

EU CITY CALCULATOR: ENHANCING CLIMATE ACTION IN EUROPEAN CITIES THROUGH CO-CREATION AND TRANSITION PATHWAYS IN A MODELLING TOOL

Author:

HECTOR RODRIGUEZ-CHAVEZ¹, SANDRA BARBERINO VIGNOLA¹, JULIA EPP¹, MONIKA ORLOWSKI¹, CHRISTIANE WALTER^{1,2}, BEATRICE MONTELEONE^{3,4}, ISABEL RODRIGUEZ⁵, ORLANDO PEREIRA⁵

Affiliation:

¹ POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY. ² BAUHAUS EARTH, GERMANY. ³ UNIVERSITY SCHOOL FOR ADVANCED STUDIES IUSS PAVIA, ITALY. ⁴ ECONOMETRICS SRL, ITALY. ⁵ ENERGY AND ENVIRONMENT AGENCY OF ARRÁBIDA, PORTUGAL.

INTRODUCTION

Cities are pivotal in combating climate change and promoting sustainable development.¹ Urban areas are responsible for 70% of global greenhouse gas (GHG) emissions and 78% of energy consumption, yet they also serve as fertile ground for innovative actors and modern concepts to operate and proliferate,² positioning them at the forefront of the transition to a low-carbon future. Local governments are essential in implementing policies to meet national climate goals, often showing high ambition to cut emissions. However, many cities face challenges in developing and implementing climate action plans due to financial constraints, increasing complexity and interconnectedness of the urban fabric, lack of capacities, limited sustainability networks, in addition to a variety of political challenges.³ This last category can include resistance to climate policies from key stakeholders, shifts in national climate policy or limited coordination between different levels of government, including urban actors.⁴ Effective policy coordination among local, regional, and national governments is crucial to leverage cities' roles in accelerating climate transition. In this complex context, broad participation is needed to engage diverse actors and integrate various perspectives for successful transition pathways and science-based policies.⁵

The European Union (EU) highlights the importance of participation and multi-level dialogues in Article 11 of the Regulation on the Governance of the Energy Union and Climate Action (2018/1999). It recognizes local authorities' critical role in sustainable energy policies, exemplified by initiatives like the Covenant of Mayors (CoM), requiring signatories to create and implement Sustainable Energy and Climate Action Plans (SECAP) to reduce emissions and adapt to climate change. In this context, the EUCityCalc project offers the EU City Calculator, a tool to quantify mitigation potentials and explore decarbonisation pathways. It supports cities in refining climate policy through a co-creation process integrating data and knowledge from multiple stakeholders.⁶

This article draws on the pilot cities' co-creation experiences with the EU City Calculator, exploring how transition pathways are used to present, discuss and validate climate policies, and how stakeholders align with

the city's objectives. By analysing these processes, the study provides insights for cities, policymakers, and stakeholders in urban climate action planning, highlighting challenges, best practices, and lessons to promote collaborative sustainable development. Local stakeholders' contributions are essential in designing effective climate strategies, central to co-creation in decarbonisation pathways.⁷ This research addresses (i) how co-creation processes, facilitated by the EU City Calculator, contribute to Climate Action Plans (CAP) development and (ii) what lessons are learned from these processes in the pilot cities. The article introduces the role of co-creation in transformation pathways development through modelling tools, outlines a mixed-method and transdisciplinary research approach, presents results, and concludes with recommendations for further research including implementation issues of CAPs. To explore further details about the EU City Calculator, please refer to the supplementary materials provided with this research or visit the project webpage.⁸

Co-creation in climate policy development

The co-creation concept,⁹ often synonymously used with co-production, involves active engagement, participation and collaboration between state agencies and citizens, extending beyond consultation to add valuable insights to outcomes.¹⁰ This concept has gained traction in urban planning, policy development, and environmental modelling, which is characterized by multidimensional processes involving knowledge transfer, production, and use.¹¹ Addressing urban challenges requires cross-sector collaboration and the inclusion of various actors in public policy, enabling joint decision-making.¹² Participation in co-creation platforms can enhance the legitimacy of decisions and innovation in implementing solutions in cities.¹³ In climate policy, co-creation engages local actors in decision-making for decarbonisation strategies, crucial for transformative processes toward climate-neutral pathways.¹⁴ This collaborative development of policies, solutions, or initiatives involves various stakeholders, including government entities, the private sector, civil society organisations, and citizens, leading to inclusive, context-specific outcomes with greater buy-in. In climate action planning, co-creation integrates local knowledge, resulting in more effective, sustainable, and adapted solutions.¹⁵ The theoretical foundation of co-creation is rooted in participatory governance, stakeholder engagement, and collaborative decision-making, recognizing that complex challenges like climate change require a holistic approach leveraging diverse experiences, resources, and insights.¹⁶ By fostering co-creation, policymakers and urban planners can ensure that strategies and plans align with local needs and priorities, making co-creation a fundamental characteristic of social innovation for urban climate policy while empowering local communities.¹⁷ Co-creation processes are significantly shaped by social, cultural, and political factors, introducing complex challenges related to governance dynamics and power distribution among stakeholders.¹⁸ While co-creation has the potential to dismantle hierarchies and existing power structures, a critical consideration is the selection and inclusion of participants.¹⁹ The availability and distribution of resources can substantially influence both the process and its representativeness. It is crucial to clearly define and communicate the role of the co-creation process in policymaking from the outset and ensure its realization by the conclusion.²⁰

Modelling tools can support co-creation by enabling the formulation of pathways, action plans, and policies. These models facilitate decision-making by incorporating diverse perspectives in collaborative processes, providing scientific insights and exploring scenarios, trade-offs, and interdependencies. They thereby enable cross-sector collaboration and knowledge integration which are prerequisites for transformative changes.²¹ However, models require social validation, reflection on concepts and values, and commitment to capacity building. This fosters stakeholder engagement and learnings to generate new scientific and socially robust knowledge.²²

METHODOLOGICAL APPROACH

The study employs quantitative and qualitative methods to outline the results and feed the discussion (see Table 1). Quantitative results of the co-creation include metrics such as the number of stakeholders involved, measures selected and integrated into the tool, together with the potential emission reductions resulting from the co-creation. Qualitative results are assessed through interviews, project reports, and surveys conducted with city representatives and other stakeholders. Pilot cities provided insights into the local co-creation process, stakeholder engagement, the selection of measures and transition pathways, and the impact of the co-creation process in each pilot city and metrics to compare similarities and differences in success.²³

Approach	Criteria	Goal	Impact on Climate Action
Quantitative	Number of stakeholders involved	<ul style="list-style-type: none"> Cover a broad range of stakeholders represented Creating responsibility, acceptance and commitment among stakeholders 	<ul style="list-style-type: none"> Integration of a broad range of expertise and sectors
	Number of measures agreed upon in the co-creation process	<ul style="list-style-type: none"> Measures as core elements for transition pathways and foundation of SECAPs Developing timelines and different scenarios to showcase differences in ambition and impact of measures on climate 	<ul style="list-style-type: none"> Developing tailored climate measures Understanding trade-offs and conflicts between measures
	Percentage of CO ₂ Emissions reduction	<ul style="list-style-type: none"> The co-creation sparks discussions for new measures with further emission reductions to the existing CAPs 	<ul style="list-style-type: none"> Enhanced climate policy through more measures Validation of existing CAPs
Qualitative	Surveys and interviews with representatives from pilot cities	<ul style="list-style-type: none"> Understanding the impact and struggles in developing CAPs through the co-creation process and with the help of the EU City Calculator web tool 	<ul style="list-style-type: none"> Revising the model itself to tailor it more to the needs of cities Understanding the advantages and limits of the tool
	Surveys and project reports of pilot cities	<ul style="list-style-type: none"> Inquiry of lessons learned in pilot cities in developing SECAPs and transformation pathways 	<ul style="list-style-type: none"> Scaling the development of SECAPs and enabling the wide usage of the webtool

Table 1. Methodological approach of the paper (authors' own)

Questions in the surveys and interviews were designed to draw out detailed responses encouraging cities to provide concrete examples and experiences. Collected data was analysed using thematic coding for qualitative responses and statistical analysis for quantitative data.²⁴

EU City Calculator co-creation process

The co-creation process was designed to collaboratively develop transition pathways for climate policies in pilot cities, actively engaging stakeholders from sectors like local government, industry, and civil society. The methodology created a platform for these groups to develop scenarios and measures together, ensuring outcomes were comprehensive, inclusive, and context-specific.

Pilot cities used a Stakeholder Mapping Tool based on the power/interest matrix and stakeholder management model,²⁵ to identify and engage relevant stakeholders, forming expert working groups crucial to the process. Groups were organised based on existing synergies and relationships, with some cities utilizing pre-existing organisations and others creating new ones to support the development of transition

pathways. The expert working groups typically included public officials responsible for SEAPs/SECAPs and related strategic plans alongside representatives from various sectors such as industry, construction, agriculture, NGOs, and academia. The composition varied by the geographic specificities of the pilot cities such as port authorities in some coastal cities.

The co-creation process, in Figure 1, involved workshops for consensus-building and iterative refinement. Initially, local stakeholders were mapped by administrative representatives to cover broad sectoral expertise and diverse perspectives. In the second and third steps, expert groups explored measures and transformation scenarios. Core workshops involved face-to-face sessions using data-based scenarios from the tool, where participants collaboratively co-designed transition pathways, making consensual decisions on measures and ambition levels while analysing impacts.

Informed decisions were made when diverse stakeholders with different perspectives understood policy trade-offs and conflicts, resulting in experts developing transformation pathways supported by society.²⁶ The process included introductory sessions to present the project and tool, sector-specific workshops to refine transition pathways, summary sessions to provide a complete city roadmap, concluding with political validation to integrate scenarios into city plans.

Accordingly, emphasis was placed on involving city officials and planners in the decision-making process. As participants mapped measures within the EU City Calculator tool, the process encouraged inclusivity and iterative refinement. In the final stage, public commitments, such as Memoranda of Understanding or monitoring groups, were established to maintain engagement and track progress.²⁷ Continuous communication and updates were essential to keep stakeholders informed and motivated throughout the process, aligning with best practices in participatory governance.²⁸ Hence, ensuring stakeholder involvement post-co-creation process is critical for implementing and monitoring proposed measures.

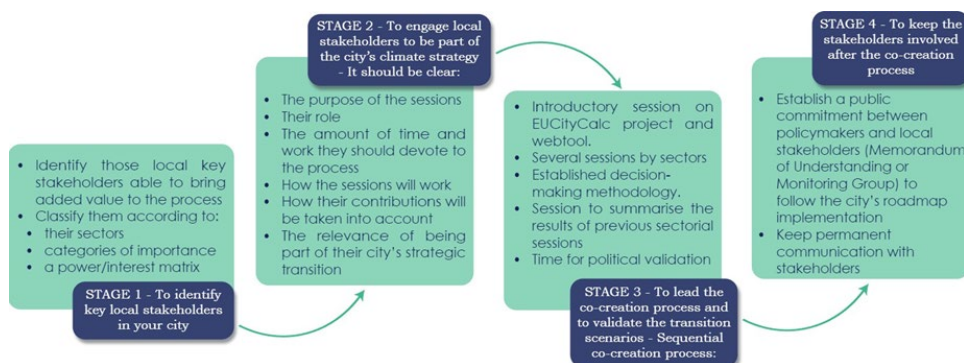


Figure 1. Methodology of the co-creation in the EUCityCalc project

RESULTS AND DISCUSSION OF THE CO-CREATION PROCESS

The impact of the co-creation process can be assessed from various perspectives, including its methodological design, application, and ongoing outcomes, such as stakeholder involvement and transition pathway co-design. Stakeholders appreciated the collaborative approach and the chance to influence climate policy development, but they also noted challenges like data availability and the need for capacity building. Most pilot cities engaged stakeholders who had not previously been involved in the development of transition pathways. For example, Mantova involved stakeholders of water management and animal husbandry monitoring, while Riga involved citizens, local businesses, and NGOs. In Riga, co-creation activities were central to all city climate plans, emphasising a clear mission and roles, with politicians involved for legitimacy. Dijon engaged smaller organisations previously not involved, while Zdar focused on those with environmental expertise. Stakeholder participation varied; Setúbal and Riga found it

straightforward due to tailored invitations, whereas Mantova and Zdar faced challenges, needing attractive events to boost participation. In Setúbal, Palmela, and Sesimbra, co-creation reinforced existing cultures but faced participation challenges in Sesimbra. In Dijon, fears of symbolic co-creation were alleviated by clear communication, emphasising the importance of transparency for sustained engagement.²⁹ The co-creation process facilitated room to discuss potential impactful measures, highlighting the need to involve new stakeholders and expand emission reduction efforts beyond industry.

Portuguese cities used face-to-face sessions to design pathways and scenarios, followed by a public commitment ceremony and the creation of a Monitoring Group. Mantova organised separate sessions for different stakeholder groups and a final event to integrate their inputs. Selection of measures involved participatory sessions where stakeholders ranked the importance of preselected measures. Factors influencing the selection included local capacity for implementation, time constraints, and the relevance of measures to existing plans. In Setúbal, Palmela, and Sesimbra, short-to-medium term measures with local scope were preferred. In Dijon, the selection of measures was influenced by the priorities highlighted by regional players and the consistency with actual GHG emissions data, while in Zdar, the main criteria were the payback period and availability of financial subsidies. In Zdar, the tool was not used due to existing documentation, but it was useful for a strategic overview when the interaction of measures in different transition pathways was unclear. In Mantova, the measures were influenced by expanding the ongoing city actions, such as bike sharing and renovation of public buildings.

Mechanisms to ensure implementation and monitoring included political validation, public commitment ceremonies, and the creation of monitoring groups. For instance, the "Arrábida Zero Emissões" monitoring group was established to facilitate the implementation and monitoring of transition roadmaps in Setúbal, Palmela, and Sesimbra.

Stakeholder involvement varied across cities (see Table 2). Riga reported 200 participants and 61 entities, while Mantova involved 25 entities. Sectors covered included transport, buildings, energy, and agriculture. The number of measures in transition scenarios also varied between cities; Riga included 46 measures, focusing on transport, while Mantova had 12 across sectors (Figure 2). Dijon included 9 measures, mainly concerning buildings and energy, while Zdar did not create new measures due to the tool's lack of local financial data and subsidies. The GHG emission reduction potential for the selected measures was substantial, with Mantova reporting a reduction of 120 tons CO₂ compared to the reference year 2005. Dijon reported a GHG emissions reduction potential of -24% to -37% between 2022 and 2030, depending on the scenario, while Riga planned to reduce its emissions by a third between 2019 and 2030 (see Table 3). It's important to note that these potential reductions are not directly comparable between cities due to the different baseline years used. This supports the argument that GHG emissions and measures were discussed and selected by each city using the EU City Calculator. However, these numbers do not represent the total emissions reductions, as many cities have implemented additional measures outside the calculations of the tool. Yet, the tool sparked discussions that led to these measures, highlighting its role in shifting the working culture of cities towards developing CAPs.

	No. Stakeholders	No. Entities
Setúbal, Sesimbra and Palmela	76	34
Mantova	63	25
Riga	200	61 and 5 private persons
Koprivnica, Varaždin and Virovitica	13	4
Dijon	43	24
Ždár nad Sázavou	7	7

Table 2. Stakeholders involved.

The co-creation process involved more than 400 actors from 160 entities across ten pilot cities, demonstrating its inclusivity and outreach. While diversity fosters creativity, it also poses challenges in consensus-building, potentially reducing group cohesiveness.³⁰ The process ultimately resulted in a total of 32 climate measures with over 93 feasible ambition levels, initially selected by expert groups, with the co-creation process sparking discussions for additional measures. Although many measures were assessed, only a few were added due to the project duration, capacities, and applicability constraints. A key outcome of the co-creation process was its ability to trigger discussions for new tailored measures, creating a cultural foundation for ongoing innovation. The quantitative results showed a significant level of stakeholder involvement in the co-creation process.

	Emission reduction in the most ambitious transition scenario in EUCityCalc	Baselines and remarks
Setúbal (PT)	9,5%	2019-2050; considering measures outside EUCityCalc, the reduction is 47%
Palmela (PT)	4,8%	2019-2050; considering measures outside EUCityCalc, the reduction is 30%
Sesimbra (PT)	12,3%	2019-2050; considering measures outside EUCityCalc, the reduction is 57%
Mantova (IT)	53,4%	2019-2050
Riga (LV)	85,0%	2019-2050
Koprivnica (HR)	54,48%	2011-2050
Varaždin (HR)	54,09 %	2011-2050
Virovitica (HR)	52,69 %	2011-2050
Dijon (FR)	98,1%	2019-2050
Žďár nad Sázavou (CZ)	0 (no transition scenario created)	0 (no transition scenario created)

Table 3. Potential GHG emissions reductions in pilot cities in the most ambitious scenario in EUCityCalc. As the model cannot include all possible measures in a city, the complete roadmaps might have higher emissions reductions.

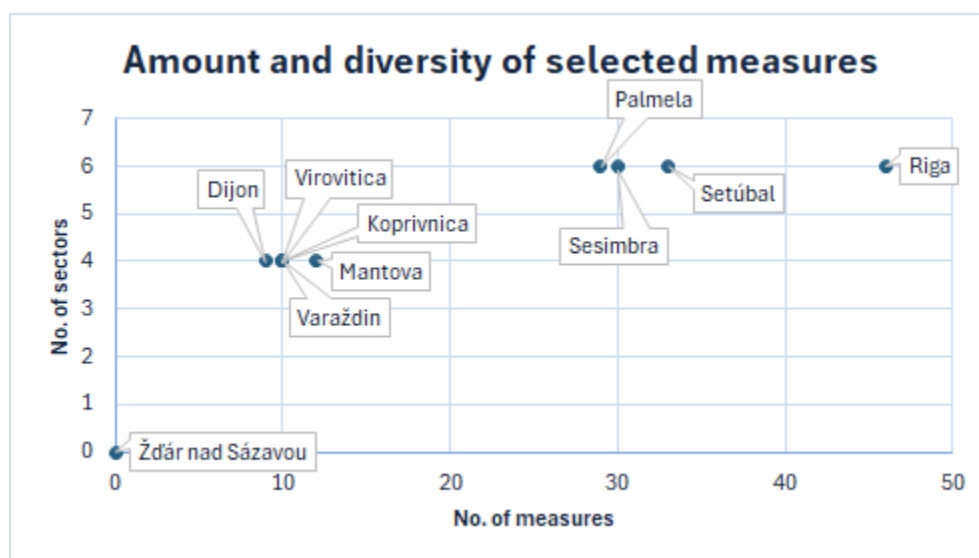


Figure 2. Number of measures and sectors in the most ambitious emission scenarios of different pilot cities.

Co-creation challenges included data availability, tool complexity, and the need for continuous stakeholder engagement and capacity building. Addressing these were crucial for success. Qualitative insights highlighted these challenges and suggested strategies for overcoming them, such as engaging departments through one-on-one meetings like Riga did. Co-creation was seen as beneficial for fostering innovation and social learning. Stakeholders could freely express the reasons for their positions, which was enlightening for decision-makers. Stakeholders and city administrations learned from each other, leading to more ambitious policies,³¹ confirming that participatory modelling generates socially robust knowledge by fostering continued learning.³²

Data collection effectiveness varied. Cities like Setúbal faced challenges in obtaining behavioural data, while others like Mantova did not collect citizen data. This is even though each stakeholder holds specific expertise and knowledge which they could contribute to the process.³³ Innovative approaches included using existing energy matrices and stakeholder surveys. The co-creation process evoked new ideas for measures like an energy poverty fund and the promotion of an innovation cluster in local industries. Our research suggests that the production of new knowledge, skills, and resources due to the engagement of different perspectives remains a key point in the co-creation processes.³⁴

Most cities reported fair discussions with equal stakeholders' opportunities. In Mantova, discussions were collaborative and constructive. In Dijon, some participants found it difficult to express their views due to the lack of quantitative sectoral data, but overall, the discussions were fruitful. The process enhanced the quality of measures and stakeholder responsibility for implementation. For example, Setúbal integrated co-creation into its local CAP, while other cities are in the process. The increased ownership and involvement that co-creation can achieve is one of its main benefits,³⁵ as it makes the attainment of longer-term visions possible.³⁶ Favourable conditions included transparent communication and high-level stakeholder involvement, while obstacles included data collection difficulties.

Recommendations for future co-creation processes include involving diverse stakeholders from inception, maintaining transparent communication, implementing feedback mechanisms, and considering all perspectives. Stakeholder surveys found the EU City Calculator useful for developing climate policies, appreciating its real-time simulations and scenario visualisations, despite needing more detailed data and complexity for non-technical users.

Overall, the co-creation process effectively engaged stakeholders, fostered innovation, and supported climate action plan development with locally tailored measures. While challenges existed, the overall impact was positive. Insights will refine methodologies and enhance stakeholder engagement in future efforts. The process significantly contributed to developing CAPs, involving stakeholders in scenario and measure development, leading to context-specific policies with broad support. The tool's maturity at the development stages of the project limited outreach, however, simulations and co-creation helped stakeholders understand decision impacts, leading to informed policymaking.

The process is valued in itself, aligning with trends in public policy and urban planning.³⁷ Collaborative approaches enable citizens to develop city ownership, empowering them and contributing to successful urban policies.³⁸ Co-creation is crucial for local climate action development and implementation, generating a new culture in planning, opening communication channels, and enabling transformative changes for climate neutrality. However, its success depends on cities' financial, structural, and cultural contexts.

The co-creation process sparked discussions on integrating new measures tailored to cities' needs, with four measures integrated into the tool. Inclusion was based on data availability, indicators, literature support, timescale, city scale, and tool linkage. While many measures were considered, only a few, particularly in energy and reforestation, were added to the tool, within the project's timeframe. The process highlighted the need for broader sectoral involvement beyond industry. Findings emphasise that while modelling tools are valuable, they have limitations. Urban spaces vary based on economic, cultural, and climatic factors,

requiring specific interventions.

CONCLUSION

The EU City Calculator proved valuable in developing dynamic transition pathways and evidence-based scenarios, enhancing the quality and relevance of CAPs. The reasons lie in the collaborative analytical and deliberative processes that allow diverse local actors to agree on pathways using visualisations.

The co-creation process enhanced the quality and relevance of CAPs in eight out of ten cities while fostering ownership and commitment among stakeholders, crucial for the successful implementation of urban climate policies. It facilitated the integration and update of (SE)CAPs, providing support for policy development. Quantitative and qualitative results demonstrated the tool's potential to contribute to significant CO₂ emissions savings and actionable climate policies. However, monitoring and evaluation mechanisms remain crucial for tracking progress and making necessary adjustments. Ensuring these collaborative efforts beyond the project's duration is essential to maintain momentum and achieve long-term climate goals.

Co-creation processes supported by modelling tools can play a key role in climate policy development by engaging a broad range of stakeholders. These processes can foster the creation of more context-specific measures and cultivate a collaborative culture within cities. This engagement ensures that the strategies developed are aligned with local needs and priorities, enhancing their relevance and effectiveness. The process highlighted the importance of involving new stakeholders and expanding emission reduction efforts beyond industry to include broader sectoral involvement within city administrations. In some cases, weak emission reduction objectives limited the effectiveness of both the tool and the co-creation process. Recommendations for improving future co-creation processes include early diverse stakeholder involvement, transparent communication, and implementing feedback mechanisms.

Our findings suggest that robust local governance structures, local data availability, political commitment, and effective stakeholder engagement significantly influenced the tool's adoption and the co-creation that ultimately can support the successful implementation of transition plans. These insights offer valuable guidance for policymakers and city administrations on leveraging decision-support tools to achieve their climate goals and promote sustainable urban development. Cities showed the importance of mutual validation of different modelling tools to increase confidence, reliability and legitimacy. A single tool proved to be insufficient for decision-making. This strategy helps overcome disagreements about input data and assumptions, a common issue in modelling tool applications.³⁹ Additionally, the co-creation process facilitates discussions about measures and pathways, fostering a new culture of working within cities. This collaborative approach can lead to commitments that endure through political changes and over time, thanks to stakeholder engagement, transparency, and ownership.

The co-creation process has proven to be a catalyst for developing context-specific measures and engaging a broader range of stakeholders in climate action planning. It demonstrates that while modelling tools provide a foundation, the dynamic nature of urban environments requires tailored approaches. The process can lead to new measures and pathways that cities can adopt, with potential support from national and international funding sources. Co-creation fosters a collaborative culture, which is essential for achieving transformative changes towards climate neutrality. Potential research gaps remain. Effective cross-level communication, balancing long-term models with short-term visions, and ensuring multi-level governance are critical areas that demand further attention. Addressing these gaps is essential for the successful implementation of climate policies and transition plans. These insights can guide future implementation of CAPs in other cities, helping to tailor approaches to specific local contexts.

NOTES

¹ Vanesa Castán Broto, "Urban Governance and the Politics of Climate Change," *World Development* 93 (2017): 1, doi: 10.1016/j.worlddev.2016.12.031.

² "Urban Energy," UN Habitat, Accessed August 7, 2024. <https://unhabitat.org/topic/urban-energy>; D. Shtjefni et al., "Governing Climate Neutrality Transitions at the Urban Level: A European Perspective," *Cities* 148 (2024): 104883, doi: 10.1016/j.cities.2024.104883. D. Shtjefni et al., "Governing Climate Neutrality Transitions at the Urban Level: A European Perspective," *Cities* 148 (2024): 104883, doi: 10.1016/j.cities.2024.104883.

³ Harriet Bulkeley and Michele M. Betsill, "Revisiting the Urban Politics of Climate Change," *Environmental Politics* 22, no. 1 (2013): 136–54, doi: 10.1080/09644016.2013.755797; Shtjefni et al., "Governing Climate Neutrality Transitions at the Urban Level," 10.

⁴ Bulkeley and Betsill, "Revisiting the Urban Politics of Climate Change," 11; Shtjefni et al., "Governing Climate Neutrality Transitions at the Urban Level," 10.

⁵ Tobias Krueger et al., "The Role of Expert Opinion in Environmental Modelling," *Environmental Modelling & Software* 36 (2012): 4, doi: 10.1016/j.envsoft.2012.01.011; Castán Broto, "Urban Governance and the Politics of Climate Change," 15; Petra Döll and Patricia Romero-Lankao Petra, "How to Embrace Uncertainty in Participatory Climate Change Risk Management—A Roadmap," *Earth's Future* 5, no. 1 (2017): 18, doi: 10.1002/2016EF000411.

⁶ Anne Van Bruggen et al., "Modeling with Stakeholders for Transformative Change," *Sustainability* 11, no. 3 (2019): 825, doi: 10.3390/su11030825.

⁷ Castán Broto, "Urban Governance and the Politics of Climate Change."

⁸ EU City Calculator, accessed August 20, 2024, <http://europeancitycalculator.eu/publications/>

⁹ Taco Brandsen and Marlies Honingh, "Definitions of Co-Production and Co-Creation," In *Co-Production and Co-Creation*, by Taco Brandsen, Trui Steen, and Bram Verschuere 1st ed. (New York: Routledge, 2018), 9-17.

¹⁰ William Voorberg et al., "A Systematic Review of Co-Creation and Co-Production: Embarking on the Social Innovation Journey," *Public Management Review* (2014): 1333-1357, doi: 10.1080/14719037.2014.930505, Available online at SSRN: <https://ssrn.com/abstract=2444075>; Helena Leino and Eeva Puumala, "What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of Participation in Cities," *Environment and Planning C: Politics and Space* 39, no. 4 (2021): 789, doi: 10.1177/2399654420957337.

¹¹ Van Bruggen et al., "Modeling with Stakeholders for Transformative Change," 2; Leino and Puumala, "What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of Participation in Cities," 782.

¹² Leino and Puumala, "What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of Participation in Cities," 781.

¹³ Voorberg et al., "A Systematic Review of Co-Creation and Co-Production: Embarking on the Social Innovation Journey," 26; Wendi Hardyman et al., "Enhancing Public Service Innovation through Value Co-Creation: Capacity Building and the 'Innovative Imagination'," *Public Money & Management* 42, no. 5 (2022): 332. doi: 10.1080/09540962.2021.1981042.

¹⁴ Castán Broto, "Urban Governance and the Politics of Climate Change," 2; Van Bruggen et al., "Modeling with Stakeholders for Transformative Change," 1.

¹⁵ Castán Broto, "Urban Governance and the Politics of Climate Change," 3.

¹⁶ Bulkeley and Betsill, "Revisiting the Urban Politics of Climate Change."

¹⁷ Castán Broto, "Urban Governance and the Politics of Climate Change," 35; Barbara Smetschka and Veronika Gaube, "Co-Creating Formalized Models: Participatory Modelling as Method and Process in Transdisciplinary Research and Its Impact Potentials," *Environmental Science & Policy* 103 (2020): 41, doi: 10.1016/j.envsci.2019.10.005; Mar Satorras et al., "Co-Production of Urban Climate Planning: Insights from the Barcelona Climate Plan," *Cities* 106 (2020): 102887, doi: 10.1016/j.cities.2020.102887.

¹⁸ Esther Turnhout et al., "The Politics of Co-Production: Participation, Power, and Transformation," *Current Opinion in Environmental Sustainability* 42 (2020): 15, doi: 10.1016/j.cosust.2019.11.009; Leino and Puumala, "What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of Participation in Cities," 794.

¹⁹ Leino and Puumala, "What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of

Participation in Cities,” 783.

²⁰ Christina Plank et al., “Climate Policy Integration Viewed through the Stakeholders’ Eyes: A Co-production of Knowledge in Social-ecological Transformation Research,” *Environmental Policy and Governance* 31, no. 4 (2021): 387–99, doi: 10.1002/eet.1938.

²¹ Van Bruggen et al., “Modeling with Stakeholders for Transformative Change,” 4.

²² Smetschka and Gaube, “Co-Creating Formalized Models: Participatory Modelling as Method and Process in Transdisciplinary Research and Its Impact Potentials,” 41.

²³ Rob Timans et al., “Mixed Methods Research: What It Is and What It Could Be,” *Theory and Society* 48, no. 2 (2019): 193, doi: 10.1007/s11186-019-09345-5.

²⁴ Swami Gurunand Jnanathapaswi, “Thematic Analysis & Coding: An Overview of the Qualitative Paradigm,” *figshare* (2021), doi: 10.6084/M9.FIGSHARE.17159249.V1.

²⁵ Aubrey Mendelow, “Stakeholder mapping,” In *Proceedings of the 2nd international conference on information systems*, Cambridge, MA: A. Mendelow, (1991): 10-24; Bourne, Lynda, *Stakeholder Relationship Management: A Maturity Model for Organisational Implementation*, 1st ed. (London: Routledge, 2009).

²⁶ Van Bruggen et al., “Modeling with Stakeholders for Transformative Change,” 1.

²⁷ Castán Broto, “Urban Governance and the Politics of Climate Change.”

²⁸ Bulkeley and Betsill, “Revisiting the Urban Politics of Climate Change.”

²⁹ Leino and Puumala, Leino and Puumala, “What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of Participation in Cities,” 782

³⁰ Maria Alina Rădulescu et al., “Conditions for Co-Creation in Infrastructure Projects: Experiences from the Overdiepse Polder Project (The Netherlands),” *Sustainability* 12, no. 18 (2020): 7736, doi: 10.3390/su12187736.

³¹ Smetschka and Gaube, “Co-Creating Formalized Models: Participatory Modelling as Method and Process in Transdisciplinary Research and Its Impact Potentials,” 41; Van Bruggen et al., “Modeling with Stakeholders for Transformative Change,” 4.

³² Smetschka and Gaube, “Co-Creating Formalized Models: Participatory Modelling as Method and Process in Transdisciplinary Research and Its Impact Potentials,” 48.

³³ Rădulescu et al., “Conditions for Co-Creation in Infrastructure Projects: Experiences from the Overdiepse Polder Project (The Netherlands),” 1.

³⁴ Hardyman et al., “Enhancing Public Service Innovation Through Value Co-creation: Capacity Building and the ‘innovative imagination,” 335; Leino and Puumala, “What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of Participation in Cities,” 785.

³⁵ Voorberg et al., “A Systematic Review of Co-Creation and Co-Production: Embarking on the Social Innovation Journey,” 17.

³⁶ Israa Hanafi Mahmoud et al., “Co-Creation Pathways to Inform Shared Governance of Urban Living Labs in Practice: Lessons From Three European Projects,” *Frontiers in Sustainable Cities* 3 (2021): 690458, doi: 10.3389/frsc.2021.690458.

³⁷ Voorberg et al., “A Systematic Review of Co-Creation and Co-Production: Embarking on the Social Innovation Journey,” 13.

³⁸ Theresa Audrey O. Esteban, “Building Resilience through Collective Engagement,” *Architecture_MPS* 17, no. 1 (2020): 2, doi: 10.14324/111.444.amps.2020v17i1.001.

³⁹ Jason Corburn, “Cities, Climate Change and Urban Heat Island Mitigation: Localising Global Environmental Science,” *Urban Studies* 46, no. 2 (2009): 413–27, doi: 10.1177/0042098008099361.

BIBLIOGRAPHY

Bourne, Lynda. *Stakeholder Relationship Management: A Maturity Model for Organisational Implementation*. 1st ed., London:Routledge, 2009. Available online at <https://doi.org/10.4324/9781315610573>.

Brandsen, Taco, and Marlies Honingh. “Definitions of Co-Production and Co-Creation.” In *Co-Production and Co-Creation*, by Taco Brandsen, Trui Steen, and Bram Verschuere, 9–17, 1st ed. New York: Routledge, 2018, doi:

- 10.4324/9781315204956-2.
- Bulkeley, Harriet, and Michele Betsill. "Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change." *Environmental Politics* 14, no. 1 (February 2005): 42–63, doi: 10.1080/0964401042000310178.
- Bulkeley, Harriet, and Michele M. Betsill. "Revisiting the Urban Politics of Climate Change." *Environmental Politics* 22, no. 1 (February 2013): 136–54, doi: 10.1080/09644016.2013.755797.
- Castán Broto, Vanesa. "Urban Governance and the Politics of Climate Change." *World Development* 93 (May 2017): 1–15. <https://doi.org/10.1016/j.worlddev.2016.12.031>.
- Corburn, Jason. "Cities, Climate Change and Urban Heat Island Mitigation: Localising Global Environmental Science." *Urban Studies* 46, no. 2 (February 2009): 413–27, doi: 10.1177/0042098008099361.
- Döll, Petra, and Patricia Romero-Lankao. "How to Embrace Uncertainty in Participatory Climate Change Risk Management—A Roadmap." *Earth's Future* 5, no. 1 (January 2017): 18–36, doi: 10.1002/2016EF000411.
- Esteban, Theresa Audrey O. "Building Resilience through Collective Engagement." *Architecture_MPS* 17, no. 1 (2020), doi: 10.14324/111.444.amps.2020v17i1.001.
- Frantzeskaki, Niki, Timon McPhearson, Marcus J Collier, Dave Kendal, Harriet Bulkeley, Adina Dumitru, Claire Walsh, et al. "Nature-Based Solutions for Urban Climate Change Adaptation: Linking Science, Policy, and Practice Communities for Evidence-Based Decision-Making." *BioScience* 69, no. 6 (June 1, 2019): 455–66, doi: 10.1093/biosci/biz042.
- Hardyman, Wendy, Steve Garner, James J. Lewis, Robert Callaghan, Emyr Williams, Angharad Dalton, and Alice Turner. "Enhancing Public Service Innovation through Value Co-Creation: Capacity Building and the 'Innovative Imagination.'" *Public Money & Management* 42, no. 5 (July 4, 2022): 332–40, doi: 10.1080/09540962.2021.1981042.
- Jnanathapaswi, Swami Gurunand. "Thematic Analysis & Coding: An Overview of the Qualitative Paradigm." *figshare* (2021), doi: 10.6084/M9.FIGSHARE.17159249.V1.
- Kotronoulas, Grigorios, Susana Miguel, Maura Dowling, Paz Fernández-Ortega, Sara Colomer-Lahiguera, Gülcan Bağçivan, Eva Pape, et al. "An Overview of the Fundamentals of Data Management, Analysis, and Interpretation in Quantitative Research." *Seminars in Oncology Nursing* 39, no. 2 (April 2023): 151398, doi: 10.1016/j.soncn.2023.151398.
- Krueger, Tobias, Trevor Page, Klaus Hubacek, Laurence Smith, and Kevin Hiscock. "The Role of Expert Opinion in Environmental Modelling." *Environmental Modelling & Software* 36 (2012): 4–18, doi: 10.1016/j.envsoft.2012.01.011.
- Leino, Helena, and Eeva Puumala. "What Can Co-Creation Do for the Citizens? Applying Co-Creation for the Promotion of Participation in Cities." *Environment and Planning C: Politics and Space* 39, no. 4 (June 2021): 781–99, doi: 10.1177/2399654420957337.
- Mahmoud, Israa Hanafi, Eugenio Morello, David Ludlow, and Giuseppe Salvia. "Co-Creation Pathways to Inform Shared Governance of Urban Living Labs in Practice: Lessons From Three European Projects." *Frontiers in Sustainable Cities* 3 (August 6, 2021): 690458, doi: 10.3389/frsc.2021.690458.
- Mendelow, Aubrey. "Stakeholder mapping." In *Proceedings of the 2nd international conference on information systems*, Cambridge, MA: A. Mendelow, (December 1991): 10-24
- Pauliuk, Stefan, and Edgar G. Hertwich. "Prospective Models of Society's Future Metabolism: What Industrial Ecology Has to Contribute." In *Taking Stock of Industrial Ecology*, edited by Roland Clift and Angela Druckman, 21–43. Cham: Springer International Publishing, 2016. Available online at https://doi.org/10.1007/978-3-319-20571-7_2.
- Plank, Christina, Willi Haas, Anna Schreuer, Jenan Irshaid, Daniel Barben, and Christoph Görg. "Climate Policy Integration Viewed through the Stakeholders' Eyes: A Co-production of Knowledge in Social-ecological Transformation Research." *Environmental Policy and Governance* 31, no. 4 (July 2021): 387–99, doi: 10.1002/eet.1938.
- Rădulescu, Maria Alina, Wim Leendertse, and Jos Arts. "Conditions for Co-Creation in Infrastructure Projects: Experiences from the Overdiepse Polder Project (The Netherlands)." *Sustainability* 12, no. 18 (September 18, 2020): 7736, doi: 10.3390/su12187736.
- Satorras, Mar, Isabel Ruiz-Mallén, Arnau Monterde, and Hug March. "Co-Production of Urban Climate Planning: Insights from the Barcelona Climate Plan." *Cities* 106 (November 2020): 102887, doi: 10.1016/j.cities.2020.102887.
- Shtjefni, D., G. Ulpiani, N. Veters, G. Koukoufakis, and P. Bertoldi. "Governing Climate Neutrality Transitions at the Urban Level: A European Perspective." *Cities* 148 (May 2024): 104883, doi: 10.1016/j.cities.2024.104883.
- Smetschka, Barbara, and Veronika Gaube. "Co-Creating Formalized Models: Participatory Modelling as Method and Process in Transdisciplinary Research and Its Impact Potentials." *Environmental Science & Policy* 103 (January 2020): 41–49, doi: 10.1016/j.envsci.2019.10.005.
- Timans, Rob, Paul Wouters, and Johan Heilbron. "Mixed Methods Research: What It Is and What It Could Be." *Theory*