

Social innovation for climate neutrality in cities: actionable pathways for policymakers

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Climate neutrality is an urgent and complex challenge that cannot be solved with technological solutions alone but requires a systemic approach. Social innovation is a key lever of change in socio-technical transformations: promoting social innovation at urban level can empower communities in shaping sustainable behavior and collective action to tackle climate change. To promote and scale social innovation at urban level for reaching climate neutrality, politicians and policymakers need to be aware of effective practices that can be implemented that match a city's readiness level. With the aim to develop a framework to support public administrations and policymakers in making informed decisions in creative favorable ecosystems of social innovation for sustainability, we triangulated the academic literature on social innovation for climate neutrality with over forty case studies to derive categories of actions, further refined, based on experts' opinions and feedback. The resulting, theoretically based and practically relevant, social innovation actionable pathways to climate neutrality are composed of ten categories: (1) Public administration capacity building in social innovation for climate neutrality; (2) Social Innovation task force and strategy making (3) Funding for Social Innovation initiatives; (4) Citizens' capacity building; (5) City Social Innovation mapping; (6) Co-creation platforms and environments; (7) Social innovation policies; (8) Incubating and accelerating social innovations, (9) Co-creation and cross-sector partnerships, and (10) Systemic innovation approaches to climate neutrality which include social innovation. For each category, related literature and case studies are provided.

Keywords: *sustainable social innovation; sustainability; social innovation ecosystems; public administration*

1 Introduction

Climate change is a grand challenge that requires a systemic approach: technological solutions need to be complemented with behavioral change at individual and community level (Geels et al., 2017; Cherp et al., 2018; Bolwig et al., 2020; Sörgel, 2021). Most people on earth live in cities, thus a focus on fostering cities' social innovation for sustainability can provide remarkable contributions to reducing greenhouse gas (GHG) emissions (Coutard & Rutherford, 2010). But how can public



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administrations, politicians and policymakers at urban level foster community solutions to climate neutrality? Cities' public administrations can be overwhelmed by the challenge, and might not have the necessary knowledge and/or expertise to make scientifically based choices to support community solutions to climate neutrality. Extant literature provides a wealth of knowledge on social innovation's potential impact for sustainability (Ceschin & Gaziulusoy, 2016; Angelidou & Psaltoglou, 2017; Schartinger et al., 2017; Andion et al., 2021; Schönwälder, 2021). Yet – to the best of our knowledge – there is no comprehensive framework that synthesizes this knowledge in actionable steps that can pragmatically support urban decision makers.

Thus, the research question we aim to tackle is: what are the key categories of intervention at urban level that can foster social innovation for climate neutrality?

Such key categories can be utilized by cities' transition teams to make informed decisions to support and scale social innovation initiatives that are aimed at sustainability in cities, as well as by scholars to identify gaps in literature which are societally relevant. To answer this question, we integrated a top-down approach, based on a systematic literature review (Bresciani, Rizzo & Deserti, 2022), with a bottom-up approach, through evidence from case studies. We then extracted key categories, which we tested with experts of the EU-funded NetZeroCities project to improve and refine the categories through multiple workshops.

The resulting social innovation for climate neutrality actionable pathways framework has pragmatic implications: it provides practitioners, politicians, and policymakers with a tool that synthesizes key actions that can be taken at urban level for creating an ecosystem that supports social innovation for systemic change, with the specific application to climate neutrality. The actionable pathways framework will be made available on the project platform to the 112 cities which are part of the NetZeroCities project.

Theoretical implications include a framework that synthesizes extant knowledge, both from academic literature and from practice-based case studies, revised and refined with experts' opinions. As the role of design has evolved to designing system innovations and transitions (Ceschin & Gaziulusoy, 2016), the main contribution of this paper is the identification and description of ten key categories of social innovation actionable pathways for climate neutrality that can innovate a city's ecosystem. Integrating knowledge from academic literature with insights from cases, the framework highlights gaps in extant literature and at the same time enriches the academic debate with

2 Pathways of actions for developing social innovations at urban level to support climate neutrality

2.1 Methodology

With the aim to develop a categorization of key interventions for developing and scaling social innovation for climate neutrality at urban level, we have conducted a systematic literature review (Bresciani et al., 2022) and triangulated the findings with a bottom-up approach, analyzing insights from practice-based cases at urban or regional level to derive categories of action (of which 36 derived from the NetZeroCities Social Innovation Observatory). Although the first version of the categorization was built bottom-up from case studies, insights from the literature required the addition of further categories of actions. During three workshops, a team of seven experts of the NetZero Cities project

(four academics with diverse background and three consultants), the categories, cases and contents were iteratively refined. A visual prototype with the ten key categories has been developed and tested with cities' representatives, and further refined based on their feedback. The detailed prototyping process is described in (Bresciani, Tjahja, Komatsu and Rizzo, 2023)

2.2 Synthesis of categories

To provide a cognitively efficient synthesis of knowledge from reviewed articles and over forty practice-based cases, the actionable pathways are composed of ten main categories, which have sub-categories of specific actions. In Table 1, for each category, information on the specific actions and related literature and cases are provided.

Table 1. Categories of key actions that municipalities can take to support climate neutrality through social innovation

Category	Actions	References	Case Studies
1. Public administration capacity building in social innovation	1.1 PA skills development with courses and workshops on social innovation for climate sustainability	Baer et al. 2021; Diepenmaat et al. 2020; Creutzig et al. 2022; World Economic Forum Report (2013)	City experiment funds; Positive Energy Districts (Norway)
	1.2 Network of experts in social innovation for climate neutrality to which the municipality has access	Terstriep et al., 2020	City-studio (Spain)
2. Social Innovation task force and strategy making	2.1 Establishment of a task force in the municipality on social innovation for climate sustainability with cross-departmental members	Ceschin & Gaziulusoy, 2016; World Economic Forum Report (2013);	PentaHelix
	2.2 Development and communication of the city strategy on social innovation for climate sustainability	Castro-Spila et al., 2016; Ceschin & Gaziulusoy, 2016; Hržica et al., 2021; Terstriep et al., 2020; Voß, J. P., & Bornemann 2011; World Health Organization, 2011	Barcelona co-creating a climate plan with citizens (Spain); Just Transition Listening Platform (Spain)
	2.3 Development of the city's media strategy on social innovation for climate neutrality	Cole, 2021; Rosenbloom et al., 2016	Framing the Sun (Canada)
3. Funding for Social Innovation initiatives	3.1 Sourcing of funding for supporting the city's social innovation interventions: philanthropy, crowdfunding, social bonds, cross-sector partnerships, change in	Hržica et al., 2021; Terstriep et al., 2020; World Economic Forum Report, 2013	Sonnet Bristol City lab; You decide; Antwerp participatory budgeting; Mannheim;

	ownership, platform for attracting investors, in-kind donations, volunteers, etc.		Just Transition Fund; City experiment funds
4. Citizens' capacity building in social innovation	4.1 Social Innovation training provided by the city or partners, to citizens, companies, NGOs personnel, schools, or other entities	Angelidou & Psaltoglou, 2017; Baer et al., 2021; Castro-Spila et al., 2016; Kim & Nam, 2017; Schönwälder, 2021; World Economic Forum Report, 2013	Ecohouse Antwerp; 1.5degree lifestyle; Real Junk food Berlin; Applause; Play!UC; Climate meal; Agroecology; EVA; Smart House training program;
5. City Social Innovation mapping / observatory	5.1 Mapping of cities' existing social innovations and potential partners in a dedicated map or platform (observatory)	Andion et al., 2021; Morais da Silva et al., 2016;	Florianopolis
6. Social innovation policies	6.1 Development of policies to support social innovation for climate sustainability. Policies can be created together with citizens and urban stakeholders	Hržica et al. 2021; Moore et al., 2015; Ostfeld & Reiner, 2020; Schartinger et al., 2017; Selloni & Manzini, 2016; Terstriep et al., 2020; World Economic Forum Report (2013)	Bologna; Milan; Apulia; Pentahelix
	6.2 The municipality actively seeks the procurement/purchase of solutions and goods that meet the criteria of social innovation (solutions that are social in the means and in the ends)	Mačiulytė & Durieux, 2020; World Economic Forum Report (2013)	Oslo Public procurement for innovative nature based solutions; Manchester; Wroclaw; Turin
7. Co-creation platforms and environments	7.1 Co-creation platforms and environments established by the public administration: SI lab, living lab, SI platform, SI incubator, SI accelerator, networking events, SI dedicated places	Andion et al., 2021; Hržica et al., 2021; Morais da Silva et al. 2016; Puerari et al., 2018; Selloni D., 2017; Terstriep et al., 2020; The Economist Intelligent Unit, 2013;	Bristol City Lab; Mannheim; Nappi Naapuri; Bologna; El dia despues; Just transition listening platform
	7.2 The city shares open data to support citizens' development of	The Economist Intelligence Unit (2013);	UK government transparent open data policy

	initiatives, and involves citizens in data collection (citizen science)	Wuebben et al., 2020.	
8. Incubating and accelerating social innovations	8.1 Social Innovation incubator established by the public administration which provides training, mentoring, infrastructures (places for co-working) and seeding (start-up funds) with the aim to activate actors to initiate and sustain social innovations for climate sustainability	Bögel et al., 2022; Corubolo & Meroni, 2015; Meroni, 2019; Nicolopoulou et al., 2017; Moore et al., 2015; Murray et al., 2010; Rizzo et al., 2020; Tjahja, 2021; Westley & Antadze, 2010; Westley et al. 2014; World Economic Forum Report (2013); World Health Organization, 2010	Impact Hub; Torino; Bristol City Lab; Mannheim City Lab
	8.2 Social Innovation accelerator which provides training, support and funding to scale existing social innovations for climate neutrality	Gabriel, 2014; Haskell et al., 2021; Kern, 2019; Massaro et al., 2022; Moore et al., 2015; Westley & Antadze, 2010; Westley et al., 2014;	Clean Cities ClimAccelerator; VeniSIA
9. Co-creation and cross-sector partnerships	9.1 Cross-sector partnerships between public administrations, companies, NGOs, universities, governmental organizations, etc, to address climate neutrality (stationary energy, energy generation, mobility & transport, green industry, circular economy, nature-based solutions) and social inclusion	Gregg et al., 2020;	Malmö; Zagreb
	9.2 The municipality initiates the co-creation of social innovation initiatives for climate neutrality together with citizens, local companies, NGOs or other local organizations, to address climate neutrality (stationary energy, energy generation, mobility & transport, green industry, circular economy, nature-based solutions) and social inclusion	Chilvers & Longhurst, 2016;	Better Reykjavik; KLIK
10. Systemic innovation	10.1 PA top-down initiatives to reconfigure the system to	Bolwig et al., 2020; Creutzig et al., 2022;	Paris 15 minute city;

approaches which include social innovation	support climate neutrality through social innovation (i.e., urban spaces design, green nudges, etc.)	Grottera et al., 2020; Hoppe & De Vries, 2019; Mukai et al., 2022; Rebaglio et al., 2022; Schanes et al., 2016;	Spain food waste policies
	10.2 PA deploys co-creation and user-centered design to leverage social innovation for achieving systemic change toward climate neutrality, i.e., in co-creating urban planning and city's circular economy	Camocini et al. 2015; Wolfram & Frantzeskaki, 2016;	Viable Cities; Blok 19 Renewal Program; Vitoria-Gasteiz

3 Description of key categories of actions for developing social innovation ecosystems at urban level to support climate neutrality

3.1 Category 1: Public administration capacity building in social innovation for climate neutrality

An essential starting point for developing government capacity for action (World Economic Forum, 2013) is to train government officials, the public administration, policy makers and politicians on what social innovation is and why it is a necessary lever to reach climate neutrality (Bresciani et al., 2022). Knowledge can be built internally, by training the public administration of the city as well as by developing a network of experts in social innovation to which the municipality has access.

3.1.1 Category 1.1: Public Administration skills development

This action can be developed by organizing courses and workshops on social innovation for climate sustainability, addressing city government officials, public administration, policy makers and politicians. Support for the need of this category of intervention is found in the academic literature: Diepenmat et al. (2020) argue that “sustainable development requires societal innovation and cannot be achieved without this” (pg. 1). In addition, Creutzig et al. (2022) demonstrate that “[d]emand-side solutions to climate change mitigation” can lead to high levels of well-being (pg. 23). Urban approaches to social innovation have already been deployed in Norway in the context of the development of Positive Energy Districts (Baer et al. 2021). In the UNDP-funded project City Experiment Fund, the city councils of five cities across South-eastern Europe and Central Asia were trained to apply system thinking for urban transformation, and designed system thinking portfolios for transforming their cities.

3.1.2 Category 1.2: Network of experts in social innovation for climate neutrality to which the municipality has access

The purpose of developing a list or network of experts on social innovation for climate neutrality is to extend a city's ability to act, creating an ecosystem that is favorable to the development of social innovation (Terstriep, 2020). In several Spanish cities, the City Studio program has taken place as a collaboration between the city and the local university. Students can obtain scholarships to design solutions for sustainable urban transformation as part of their thesis. Students have two tutors for the thesis: an academic and a civil servant.

3.2 Category 2: Social Innovation task force and strategy making

After the municipality has been mobilized and has developed the knowledge on the relevance and the methods to develop social innovation for sustainability, it needs to create a dedicated team and a strategy in order to proactively support community innovation for sustainability.

3.2.1 Category 2.1: Establishment of a task force in the municipality on social innovation for climate sustainability with cross-departmental members.

System innovation and transitions (Ceschin & Gaziulusoy, 2016) require cross-departmental teams that mobilize, integrate and align resources (World Economic Forum, 2013) as well as knowledge from the entire municipality. In the EU-funded PentaHelix project, a regional task force was established to provide the empowerment to local and regional authorities for developing actions toward climate neutrality. The aim of the project was to mobilize actors from five key stakeholder groups, public authorities, industry, academia, NGOs and citizens, to find innovative and cost-effective methods to design and implement sustainable energy and climate action plans.

3.2.2 Category 2.2: Development and communication of the city strategy on social innovation for climate sustainability

To achieve systemic change, the city's strategy for climate neutrality needs to embed collaborative processes, and co-design solutions and methods that proactively include and activate citizens towards sustainability (Itten et al., 2021). Favorable innovation ecosystems can be deliberately planned (Terstriep, Rehfeld & Kleverbeck, 2020) to foster system innovations and transitions (Ceschin & Gaziulusoy, 2016). The city strategizing process should consider that the co-creation of public services and involvement of stakeholders in policy making can face organizational barriers within the public administration; the organization needs to be sufficiently mature and knowledgeable to implement co-creation processes (Hržica et al., 2021). Other barriers identified in the academic literature are the increased workload for civil servants due to co-creation of public services, and the potential negative image of the municipality and costs of implementation (Hržica et al., 2021). According to the World Health Organization (2011), the strategizing process should begin with the end in mind, by planning pilot projects and include reflexive learning (Voß & Bornemann, 2011).

The city of Barcelona (Spain) has co-created a “holistic” climate plan with its citizens, which includes climate justice and activates the general public. To create the climate plan, the process involved the interviewing of over 100 city administrators across different departments of the city, and the creation of specific working groups, resulting in a total collection of 424 actions and 100 indicators to monitor performances.

Co-designing a portfolio of actions is one of the aims of the Just Transition Listening Platform, an open innovation platform developed in a mining region in northern Spain, which visualizes the impact of municipalities, map initiatives and co-design actions in accordance with the UN's Sustainable Development Goals.

3.2.3 Category 2.3: Development of the city's media strategy on social innovation for climate neutrality

Socio-technical transitions for decarbonization require transformations at societal and cultural level: the media has a strategic role in agenda setting for politicians, and in shaping citizens' opinion and behavior. In the highly cited article Sociotechnical transitions for deep decarbonization, Geels et al.

(2017) illustrate the case of solar electricity in Ontario (Canada) by adopting a discursive approach to understand socio-technical transitions, shedding light on the key role of the media in decarbonization (based on Rosenbloom et al., 2016).

3.3 Category 3: Funding for social innovation initiatives

A key barrier for municipalities to implement actions towards climate neutrality, in particular in a systemic approach, is the financial cost (Hržica et al., 2021) or lack of funds. The ability to source funding is therefore crucial to develop and sustain social innovation initiatives for sustainability.

3.3.1 Category 3.1 Sourcing of funding for supporting the city's social innovation interventions

To take action, the public administration needs to have the necessary fundings or develop the ability to secure them (World Economic Forum, 2013; Terstriep, 2020) from a variety of sources, such as philanthropy, crowdfunding, social bonds, cross-sector partnerships, change in ownership, platform for attracting investors, in-kind donations, and volunteer work.

Cities that are experimenting with crowdfunding, in addition to the above mentioned Just Transition Listening Platform project (an open innovation platform in northern Spain) and the five cities of the Just Transition Fund project (Southeastern Europe and Central Asia), include the Bristol city lab (U.K., and Mannheim city lab (Germany).

In Bristol, the city council used crowdfunding to raise capital for installing energy efficiency measures in the city's community buildings. The council also tested the use of Community Municipal Bond mechanisms to raise funds to increase municipal buildings' energy efficiency.

Mannheim' city lab (Social Innovation in Energy Transitions) aimed at the development of the Neckarstadt-West neighborhood, an area with many residents with migration background, where language barriers posed a challenge engaging residents in energy transitions. The city lab entailed a neighbourhood crowdfunding scheme for energy efficiency measures, in addition to mobile participation containers, apps for a gamification approach to energy transition, and energy role model flats.

Another popular approach is participatory budgeting: the city of Antwerp (Belgium) gave its citizens the autonomy to spend 10% of the annual city budget. This approach fostered more participation, engaged and empowered communities of neighborhoods. Furthermore, citizens became more aware of needs of different people in the city, ways and resources to satisfy those needs, and the competence needed to collaboratively implement solutions.

3.4 Category 4: Citizens' capacity building in social innovation

3.4.1 Category 4.1: Social Innovation training provided by the city or partners, to citizens, companies, NGOs personnel, schools or other entities

Providing knowledge to citizens and local actors on social innovation and its potential for climate neutrality empowers urban stakeholders through learning practices on collaborating among themselves and/or with the city (Castro-Spila et al. 2016), enabling them to propose and implement innovative solutions that can increase the city sustainability, community building, and be better equipped for developing new start-ups to tackle climate change. Furthermore, engaging citizens is a key opportunity to boost the circular economy (Schönwälder, 2021), energy districts (Bear et al. 2021), and a variety of social innovation initiatives for urban development (Angelidou & Psaltoglou, 2017). In

addition, businesses and NGOs need training on participative approaches in order to be able to understand and leverage co-creation of initiatives with urban stakeholders and municipalities (Kim & Nam, 2017).

In Tartu (Estonia), the Smart House training program was developed to foster behavioral change toward sustainability and smart city living. Residents of pilot areas were encouraged to learn from each other by training “ambassadors” in every pilot area to support their neighbors in smart city living.

In Belgium, the Ecohouse Antwerp is an advice and demonstration centre for sustainable building and living run by the city of Antwerp. It is open to the general public, focusing, in particular, on vulnerable groups. Workshops and advice on energy retrofitting are provided as well as suggestions for saving energy and money for sustainable building and living.

In Finland, the Climate Meal tool was developed under Forum Virium, an innovation company owned by the city of Helsinki. The tool allows restaurants to calculate and communicate their meals’ carbon footprint and label their dishes to help consumers identify dishes with the lowest carbon footprint.

Citizens’ training can be boosted with gamification approaches, such as the 1.5 degree lifestyle project deployed in Finnish cities, which aims to lower participants’ carbon footprint and raise awareness on one’s behavioral impact on sustainability. In addition, the tool allows to measure project success by calculating the carbon footprint at the beginning of the project and comparing it to later timepoints. Similarly, the Play!UC (Playing with Urban Complexity) in the Netherlands, Belgium and Austria aims to trigger sustainable behavior through games, using a co-located serious game approach aimed at young adults.

3.5 Category 5: City social innovation mapping/observatory

3.5.1 Category 5.1: Mapping of cities' existing social innovations and potential partners in a dedicated map or platform (observatory)

To be able to connect actors in a city, in order to co-develop solutions and strengthen communities, the city, as well as the stakeholder themselves, needs to be aware of the main players and resources available in the city. The purpose of a social innovation observatory is the mapping of existing initiatives and their networks. Scaling up social innovation requires a collaborative, networked approach to talking problems (Morais da Silva et al., 2016). Mapping existing players and resources enables social innovation to thrive, as in the case of the Social Innovation Observatory of Florianopolis in Brazil (Andion et al., 2021), a co-developed collaborative platform which maps the social innovation ecosystem of the city.

3.6 Category 6: Social innovation policies

3.6.1 Category 6.1: Development of policies to support social innovation for climate sustainability. Policies can be created together with citizens and urban stakeholders

Schartinger et al. (2017) posit that “[i]n Environment and Climate Change, the initiatives seemed to primarily rely on non-governmental and non-profit organizations, and more than others on private companies (together with Energy Supply and Transport and Mobility). Public bodies are underrepresented in Environment & Climate Change compared to the other policy fields. The strong involvement of private companies as actors in the social innovation initiatives in Environment and Climate Change also explains the prominent role of economic returns from own products and services in the funding of these social innovation initiatives.” (pg. 2).

Thus, in order to scale the impact of social innovation as a key lever for reaching climate neutrality, municipalities need to act at policy level (Moore et al., 2015), to create favorable social innovation ecosystems (Terstriep et al., 2020). The lack of public services readiness to support social innovation has already been identified as a barrier to co-creation in public administrations (Hržica et al. 2021), despite evidence of the usefulness of the approach for decarbonization (Ostfeld & Reiner, 2020). Yet, there is evidence that innovative governance needs “policy constellations”, which are “clusters of initiatives able to interact positively with the socio-technical system on which they seek to impact” (Selloni & Manzini, 2016, pg. 128). A systemic impact can be created when an ecosystem is developed with mutually synergic initiatives with a world vision that is shared by the actors (Selloni & Manzini, 2016, pg. 128), moving “beyond binary choices in crafting responses to social, economic, and environmental challenges” (World Economic Forum, 2013, pg. 5) to leverage actors for public benefit. As reported by Selloni and Manzini (2016), Italian regions that have already developed policies constellations which support social innovation include Milan (Milan Smart City), Apulia (Bollenti Spiriti) as well as Bologna.

The case of Bologna is particularly relevant, as it fostered a participatory approach to policy-making to create a collaborative city. For this purpose, the city adopted a political process that involved top-down and bottom-up measures, including participatory budgeting. The city provides a platform for citizens to co-design community projects through collaborative pacts for urban development and socio-cultural projects. This collaborative approach to policy-making led to the gradual adoption by the government of a citizen-centered perspective of public value creation.

With a top-down approach, the project PentaHelix (in five countries), aimed at empowering local and regional authorities to develop and implement actions for energy and climate neutrality, contributes to shape both national and European climate and energy goals as well as policies.

3.6.2 Category 6.2: The municipality actively seeks the procurement/purchase of solutions and goods that meet the criteria of social innovation (solutions that are social in the means and in the ends).

Public procurement has the potential to role model and shape market forces, by engaging market stakeholders to sustainable practices (World Economic Forum, 2013). Specific interest in the procurement of innovative nature-based solutions is rising, although barriers should not be overlooked (Mačiulytė & Durieux, 2020). A publication by the European Commission, Directorate-General for Research and Innovation outlines case studies of cities in Europe that used public procurement of nature-based solutions, noticing that most cities were supported by the Horizon 2020 funding program (Mačiulytė & Durieux, 2020), such as Manchester (UK), Wrocław (Poland), Turin (Italy), etc.

An emblematic case is the city of Oslo (Norway), which declares to be committed to using public procurement as a tool to support and drive the transition to sustainable consumption. Such commitment is integrated at the top management level of the city of Oslo and is included in the local action plan. Spending about 2 billion euro per year on procurement, the city of Oslo possesses substantial buying power. The city collaborates in the Network on Green Growth through Public Procurement financed by the Nordic Council of Ministers.

3.7 Category 7: Co-creation platforms and environments

This category of actions focuses on data and platforms provided by the municipality to citizens and urban stakeholders, to network and collaborative create solutions to climate change.

3.7.1 Category 7.1: Co-creation platforms and environments established by the public administration

To support the development and scaling of innovative social practices for decarbonization, it is crucial that the municipality provides physical and online spaces as well as platforms where urban stakeholders can become aware of each other, meet and collaborative experiment potential solutions (Morais da Silva et al., 2015), and to find new solutions to old problems (Economist Intelligence Unit, 2013, pg. 7) through new forms of economies, such as sharing, peer-to peer economy and collaborative consumption (Selloni, 2017 pg. 15).

Such spaces and platforms include social innovation/urban living labs (Puerari et al. 2018), social innovation online platform, social innovation incubators and accelerators as well as networking and co-creating events. The purpose is to create environments that are supportive to scaling through partnerships, local community engagement, philanthropy, collaboration with other social innovations or enterprises, etc. (Terstriep, 2020; Andion et al., 2021).

Exemplary case of cities that have developed co-creation platforms include the above-mentioned cases of Bristol City Lab, Mannheim City Lab, Bologna as well as novel approaches: Better Reykjavik, is an online platform to connect citizens to the city and between themselves. Over 20% of Reykjavik's inhabitants utilize the platform regularly for participatory budgeting, agenda setting and policymaking. Users can submit media content, which is mediated through the use of AI. In Athens (Greece) the Synathina listening platform is the social innovation platform of the City of Athens for engaging citizens in problem-solving and reform. The city's community groups can submit their ideas on how to improve life in the city and get connected to the relevant government representatives, non-governmental organizations, and private businesses that can support their efforts.

In Helsinki (Finland), the Nappi Naapuri map and location-based social web service was developed by the municipality to create a neighborhoods and local communities with increased social wellbeing and participation. In Spanish cities, El dia despues is a multi-stakeholder platform for action towards climate neutrality, creating collectives who develop ideas and plans to address the sustainability. Within these communities, there are experts and professionals from the field who collaborate to create different services that can lead to positive changes.

3.7.2 Category 7.2: The city shares open data to support citizens' development of initiatives, and involves citizens in data collection (citizen science)

Making data publicly accessible is relevant for "improving outcomes and productivity in our public services; promoting higher quality and more efficient services, choice and accountability and encouraging economic growth – it enables the development of tools to support users, commissioners and providers of public services" according to the UK government transparent open data.

In addition, citizens collecting and sharing data can provide a valuable source of information to better understand citizens' behavior and the impact of interventions (Wuebben et al. 2020).

3.8 Category 8: Incubating and accelerating social innovations

3.8.1 Category 8.1 Social Innovation incubator established by the public administration

Social innovation incubators for climate neutrality typically provide training, mentoring, infrastructures (places for co-working) and seeding (start-up funds), with the aim to activate actors to initiate and sustain social innovations for climate sustainability. Bögel et al. (2022) outline the role of spaces to connect actors, in particular for “scaling in transitions”, based on a collective understanding of agency. The role of incubators and common (virtual and physical places) for networking is outlined in academic literature, which provides frameworks and typologies of scaling methodologies for social innovation (Murray et al. 2010; Westley & Antadze, 2010; Westley et al., 2014; Corubolo & Meroni, 2015; Nicolopoulou et al., 2017; Meroni, 2019). Beyond starting social innovations, the role of incubators is to provide support for sustaining (Rizzo, Deserti & Komatsu, 2020; Tjahja, 2021) and scaling (World Health Organization, 2010), which are crucial and challenging phases of any new venture (World Economic Forum Report, 2013).

A well-known example of such hubs for social innovation aimed at sustainable practices is Impact Hub, a global network of local impact innovation incubators and accelerators which is now present in over 100 cities in five continents and has supported over 25,000 entrepreneurs. An impact hub is a co-working space, meeting and training center, and acts as an incubator and accelerator for socially oriented enterprises and NGOs.

An example of city-funded social innovation incubator is found in Torino (Italy), which co-established an incubator certificated by Italian Ministry of Economic Development, in which community engagement, capacity building and co-design are the core modalities to develop innovations to tackle societal challenges.

3.8.2 Category 8.2: Social Innovation accelerator to scale existing social innovations for climate neutrality

Incubators and accelerators can be found together or can constitute separate entities. Accelerators typically provide advanced training on scaling impact, funding to grow existing promising social innovations, and the network to scale initiatives with powerful corporate partners. Advancing systemic innovation cannot be achieved with small-scale initiatives alone, but requires large players (i.e., established companies or governmental actors) to scale (Gabriel, 2014; Moore et al., 2015) for greater impact (Westley & Antadze, 2010). As outlined by Kern (2019), cities can act as leaders in multi-level climate governance by upscaling local experiments.

An example of an accelerator program for climate neutrality is the Clean Cities ClimAccelerator, co-founded by the EU, predominantly based on the cities of Vienna (Austria) and Madrid (Spain), and is a program for high impact and high growth clean-tech start-ups that help cities achieve climate neutrality through system-level innovations. The accelerator matches start-ups with “challenge-owners”; it provides fundings to focus the solution and network with other ventures.

VeniSIA provides an example of a sustainability innovation accelerator based in Venice (Massaro, Dal Mas & Bagnoli, 2022) focused on sustainable business ventures. Experts of co-design work together with pools of corporations, innovators, institutions and academics (from Ca’ Foscari University of Venice which co-established the accelerator) to align goals and efforts for a sustainable city.

3.9 Category 9: Cross-sector partnerships and co-creation

3.9.1 Category 9.1: Cross-sector partnerships to address climate neutrality and social inclusion

Municipalities can establish cross-sector partnerships to mobilize actors (Gregg et al., 2020) to provide solutions toward decarbonization and social goals, by creating organizations composed by the municipality and other entities such as (local) companies, NGOs, universities, other governmental organizations, etc. These (public-private) partnerships can tackle climate neutrality by addressing stationary energy, energy generation, mobility & transport, green industry, circular economy, nature-based solutions, among others.

The city of Malmö (Sweden) selected an approach of private-public funding to tackle climate neutrality and climate adaptation by focusing on private developers through “stakeholder partnership processes”, which entails dialogues with developers at the beginning of urban development processes.

The city of Zagreb (Croatia) developed a partnership for “fair energy transition” to map energy-poor households, evaluate energy needs, and provide information on energy use with the aim to implement low-cost energy efficiency solutions. The partnership entails the City Council, NGOs, students and academia.

3.9.2 Category 9.2 The municipality initiates the co-creation of social innovation initiatives for climate neutrality together with citizens, local companies, NGOs or other local organizations, to address climate neutrality and social inclusion

Aside from being part of or support public-private partnerships, municipalities can be the initiators of co-creation initiatives for climate neutrality (Chilvers & Longhurst, 2016). The platform Better Reykjavik was co-created in 2010 by Reykjavik City (Iceland), Citizens Foundation and citizens, to crowdsource solutions to urban challenges and has additional democratic functions; over 20% of Reykjavik population utilizes the platform regularly (27,000 users), primarily for participatory budgeting.

The KLIK (Križevci Climate Innovation Laboratory) is a cooperative founded in 2020 to make Križevci (Croatia), an energy self-sufficient city, and to foster citizens’ engagement in the energy transition. The cooperative identifies the needs of the local community and empowering the local community through cooperation, joint creation and capacity building.

3.10 Category 10: Systemic innovation approaches to climate neutrality through social innovation

3.10.1 Category 10.1: PA top-down initiatives to reconfigure the system to support climate neutrality through social innovation

The municipality has a remarkable power to foster social innovation for climate neutrality by reconfiguring urban dynamics (Rebaglio, Di Prete & Borghetti, 2022). For instance, by (co-creating) urban planning that fosters social interactions and lowers GHG emissions, by providing physical places for community building, sustainable lifestyle (Grottera, 2020) and green nudges (Schanes et al., 2016; Mukai, 2022).

A notable example is the Paris 15-minute city, a well-known urban planning concept which is based on designing urban design such that most daily necessities can be achieved by walking or cycling within 15 minutes from home, through pedestrian areas and cycling lanes.

In Spain, a new law introduced in 2022 stipulates that all companies and entities that produce, distribute and sell food have to have conceived plans to prevent food waste. The policy is implemented with fines up to 500,000 euro for very serious food waste. This preventive top-down measure is aimed at fostering collaboration between entities and between sectors (including NGOs and food banks) to lower waste and GHG from production that is not utilized.

3.10.2 Category 10.2 Public Administration deploys co-creation and user-centered design to leverage social innovation for achieving systemic change toward climate neutrality
Municipalities can foster systemic approaches, not only with top-down initiatives, but also by co-creating systemic solutions to urban planning and circular economy (Wolfram & Frantzeskaki, 2016). The public administration can “develop radically new ways of living and working, such as ecological villages based on a sustainable and solidary economy replacing a societal model based on economic growth, often alternative ideological models as well” (Camocini, Rebaglio & Petrillo, 2015, pg. 2)

Viable Cities (Sweden) is a well-known systemic innovation program focusing on the transition to climate-neutral and sustainable cities to support new forms of governance, citizen engagement, cooperation, policy development, to accelerate the climate transition to reach climate neutrality by 2030.

The Blok 19 Renewal Program in Zagreb (Croatia) is a collaborative city initiative to develop an inclusive and climate-friendly renovation of the historical center. After the earthquake, the city envisioned an inclusive renovation of the historical neighborhood, including measures for climate change mitigation and adaptation. After several studies, the city mayor invited all experts and citizens to participate in the development of the final neighborhood plan.

Similarly, in Vitoria-Gasteiz (Spain) the city adopted a participatory approach to reorganize the city into superblocks, car-free areas that maximize public space for new social uses. The concept of superblocks is an urban innovation that aims to achieve low-carbon mobility, following a participatory approach at the city and neighborhood level.

4 Implications and conclusions

The presented categorization of key actions that support social innovation as a lever towards climate neutrality in cities, provides a synthesis of the literature complemented and enriched with practice-based cases. The resulting pathways highlight research areas that emerge from cases, but are not extensively covered in the literature despite their practical relevance, such as public procurement, urban strategy making on social innovation for climate neutrality or media strategies. Integrating social-technical transitions for decarbonization (Geels et al., 2017; Cherpet al., 2018) is a complex challenge: the presented key categories can provide a simplification of knowledge, which makes it accessible to decision makers as well as to scholars who wish to provide operationally relevant contributions. By proposing these categories, our intention is not to oversimplify the complexities of a reality which is highly interconnected and mutable, but to synthesize current knowledge to make it more cognitively efficient for non-experts. Future research could focus on testing the effectiveness of the proposed actionable categories and understand their local specificities, for continuous learning and refining our understanding of the role of social innovation in addressing societal grand challenges.

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