infrastructure investments	planned to extend the existing services of on demand transportation o of GUST, FLUX and VOmobil, new tram tracks, P+R, busses with more passenger capacity, punctuality, bicycle storage at stations	PediBus campaign for walking, establishing walking zones in front of schools	modal split, data on the degree of motorization, number of bicycle parking facilities, vehicle parking permits, public transport service area, passenger numbers, or the area of pedestrian and shared spaces
LJ-MOB-01	Public Transport in the Ljubljana Urban Region	Car sharing connected to a park and pool sharing model, P & R scheme (car parks, arrangement of bus stops, comprehensive, information system); concentration of services; smart card system, vending machines	bicycle storage facilities, bicycle rental service and network of bicycle rental shops; ensuring safe cycling routes primarily in the city centre (more friendly, urban traffic regulation for cyclists involving cycle zones, areas closed to motorised traffic, and low speed motorised traffic in other parts of the city centre); carriage of bicycles on buses	enhanced carrying capacity of buses; low-floor vehicles, comprehensive information system; safe footways (wide pavements), signalisation giving priority to pedestrians, arrangement of bus stops (shelter, seating, quietness, cleanliness etc.) offer of additional services (shops) external accessibility to public transport by walking and non-motorised transport modes such as bicycles, and P+R	new urban green spaces, walking paths and parks; pedestrian routes primarily in the city centre (more friendly, urban traffic regulation for pedestrians, pedestrian zones, areas closed to motorised traffic, and low speed motorised traffic in other parts of the city centre);	scenarios to reduce GHG emissions, modal split
LJ-MOB-02	Sustainable Urban Mobility Plan of the Ljubljana Urban Region (for the people and space in an innovative and advanced region)	Avant2Go rent service of exclusively electric cars; comprehensive study of the P+R network; smart planning and allocation of surfaces for stationary traffic; enable the development of public transport or encourage the forms of carpooling and car sharing	construction of adequate infrastructure at the destination (bicycle storage facilities, charging stations for electric bikes, etc.) The adaptation of cycling routes for a faster journey (wider cycle paths, flatter ramps, etc.); The connection of rail passenger transport and cycling	co-modality of bike and public transport; Renovation of existing and establishment of new public transport stations and stops, The extension of existing public transport routes and the introduction of clock-phased timetable; The introduction of an integrated public transport ticket for all users	access to intermodal points with safe and comfortable walking paths; improved intermodal points for pedestrians; introducing access restrictions to the urban centre (e.g. walking zones, environmental zones with special access regimes)	modal spilt, implementation of the needs analyses
GZ-MOB-2A-C	Leitlinien – Mobilitäts-strategie der Stadt Graz – Verkehrspolitische Leitlinie 2020 / Handlungsfelder & Maßnahmen / Ziele	property developer contracted to implement (e.g. car sharing offers, bicycle service, public transport departure displays, information material); Car-sharing concepts	Infrastructure as well as traffic organization to implement measures for cycling; city of short distances	extension of bus stop system and development of new areas; punctuality strategy,	priority to ensure accessibility of densely used areas (city centre, residential areas, leisure and educational facilities); city of short distances	modal split, additional indicators such as walking distance to public transport, air quality and environmental quality, number of people in cars, road safety