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Urban sustainability in Europe

Learning from nexus analysis

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COVID-19 preamble

The coronavirus crisis has had wide-ranging impacts on cities and is likely to remain deeply intertwined with efforts to transition towards more environmentally sustainable urbanisation patterns for years to come. Wherever possible, this report reflects briefly on the immediate response to and longer-term implications for cities of the coronavirus crisis in each of the eight urban environmental sustainability nexuses. However, the research for this report and the analysis of these nexuses was largely finalised before the coronavirus emerged in Europe. More research would be required to understand how the responses to COVID-19 have evolved and what the outcomes of the post-pandemic recovery will be that will also affect cities' achievement of the nexus objectives presented in this report.

We know that cities have been at the forefront of the health crisis from the very beginning, not only bearing the worst impacts but also becoming essential actors in proactively and innovatively addressing the health emergency, as well as dealing with the wider social and economic ramifications. It is clear that city, national and EU budgets will come under strain as a result of the economic crisis, which may result in reduced budgets for core environmental initiatives in the years ahead.

At the same time, many policies that have been implemented primarily to deal with the health emergency will also have long-term environmental and quality of life benefits (e.g. improved active travel infrastructure, access to green infrastructure). These policies will also improve urban resilience to shocks (e.g. extreme weather events). There is a growing movement of cities in Europe actively committing to a green recovery from the crisis — supported by initiatives at the EU level, such as the European Green Deal.

As regards cultural shifts, similar uncertainties exist. While people may be more attuned to the importance of clean air and high-quality green spaces, we are also seeing, for example, growth in single-use plastics, and a renewed preference for the use of private cars over public transport, which may have serious environmental consequences.

What is clear is that, for most Europeans, the pandemic has caused abrupt changes in daily routines that will have far-reaching consequences for cities. For many urban dwellers, working from home has become the new normal, video conferences have replaced face-to-face meetings (and related business travel), online shopping is taking over from physical retail, and people are becoming better acquainted with their immediate neighbourhoods and local green spaces.

The coronavirus crisis is clearly a challenge of unprecedented proportions, while also offering a window of opportunity that may accelerate sustainability transformations in cities. From the perspectives of both research and practice, it is clear that there is a long agenda of issues that will have to be tackled in the months and years ahead. These include, for example, what a green recovery looks like for different cities; the meaning of urbanity and the appropriate mix of land uses; new requirements for the design of the public realm and green spaces; opportunities and challenges presented by new modes of transport; changes in urban functions (e.g. homes becoming the hub of day-to-day life and office buildings being converted to housing); the impact on local business and service providers (e.g. less inner-city footfall); the role of technology and digital futures; urban and regional production (e.g. food, clean energy) and value chains; and considerations of new forms of urban decisionmaking.

While current efforts are rightly focused on tackling the immediate challenges posed by the pandemic, it is important to swiftly put in place recovery pathways that align with wider sustainability objectives. The EU's ambition of climate neutrality by 2050 and its European Green Deal must stay on track, while continuing to recognise the profound societal changes we are undergoing.

Moving forward, it will be ever more important to ensure a fair transition for all while rebuilding our economies sustainably. One important legacy of this crisis is likely to be the realisation that behaviours, institutions and even infrastructure can be changed a lot faster than may have previously been assumed. We are not as 'locked-in' to certain ways of doing things as we thought and, if needed, can radically transform how our cities operate and how we operate within them. This has important implications for cities when it comes to the transformation of systems that will be required to tackle the climate and ecological crisis in the years to come.

Executive summary

Background and approach

This report presents the results of research undertaken to support the preparation of the EEA report *Urban sustainability in Europe — Avenues for change.* It presents the detailed analysis of eight urban environmental sustainability nexuses. These examples were used to help understand the complexity of urban systems and explore how, in practice, using nexus analysis could help identify existing challenges, potential trade-offs, actions to achieve urban sustainability objectives and opportunities to move towards better coordinated and integrated policy and action. The analysis is followed by overall findings and lessons in support of policy integration and action. This report is also a part of a series of outputs prepared by EEA as presented in Figure ES.1.

The *European environment — state and outlook 2020* report emphasises the key role cities play in wider sustainability transitions across Europe. Cities are hubs of creativity, innovation and learning and have the capacity to effect systemic changes across a range of critical environmental issues (EEA, 2019a). Cities concentrate people, jobs and economic activity. However, this also means that they are disproportionately affected by social challenges such as segregation, poverty and inequality (EC, 2016a).

Vulnerabilities from climate change and other environmental stresses will also be felt most acutely in urban areas because of the higher densities of people and infrastructure and because of cities' dependence on their hinterlands for food, water, energy and other resources (EEA, 2019a). The EEA's in-depth analysis of drivers of change of relevance for Europe's environment and sustainability (EEA, 2020a) emphasised that cities have a primary role in pushing forward societal change by promoting the circulation of ideas and encouraging social and technological innovations, experiments and changes in values, lifestyles and approaches to governance.

Cities are therefore both places where systemic challenges must be met and places of opportunity to address these challenges. Of course, cities differ enormously in the challenges they face and the tools they have available to address them. Sharing concrete examples of the many different expressions of urban sustainability can help to inspire city governments, irrespective of their context, to recognise that there is a transition pathway that is right for them.

Urban environmental sustainability: a framework

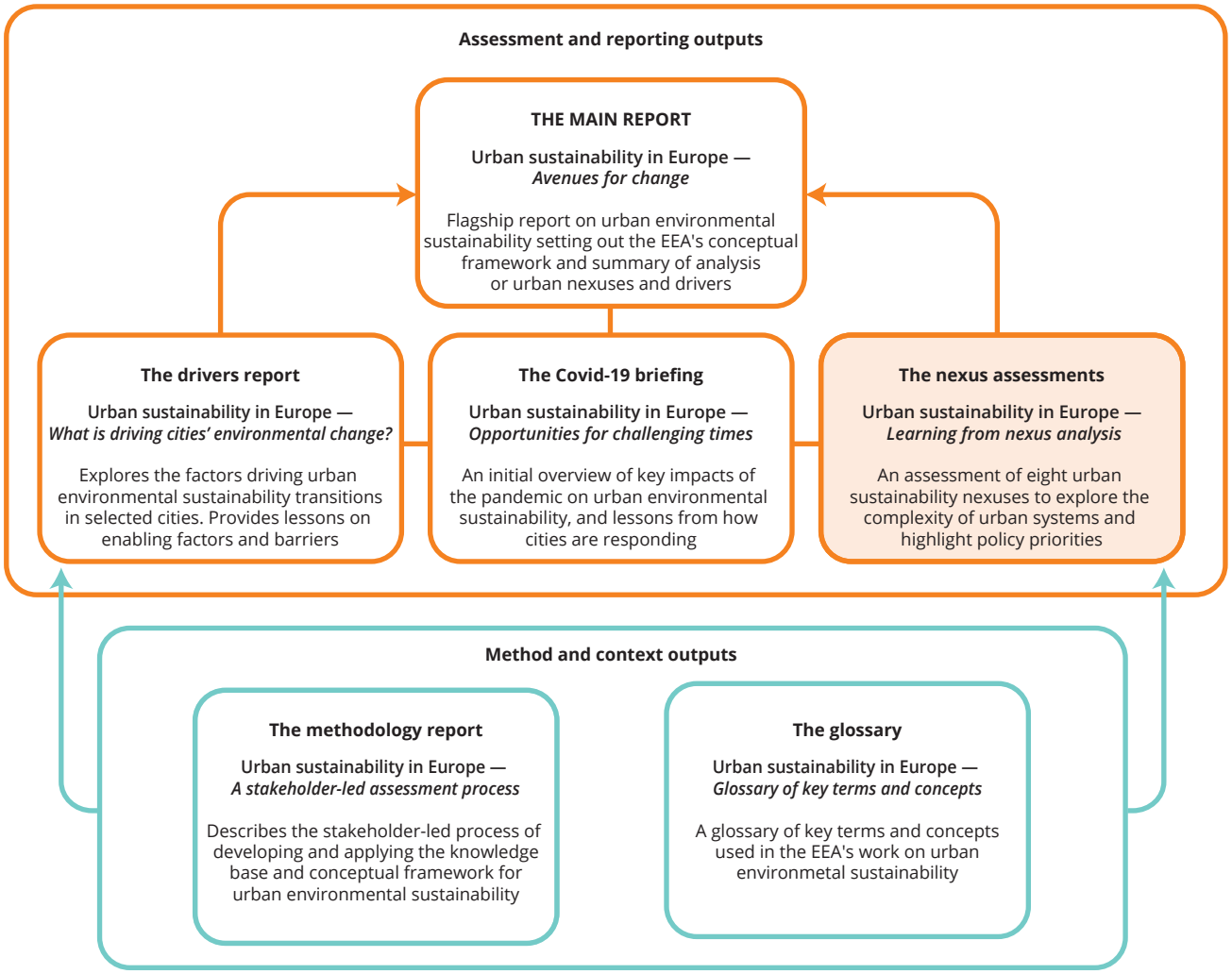
Although there is no single agreed definition of urban sustainability, or what a sustainable city might look like, there is broad agreement on what contributes to urban sustainability. This includes the need to address economic, social and environmental issues in an integrated way and to ensure that cities are inclusive, safe, resilient and sustainable. For the EEA, urban environmental sustainability means encouraging revitalisation and transitions of urban areas and cities to improve liveability, promote innovation and reduce environmental impacts while maximising economic and social co-benefits.

Urban systems are inherently complex, as is the concept of urban environmental sustainability. To help understand the range of factors that will influence the transition towards urban environmental sustainability, a conceptual framework for urban environmental sustainability has been developed. The framework is designed to help support assessment and analysis.

The conceptual framework is based on four main components (see Figure ES.2). These are:

- Lenses — a range of perspectives on urban environmental sustainability that represent priority issues or concerns reflecting the EEA's environmental remit and can be used to guide/focus assessment and analysis.
- Context — the range of current and historical, physical, social and institutional characteristics that create and shape the setting in which a specific city exists, develops and functions. Each city's context has a considerable influence on the transition to urban environmental sustainability.
- Enabling factors — relatively high-level forces that, based on their level of availability, can facilitate (drivers) or hinder (barriers) the transition towards urban environmental sustainability.
- Building blocks — key qualities that contribute to urban environmental sustainability. Depending on the context and enabling factors, different building blocks will be the inputs required to transition towards urban environmental sustainability.

Figure ES.1 **The EEA's reports and outputs on urban environmental sustainability transitions being published in 2020 and 2021**



Source: EEA.

The conceptual framework is intended to be applied in different ways to support the analysis of cities from the perspective of environmental sustainability. It has been used to develop and inform the analysis of urban nexuses and research into drivers of and barriers to sustainability in cities that are summarised in this report.

The urban nexus approach: towards integrated, cost-effective actions

To address systemic environmental challenges and accommodate a greater number of people in the coming decades while improving the quality of life of their residents, European cities must urgently shift towards a more integrated approach to policy and action. There is a need for cross-cutting strategies to address key systems (e.g. energy, mobility) and support the transformation to a low-carbon and circular economy. Nexus analysis provides a way of helping to understand complex systems and identify better coordinated polices and actions to support urban environmental sustainability.

Drawing on the conceptual framework, literature review and stakeholder input, eight example nexuses were selected for assessment:

- Climate resilience nexus
- Quality of life nexus
- Urban accessibility nexus
- Environment and health nexus

- Food security nexus
- Closing the loop nexus
- Clean energy nexus
- Sustainable buildings nexus.

Each of the priority nexuses is framed around a nexus objective (e.g. clean energy, accessibility) and selected interacting policy areas. Measuring progress towards nexus objectives could be achieved by either using existing overarching indicators or indices or creating new ones, for example an overall index of urban climate resilience, or by monitoring a range of outcomes associated with achieving the nexus objective, for example, in the case of climate resilience, measuring the change in flood risk to urban communities. The nexus analyses presented in this report are intended to be illustrative and explore selected examples of interacting areas of policy and action. A comprehensive compilation of potential nexus indicators has not been completed; however, results of an initial overview of potentially relevant indicators for each nexus from EEA or other sources were presented. Where these are available, potential indicators for each key nexus issue are proposed (i.e. an overall indicator or indicator set related to the nexus objective), as are indicators for measuring nexus outcomes.

The urban nexus approach can help to identify opportunities to coordinate policymaking and action. Policymaking and action are often developed in silos, addressing specific sectors or issues, with sometimes competing objectives. The urban nexus approach, through which two or more urban policy areas are considered together, can help identify synergies, co-benefits and trade-offs. In this way opportunities can be prioritised to achieve better coordinated and cost-effective policymaking and action.

To achieve sustainability transitions, policy needs to be integrated vertically as well as horizontally. Cities often have a degree of autonomy in their governance and so they can, to some extent, influence change independently. However, cities also have interrelationships and interdependencies at different scales, including at the EU and national scales, as well as with neighbourhoods and communities. The nexus approach focuses on the horizontal integration of policy within a city; however, it is also important to consider vertical integration of policy between a city and other scales.

The priority urban nexuses analysed illustrate how interconnected and complex urban systems are. They operate at different levels and interact in many ways. For example, meeting the nexus objective of urban climate resilience relates to other nexus objectives, in particular quality of life, urban accessibility, environment and health, and food security. However, assessing the nexuses individually helps break down the challenges into more manageable issues while also still considering their interconnectedness.

Overall policy and governance implications

Looking across the lessons emerging from the nexus analysis, some overall policy and governance implications are identified:

- Cities are complex systems and a wide range of different types of actions are seen across the nexuses and can be linked to high-level policy agendas (e.g. at the EU scale). However, the nexus analysis shows that in practice a relatively small number of policy agendas can be identified that may be key to achieving urban environmental sustainability. A total of 18 policy agendas were identified, for example building adaptive capacity and reducing vulnerability to climate change; improving the quality of and access to public open space and creating or improving green infrastructure and urban ecology; using digital technology; and promoting participation and empowerment of stakeholders and citizens.

- The COVID-19 pandemic is likely to remain intertwined with policymaking and actions across sectors and affect the transition to urban environmental sustainability in the immediate future and longer term. Although the overall implications of COVID-19 on progress towards the nexus objectives is unclear, many of the actions envisaged will be influenced by the response to and need to recover from the pandemic. Cities may have an opportunity to take advantage of the moment to implement a green recovery.

- A lack of coordinated and integrated policy and action can result in trade-offs. The analysis showed that nexuses interact through thematic and hierarchical links, as well as through specific actions and interventions. An action intended to help achieve one nexus objective can lead directly to trade-offs in the achievement of other nexus objectives.

- Some actions provide opportunities to deliver co-benefits simultaneously across various urban sustainability objectives in a cost-effective way. For example, developing and improving green infrastructure in cities can help to reduce flood risk and urban overheating (Climate resilience nexus), reduce air and noise pollution and encourage active travel (Environment and health nexus), and improve people's satisfaction with their surroundings (Quality of life nexus).

- Cities are well-placed to be leaders in delivering the transition to a low-carbon sustainable economy and have a pivotal role in achieving related EU policy objectives. For most of the policy areas across the nexuses, cities can design, resource and implement sector-specific policy and actions without necessarily requiring the reform of the policymaking process at national and/or EU scales. However, EU and national governments also have an important role in ensuring complementarity between

policy at different scales and in helping cities to overcome challenges to achieving the nexus objectives.

- Achieving urban sustainability will require new governance approaches. Such approaches could include systematic identification of conflicts and barriers across policy sectors; horizontal and vertical integration and coordination of measures; empowerment of all residents and enabling them to have a greater say in urban decision-making.

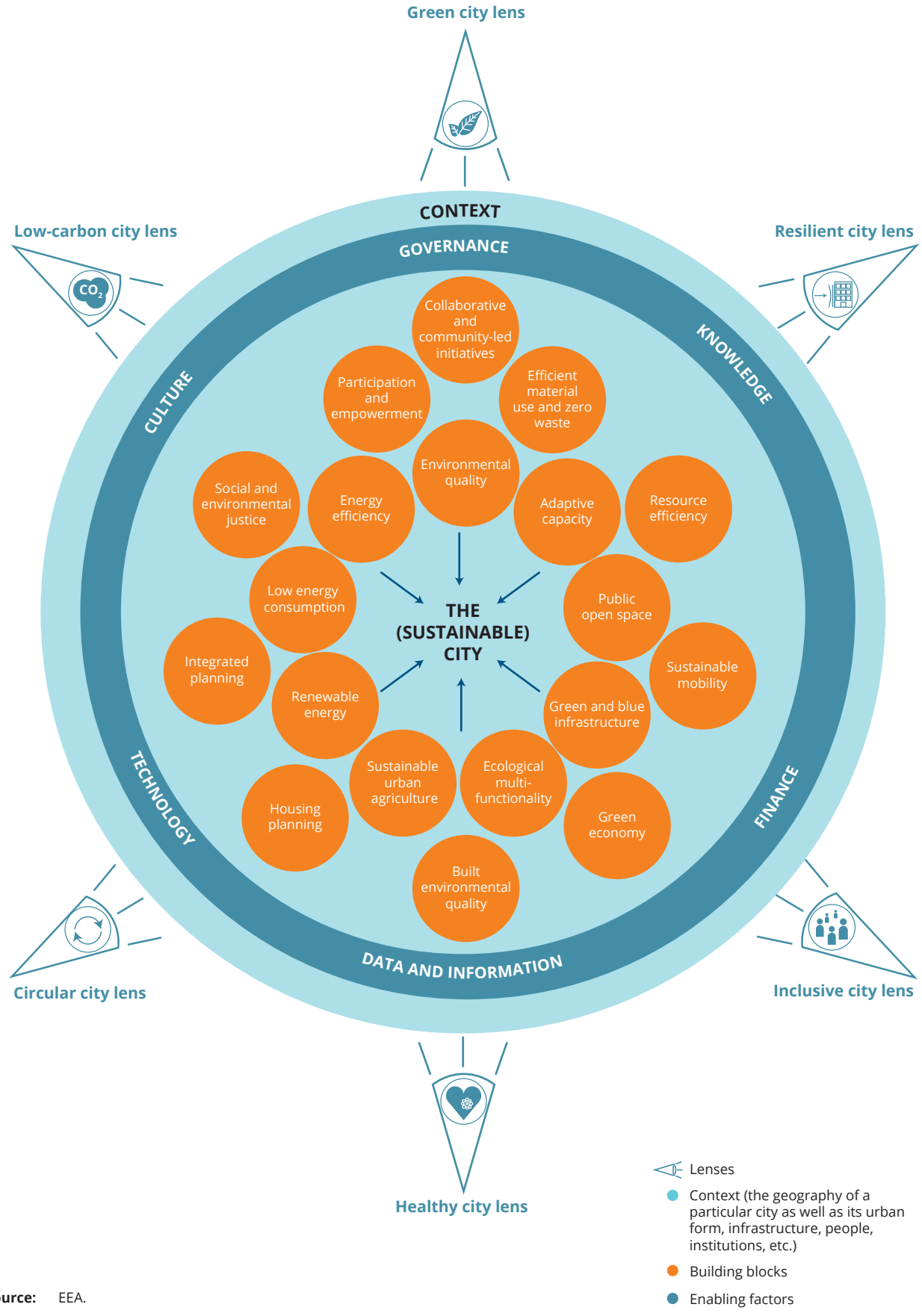
- Citizens and communities are fundamental to help cities reach their urban sustainability objectives. People are a fundamental part of the various systems (food, energy, transport, etc.); thus to be truly effective, equitable action and collaboration must be central to any policy responses.

- The nexus analysis could make use of composite indicators. The nexus analysis shows that there is a limited number of such indicators available that could support nexus assessment. This contrasts with the abundance of quantitative contextual indicators focusing on a single topic.

- The nexus analysis is a useful approach to improve urban policy integration. Applying this approach encourages communication and coordination and can help decision-makers to identify key actions to meet the selected urban sustainability objectives. Potential blind spots in decision-making processes can also be uncovered by highlighting potential trade-offs. The EEA conceptual framework for urban environmental sustainability is useful for decision-makers who need to identify key actions to meet the selected urban sustainability objectives. The lenses and building blocks that are embedded in the framework can help to identify the focus of analysis and provide a set of relevant actions to contribute to urban environmental sustainability.

- A number of research needs and opportunities were identified, including applying the nexus approach at different levels, such as within cities, and at national and European levels (using selected clusters of cities); using cities to test and experiment with solutions to complex transition challenges, for example through EU and national research agendas; and developing new measures of progress towards urban sustainability, including composite indicators and measures combining quantitative and qualitative evidence.

Figure ES.2 **Conceptual framework for urban environmental sustainability**



Source: EEA.

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1 Introduction

1.1 Background

1.1.1 Purpose of the report

This report presents the results of research undertaken to support the preparation of the EEA report *Urban sustainability in Europe — Avenues for change* (EEA, 2021). It presents the analysis of eight urban environmental sustainability nexuses. These examples were used to help understand the complexity of urban systems and explore how, in practice, using nexus analysis could help identify existing challenges, potential trade-offs, actions to achieve urban sustainability objectives and opportunities to move towards better coordinated and integrated policy and action. The analysis is followed by overall findings and lessons from the example nexuses. These findings are also summarised in the main *Urban sustainability in Europe — Avenues for change* report.

1.1.2 The need for integrated policymaking in cities

The European environment — State and outlook 2020: Knowledge for transition to a sustainable Europe (SOER 2020) stresses that achieving sustainability transitions requires coherence across policy domains and scales. Policies and actions are often developed in silos, addressing specific sectors or issues, with contrasting objectives (EEA, 2019a). Likewise, research and knowledge development are frequently compartmentalised along disciplinary boundaries. This means that misalignment and conflicts are inevitable, and it limits shared understanding of systemic challenges and responses that fully reflect the 'barriers, opportunities, trade-offs and co-benefits associated with systemic change' (EEA, 2019a). There is a need for 'policies that embrace the inherent interconnectedness of systems components, interactions across systems, and links between economic, social and environmental goals' (EEA, 2019a).

This is certainly the case in cities and metropolitan area and their peripheries, where the complexity of interactions between socio-economic and environmental factors present significant challenges for improving quality of life while minimising environmental pressures and resource depletion. However, urban areas also provide opportunities for positive systemic change. What is needed is better coordination and prioritisation of policy and action across sectors. The prioritisation aspect is particularly important here, as 'total integration' of everything with everything else as part of political processes is impossible. However, recognising and prioritising critical interrelationships that have not been addressed appropriately is a key first step for better integrated policymaking (Rode, 2018). By considering priority interlinkages between systems and policy areas, environmental, social and economic trade-offs and co-benefits ([1]) can be identified (Rode, 2018; EEA, 2019a).

1.1.3 The nexus concept and urban nexus analysis

One approach to thinking about the interactions between systems and policies is the nexus approach. Box 1.1 provides more information on the nexus concept, approach and analysis. A nexus is defined as the interlinkages and interrelationships between two or more systems (e.g. food and energy) or policy areas. Nexus analysis refers to the identification and analysis of the interactions, interrelationships and interdependencies among sectors and policies or other interventions. The nexus approach involves proactive and integrated policy engagement with such interrelated sectors, resulting in a new approach to developing policy and action. In an urban context this means considering together two or more urban policy areas in order to address a specific urban environmental sustainability problem or to advance a policy objective. By identifying priority synergies, co-benefits and trade-offs, opportunities can be identified for better coordinated and integrated policy and action.

Considering urban issues in this way is intended to improve our understanding of interactions and enable more coherent and effective policy and other interventions that can identify and minimise trade-offs and 'reduce environmental pressures... realising potential co-benefits for human health and well-being' (EEA, 2019a). A nexus approach can help decision-makers choose the most appropriate policy measures or other actions to help identify cost-effective interventions and minimise hidden or unanticipated costs. Cost-effectiveness is defined as either, for a given outcome (e.g. a percentage reduction in air pollution), minimising the net-present value of costs or, for a given cost, maximising the relevant outcome(s) (EC, 2014).

([1]) A co-benefit is where the delivery of one policy area or intervention can help achieve outcomes in another policy area. For example, an intervention to encourage active travel (walking and cycling) could have the main objective of improving public health but might have co-benefits of reducing congestion and air and noise pollution, thus improving quality of life.

In the context of urban environmental sustainability, cost-effectiveness also considers the co-benefits of an intervention (e.g. the health benefits of meeting a primary objective of reduced air pollution).

In summary as presented in Figure 1.1, the potential benefits of conducting nexus analysis for urban environmental sustainability are to:

- help manage the complexity of urban systems by identifying critical interrelationships, co-dependencies and trade-offs between selected aspects of urban environmental sustainability and/or desired policies and other interventions;
- identify and assess specific counteracting and reinforcing policies and other interventions and their outcomes;
- improve understanding of how to achieve multiple outcomes and objectives together and take advantage of co-benefits;
- identify opportunities for improved policy integration and efficacy, by jointly considering multiple objectives and desired outcomes;
- through the above, help to identify cost-effective urban sustainability policy and action.

Box 1.1 The nexus concept and its use in an urban context

The term 'nexus' by definition refers to the interlinkages or connections between two or more elements. A 'nexus approach' implies explicitly considering these connections or interlinkages between resources or sectors and the implications of these in, for example, the context of a strategic or policy goal (Magic Nexus, 2018). Hoff (2011) puts the nexus approach in the context of system efficiency over sector productivity: 'The nexus focus is on system efficiency, rather than on the productivity of isolated sectors.' The Food and Agriculture Organization of the United Nations considers the nexus approach as a 'conceptual approach to better understand and systematically analyse the interactions between the natural environment and human activities, and to work towards a more coordinated management and use of natural resources across sectors and scales' (FAO, 2014).

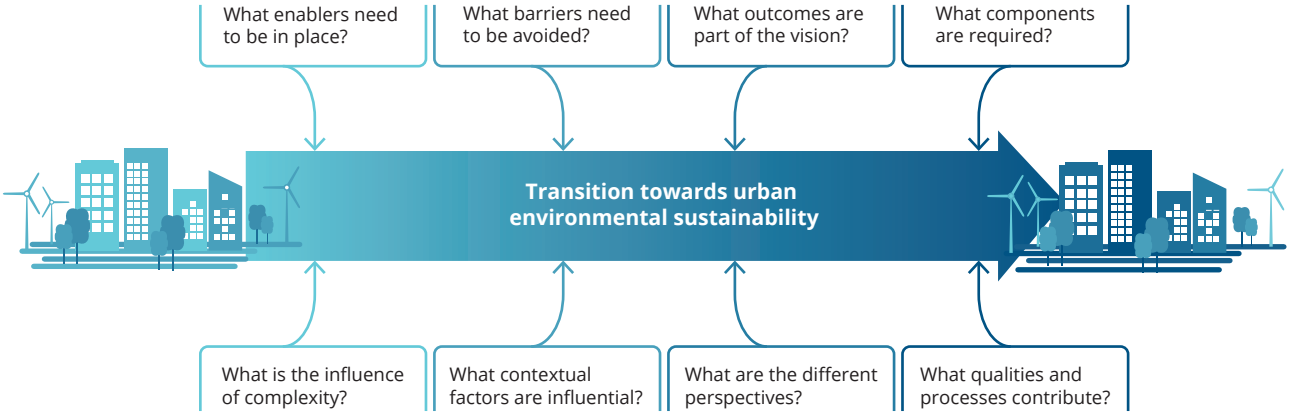
The nexus approach therefore explicitly recognises synergies and trade-offs as necessary for the development of response options. The approach helps ensure the sustainability of the environment and people's livelihoods, facilitating more integrated and cost-effective policymaking, planning, implementation, monitoring and evaluation.

The EEA's 2020 state of the environment report introduces the concept of the 'resource nexus'. This recognises that 'links between … systems arise because of their shared reliance on natural systems, both as a source of resources and as a sink for wastes and emissions'. This shared reliance means that 'addressing problems in one area may simply shift the burden to other systems'. A resource nexus approach can also help highlight the interdependence of production and consumption systems and their cumulative impacts (e.g. on ecosystems). Achieving the transition to a low-carbon, resource-efficient economy 'will require that the interlinkages across systems are considered and the trade-offs and co-benefits identified' (EEA, 2019a).

The focus of existing definitions of the nexus approach is predominantly on resource efficiency and the management of scarcity. However, in an urban context a different focus may be appropriate. UNESCAP (2016) discusses the urban nexus as focusing on the interlinkages among various elements and their 'conversion pathways' — the extraction, supply, distribution, end use, disposal — in consumption and production chains of socio-economic sectors. Furthermore, UNESCAP suggests that cities serve as a nexus, or a focal point that connects and is shaped by economic, technological and social forces (UNESCAP, 2016). UNESCAP (2016) and Lehman (2018) propose an 'intra-urban nexus' and a 'nested urban nexus', the former focusing 'solely on what is urban in the nexus framing', including urban metabolism, infrastructure and human security, while the latter recognises that nexus dynamics need to be understood in the context of driving and constraining forces at both lower and higher levels, meaning that nexus analysis at a city level will need to consider developments at other levels, e.g. global, regional or national policy developments and ecosystems at sub-national and regional levels.

ICLEI and GIZ (2014) defined the use of urban nexus analysis as an 'approach that guides stakeholders to identify and pursue possible synergies between sectors, jurisdictions, and technical domains, so as to increase institutional performance, optimize resource management, and service quality'. Rode (2018) discusses the urban nexus as helping to facilitate a move away from the 'functionally segregated city and its simplistic view of the relationship between urban life and city design' towards an approach that can 'better address the complexities, interrelationships and co-dependencies … characteristic of city systems'. Rode (2018) in particular focuses on what is seen as 'the critical nexus' of urban form and transport, which provides a good illustration of the nexus approach in practice, as 'both elements need to be dealt with jointly to provide accessibility to people, goods and ideas in cities'.

Figure 1.1 The value of conducting nexus analysis for urban environmental sustainability



Source: EEA.

1.2 Priority urban sustainability nexuses

Drawing on the urban environmental sustainability conceptual framework (see Chapter 2 of the *Urban sustainability in Europe — Avenues for change* report), literature review and stakeholder input, eight priority urban sustainability nexuses were identified and selected. Table 1.1 presents an overview of these nexuses. The eight nexuses were selected to cover a range of key urban sustainability objectives and to reflect the main topics addressed by EU environmental and climate policies. They also highlight some of the most critical interrelationships between sectors that are currently not considered appropriately as part of policymaking and action. They are not, however, intended to be comprehensive, as a great many other sustainability objectives and critical interrelationships exist, and in meeting these objectives a very large number of critical policy interactions or nexuses could be identified.

The overall aim of the urban nexus analysis is to explore critical interlinkages and interrelationships between two or more policy areas that need to be considered together in order to advance an urban sustainability objective. The selected urban nexuses are intended to be examples of how this analysis approach could be used in practice to identify existing challenges to achieving urban sustainability objectives and opportunities to move towards better coordinated and integrated policy and action.

Each nexus is framed around meeting a high-level urban sustainability objective (e.g. climate resilience, food security) that is systemic in nature and requires coordinated policymaking and action. Meeting these nexus objectives could require interventions in a large number of policy areas. However, for the nexus analysis in each case, three interlinked policy areas were selected to help identify examples of key interactions, challenges and opportunities for prioritisation and coordination of policy and interventions. Different or additional policy areas could be selected to broaden the analysis or to focus on other policy priorities. However, the selection for this analysis is intended to represent some of the key areas in which coordinated policy is required. Although different cities may use different terminology and have divergent levels of authority or autonomy, the selected policy areas are intended to be representative of strategy, policy and other interventions commonly seen in cities.

The assessment draws on the conceptual framework, by considering actions in the context of the 'building blocks' of urban sustainability that are relevant to the key policy areas in each nexus. Each nexus analysis also explores one example of a challenge and the actions to address it in more detail. By focusing the analysis in this way, the intention is to facilitate a more detailed assessment than would be possible if a larger number of challenges and actions were considered. Of course, each nexus has many potential challenges and associated actions and these will differ from city to city.

The nexus analysis is based on an assessment of what challenges cities typically face in meeting urban sustainability objectives, which critical interrelationships are currently 'under-serviced' and how action can be better coordinated and/or prioritised across the selected policy areas. In doing so, the analysis can identify co-benefits and trade-offs and help to improve the cost-effectiveness of interventions.

A template was used to develop each example nexus. Following the template, each nexus analysis includes:

- an introductory section setting out **why the nexus objective is important** for urban sustainability and summarising key relevant EU and international policy frameworks;
- a **nexus figure** that presents visually the interlinked selected policy areas that the nexus is based around, as well as the key building blocks relevant to meeting the nexus objective (see the template nexus figure in Figure 1.2);
- an overview of the main **challenges and actions** for cities in meeting the nexus objective (including policy and range of other interventions);
- an assessment of one selected **example interrelated area of policy and action**, including a case study from a European city;
- a summary of the **lessons** for achieving the nexus objective;
- a list of sources of additional **information and existing networks** relevant to the nexus.

Each of the priority nexuses is framed around a nexus objective (e.g. clean energy, accessibility) and selected interacting policy areas. Measuring progress towards nexus objectives could be achieved by either using existing overarching indicators or indices or creating new ones, for example an overall index of urban climate resilience, or by monitoring a range of outcomes associated with achieving the nexus objective, for example, in the case of climate resilience, measuring the change in flood risk to urban communities. The nexus analyses presented in this report are intended to be illustrative and explore selected examples of interacting areas of policy and action. A comprehensive compilation of potential nexus indicators has not been completed; however, Annex 1 sets out the results of an initial overview of potentially relevant indicators for each nexus from EEA or other sources. Where these are available, potential indicators for each key nexus issue are proposed (i.e. an overall indicator or indicator set related to the nexus objective), as are indicators for measuring nexus outcomes.

Figure 1.2 Template nexus figure

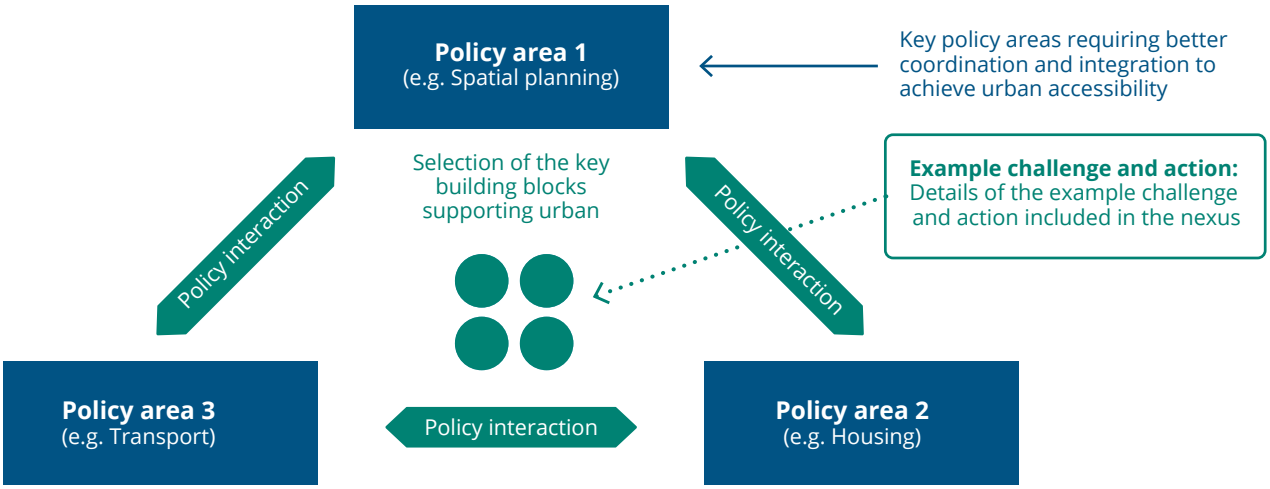
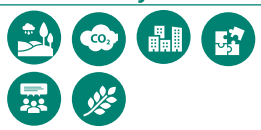
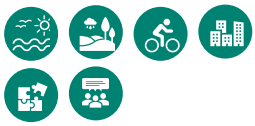
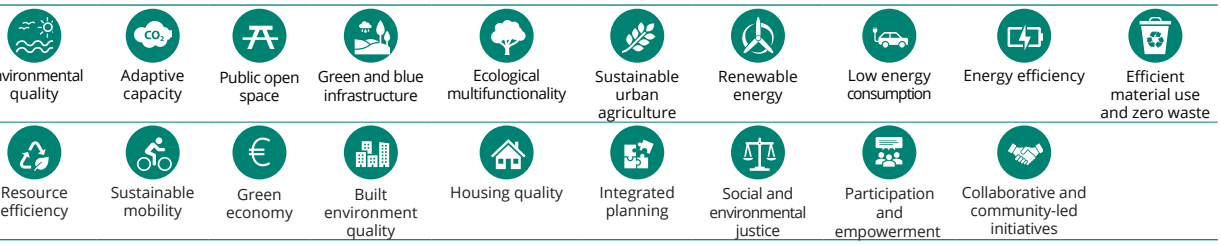


Table 1.1 Overview of the eight example nexuses

Urban sustainability objective — the 'nexus objective'	Key interlinked policy areas that need to be considered to achieve the nexus objective	Building blocks relevant to the key policy areas (see key below)	Example challenges and the actions to address them
Environment and society nexuses			
Climate resilience	• Spatial planning • Green infrastructure • Built environment		Managing urban flood risk by using nature-based solutions
Quality of life	• Urban design • Spatial planning • Nature and biodiversity		Increasing access to green space through integrated land use planning
Urban accessibility	• Spatial planning • Transport • Housing		Increasing urban density through transit-oriented development
Environment and health	• Environment • Green infrastructure • Transport		Improving air quality by creating car-free cities
Food security	• Urban food • Spatial planning • Waste management		Promoting urban agriculture through small-scale innovation projects
Resources and energy nexuses			
Closing the loop	• Resources and materials • Waste management • Green economy		Reducing waste, encouraging reuse and boosting local economies through 'urban resource centres'
Clean energy	• Built environment • Spatial planning • Energy		Decentralising energy production by using clean energy sources
Sustainable buildings	• Resources and materials • Built environment • Urban design		Reducing resource consumption in building construction and use by adopting innovative design, materials and systems

Key to building blocks:

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2
Climate resilience nexus

2.1 What is climate resilience and why is it important in an urban context?

Climate change is increasingly affecting urban life in a multitude of ways. This is an urgent issue: in 2019 the European Parliament declared a climate and environmental emergency, and we also saw the emergence of the youth strikes for climate movement (EC, 2019a). Careful planning and action that considers climate risks can make a city more resilient. The importance of urban resilience to climate change is emphasised in the EU strategy for adaptation to climate change (EC, 2013) and by the Climate Adaptation Partnership of the urban agenda for the EU (Climate Adaptation Partnership, 2018). As part of the European Green Deal a new, more ambitious, EU strategy on adaptation to climate change is planned in 2020/21 (EC, 2019b; EEA, 2020a). To provide a legal basis for the European Green Deal goal of the EU becoming climate neutral by 2050, the European Commission has proposed the first European Climate Law (EEA, 2020a). The law aims to ensure that all EU policies and all sectors of the economy and society contribute to the goal of climate neutrality.

A range of perspectives and definitions of resilience exist across policy, practice and research. This ranges from a narrow, engineering-based, structural definition of resilience to an interdisciplinary concept focused on the interrelationship between social and ecological systems (Armitage et al., 2012). A distinction is also made between proactive and reactive resilience. Reactive resilience focuses on resistance and 'bounce-back' after a shock and suggests a return to the status quo. Proactive resilience emphasises adaptation and transformation in response to both shocks and stresses and suggests a need to change existing conditions (Twigger-Ross et al., 2015). Proactive resilience is particularly relevant in relation to urban sustainability. By avoiding 'bouncing back' to a previous, potentially unsustainable state, cities can adapt, transform and learn while following new trajectories for future development (Chelleri et al., 2015).

Urban areas are affected by climate change in direct and indirect ways. It is often the result of the compounded effects of climate hazards and the consequences of unsustainable forms of urban development, such as air pollution or limited surface water drainage in cities. Building urban resilience implies moving away from unsustainable urban development practices while implementing measures to adapt to and mitigate climate change. Recognising and accounting for the synergies between adaptation and mitigation measures can help ensure that managing climate change impacts will also reduce the impacts of greenhouse gas (GHG) emissions and vice versa.

A climate-resilient city requires individuals, communities, institutions, businesses and systems to have the capacity to reduce exposure to, prepare for, cope with, recover better from, and adapt and transform as needed in response to the impacts of climate change.

The focus of this nexus is on the objective of achieving urban climate resilience, which is an important aspect of urban environmental sustainability. Enhanced climate resilience will help a city tolerate climate change impacts and natural disasters. In doing so, it can avoid the potential collapse of social, economic, and technical systems and infrastructures. Such a collapse of urban systems may have far-reaching consequences for individuals and urban communities. A city that lacks climate resilience may be vulnerable to even small disturbances, such as localised flooding events.

If cities enhance their climate resilience this can also support progress in other nexuses, in particular:

- **Environment and health** — through more sustainable use of land and through green infrastructure (GI) measures that sequester carbon, maintain and enhance biodiversity and improve air quality.
- **Sustainable buildings** — through standards for new and retrofitted buildings to reduce GHG emissions, and through using sustainable heating and cooling to help buildings adapt to a changing climate.
- **Quality of life (QoL)** — through nature-based solutions (NbS) that can, for example, reduce flood risk and protect people's homes.

Climate resilience can also contribute to other nexus outcomes, including 'closing the loop', through minimising consumption of resources to prevent GHG emissions, and 'clean energy', for example by using rooftops for renewable energy production to reduce GHG emissions.

2.1.1 The climate resilience nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response

As the COVID-19 pandemic and subsequent lockdown measures altered all aspects of urban life, many cities had to reconsider their resilience to large shocks, including climate change. Ensuring access to urban green spaces for the public emerged as a fundamental strategy of cities when coping with this crisis. In addition, local authorities across Europe are reshaping their transport networks by reallocating some road space from private cars to public transport, pedestrians and cyclists. This has provided cities with opportunities to reduce emissions from vehicles and increase greening (EEA, 2020a). The requirement for social distancing to manage the spread of the virus has also led cities to review and adjust their heat action plans. This is due to the potential contradiction between advice given to the public for managing heat stress and that for managing COVID-19, such as the advice to go to public air-conditioned spaces (EEA, 2020a).

Longer-term implications as cities draw up and implement COVID-19 recovery plans

The COVID-19 pandemic is highlighting the importance of cities being resilient to shocks. The growing awareness of resilience as a wider concept and the cascading effects of the COVID-19 crisis across systems (e.g. mobility, food) have highlighted the importance of planning for future risks. The pandemic has also had a disproportionate impact on the most vulnerable groups in society. In their resilience strategies cities need to reflect on the social justice implications of climate risks and adaptation actions.

As part of their green recovery plans cities could take advantage of the Next Generation EU recovery package ([2]) and support from national governments to implement measures that also build climate resilience. The COVID-19 pandemic also strengthens the case for the climate adaptation and mitigation potential of green areas in cities. While cities are managing the health crisis, these circumstances provide an opportunity to mainstream adaptation across policy areas and to make it an essential part of a green recovery. For example, in their policies for sustainable and healthy buildings, cities could encourage increased use of vegetation to manage urban heat waves. The pandemic is likely to result in major changes across various sectors that may have climate adaptation and mitigation benefits. For example, cities will need to revisit and change the transport infrastructure to shift the focus from mobility to accessibility and to prioritise active transport.

2.2 Interlinked policy areas contributing to climate resilience in cities

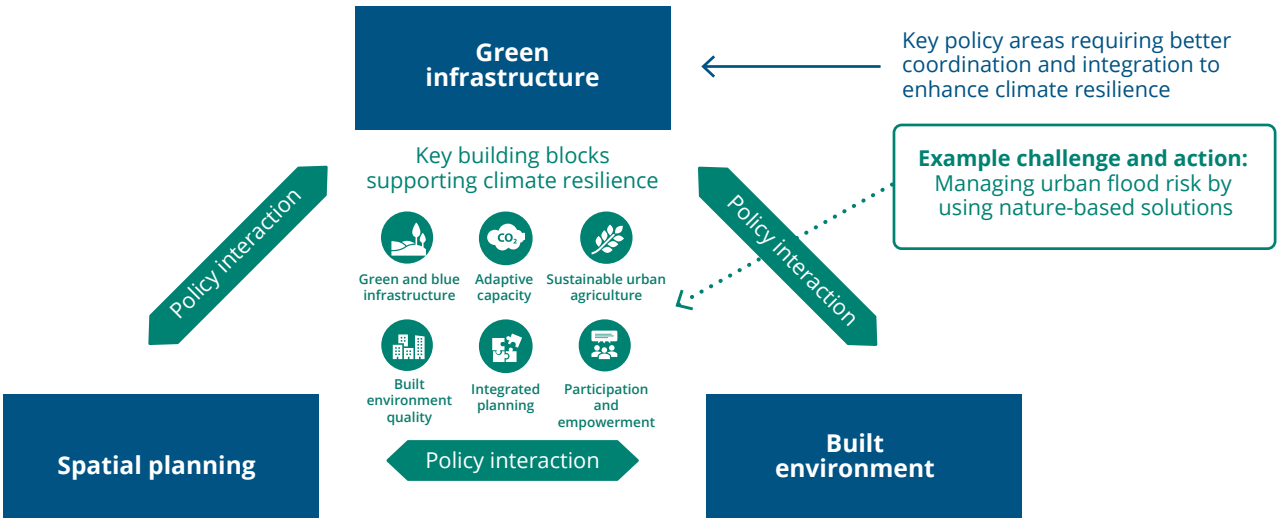
Climate resilience is a broad area, and making cities more resilient will require coordinated action across a wide range of policy areas. This nexus focuses on three interconnected policy areas: spatial planning, GI and the built environment. Considering these together can lead to a more transformative approach to adaptation to and mitigation of climate change impacts (Figure 2.1). Addressing adaptation and mitigation together may also be cost-effective way of improving climate resilience.

Integrating these selected nexus policy areas is also likely to help minimise trade-offs and lead to co-benefits. For example, NbS can have adaptation (e.g. flood risk management) and mitigation (e.g. carbon sequestration) outcomes, but they can also enhance QoL by creating or enhancing green spaces; encourages sustainable transport whereby space is created for cycling and walking; provide socio-economic benefits (create new green jobs, make areas more attractive to investors, reduce health service costs); and improve air quality (Raymond et al., 2017; IEEP, 2021).

Yet, there are also some potential trade-offs. For example, the creation of green spaces in inner city areas may conflict with the goal of a 'compact city'. This concept aims to make cities more accessible to sustainable transport (walking, cycling and public transport) in order to reduce urban sprawl. In addition, creating or enhancing green spaces can lead to higher land and property prices in adjacent neighbourhoods and may trigger gentrification (Raymond et al., 2017). Without accompanying policies and measures (e.g. related to affordable housing) this may exacerbate inequalities within cities.

([2]) https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940

Figure 2.1 The climate resilience nexus: key policy areas and building blocks



The following sections explore some of the key challenges of achieving climate resilience in cities and how coordinated action can enhance it. Table 2.1 then provides an overview of the challenges and actions to address them. There follows a more detailed assessment of an example illustrating how coordinated action can help achieve climate resilience in cities: managing urban flood risk by using NbS (Section 2.2.1).

Challenges of and actions for achieving climate resilience in cities

Under a changing climate, cities will need to respond to a range of impacts. These could include heat waves, wildfires, extreme weather events (e.g. storms, hail), more intense precipitation, coastal flooding and sea level rise, pluvial and river flooding, and drought. Building urban climate resilience requires taking action to avoid, minimise and withstand climate change impacts while also adapting and transforming as needed (rather than returning to the status quo). From an urban sustainability perspective, actions to build resilience should aim to minimise consumption of resources, ensure equitable distribution of the benefits of adaptation to all and enhance economic sustainability.

To enhance climate resilience cities will need to build adaptive capacity and reduce vulnerability. The specific actions a city government chooses will depend on a range of contextual factors and conditions, including:

- the resilience of existing infrastructure and systems;
- the location and geographical setting of the city (e.g. coastal, topography);
- existing environmental qualities, and physical and social conditions;
- existing levels of inequality and vulnerability;
- existing awareness of and political support for climate action.

The 2020 EEA report on urban adaptation in Europe notes that 'the number of local authorities committed to adaptation and the number of those planning and implementing adaptation measures has grown rapidly' with 'over a quarter of the population in EEA-38 … living in local authorities committed to adaptation under the Covenant of Mayors for Climate and Energy' (EEA, 2020a). In spite of this progress, the adoption of local adaptation strategies has been slower than originally envisaged. By 2020 all cities with more than 150 000 inhabitants were expected to have adopted an adaptation strategy. In 2018, only 40 % of this target had been achieved (EEA, 2020a). This means that many cities still lack coherent, cross-sectoral resilience strategies. Climate adaptation and resilience is also rarely mainstreamed across other policy areas. There is thus a need for cities to prepare comprehensive resilience strategies. The COVID-19 pandemic might encourage local policymakers to take action, as it has highlighted the importance of cities being resilient to unprecedented shocks.

However, many cities lack the technical and institutional capacity to strategically prepare for climate change and to build adaptive capacity. Cities can seek to build technical and institutional capacity by engaging with city networks such as the Covenant of Mayors, which has developed resources and

materials to support cities ([3]), such as its Urban Adaptation Support Tool ([4]) (developed jointly with the EEA). The Covenant of Mayors also provides opportunities for peer-to-peer learning, such as through twinning, capacity-building events and webinars. Another means of building capacity could be through training or recruiting experienced officers with responsibility for climate resilience.

As well as capacity to develop climate resilience strategies, a further capacity-related challenge can be insufficient expertise and knowledge of the range of climate change adaptation approaches (e.g. incremental and transformative) and specific measures that should be implemented. There are mechanisms that cities can adopt to help build their institutional and technical capacity.

Alongside technical and capacity challenges, financing climate resilience interventions may also act as a barrier. However, various potential sources of funding may be available to European cities. Funding at the national level will vary between Member States. EU-level finance potentially available to cities includes the following: the EU LIFE ([5]) programme, which supports projects exploring innovative ways of integrating adaptation into urban land use planning, building layouts and management of natural resources; the European Regional Development Fund (ERDF) ([6]), which prioritises climate adaptation funding; and the European Investment Bank (EIB), which supports adaptation interventions such as Jessica (Joint European Support for Sustainable Investment in City Areas) ([7]). Cities could also take advantage of the Next Generation EU recovery package ([8]) to build adaptation measures into their recovery from the COVID-19 pandemic. The Covenant of Mayors website provides a comprehensive overview of funding available to cities for actions to address climate change ([9]). There are also international financial institutions that provide support for cities to address climate change issues. For example, the European Bank for Reconstruction and Development Green Cities programme ([10]) helps local authorities to invest in sustainable municipal infrastructure.

Where cities have resilience strategies in place, together with the finance and the technical capacity to implement them, a range of approaches can help adapt and transform cities into attractive, climate-resilient and sustainable places. Approaches for 'coping' with extreme events and 'incremental' adaptation to improve existing adaptation measures can both offer effective short- and medium-term solutions (EEA, 2016b). Where more fundamental change is required, 'transformative' adaptation offers longer-term solutions. Transformative adaptation addresses the systemic nature of climate change and enables cities to embrace change (EEA, 2016a). An example of a transformative approach can be found in the Netherlands, where the country is attempting to find ways of living with different water levels, instead continuing to try to keep the water out. Box 2.1 provides examples of incremental and transformative approaches.

Climate change impacts do not affect all citizens in the same way. Extreme events, such as flooding caused by heavy rainfall or heat waves, often have the most impact on vulnerable groups in society. Similarly, approaches to building resilience to climate change can also exacerbate social and economic inequalities. Understanding inequalities with respect to climate impacts and solutions is a key condition for addressing this challenge. Yet, in most European cities there is still limited awareness of this problem and of the need for adaptation and mitigation interventions to be designed to address the needs of vulnerable groups (ETC/CCA, 2018).

([3]) https://www.covenantofmayors.eu/support/adaptation-resources.html
([4]) https://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast/step-0-0
([5]) https://cinea.ec.europa.eu/life/life-calls-proposals_en
([6]) https://ec.europa.eu/regional_policy/en/funding/erdf
([7]) https://www.eib.org/en/products/mandates-partnerships/esif/index.htm
([8]) https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940
([9]) https://www.covenantofmayors.eu/support/funding.html
([10]) https://www.ebrdgreencities.com

Box 2.1 Examples of incremental and transformative approaches to adaptation

Examples of incremental and transformative approaches to dealing with selected climate change impacts (flooding and overheating) include (based on EEA, 2016a, p. 35):

- **Flooding:**
  - **coping approaches** — e.g. making flood insurance obligatory to distribute the burden of economic damage from flooding across society;
  - **incremental approaches** — e.g. adding floodgates to buildings, upgrading sewerage systems and using sustainable urban drainage systems;
  - **transformative approaches** — e.g. land use and spatial planning to create space for water; reducing soil sealing to allow natural drainage; placing infrastructure on higher ground; retreating from low-lying flood-prone areas; making use of floating buildings and infrastructure; developing infrastructure and buildings that can be temporarily flooded with little or no damage; harvesting and reusing rainwater; and using nature-based solutions and green infrastructure (see Section 2.2.1).
- **Overheating:**
  - **coping approaches** — e.g. providing heat alerts for the most vulnerable people and directing them to 'cooling centres' or other places where they can stay cool;
  - **incremental approaches** — e.g. additional and/or improved air conditioning;
  - **transformative approaches** — e.g. changing city design (e.g. cooling through use of green infrastructure), changing building design (e.g. using passive cooling) and changing behaviour (e.g. working in the cooler parts of the day).
- **Water scarcity and droughts:**
  - **coping approaches** — e.g. encouraging lower household consumption (e.g. recommending taking showers instead of baths, using water-saving appliances in households and buildings, prohibiting garden watering and swimming pool refilling); selecting drought-tolerant plants in urban areas and introducing new regulations in the agricultural sector (e.g. temporary interdiction of using water sprinklers, allowing only drip irrigation at night); and introducing temporary emergency measures to protect freshwater bodies and reservoirs;
  - **incremental approaches** — e.g. meeting the demand for water by getting it from deeper wells, desalinisation, from other regions and additional storage, water rationing and reducing leakage.
  - **transformative approaches** — e.g. reducing the demand by using water-saving appliances in households and buildings, reusing and recycling water, awareness raising, establish water-saving behaviours and changing production processes (e.g. agriculture, livestock) to use less water, and creating infiltration areas based on ecosystem services for replenishing groundwater.

This challenge can be addressed through a range of mechanisms. Engaging local citizens (including vulnerable groups and those less likely to engage in 'traditional' citizen participation processes) through participative decision-making on the choice and design of adaptation and mitigation options can help to identify the difficulties and needs of disadvantaged groups (EEA, 2020a). In planning and designing climate adaptation (and mitigation) interventions the needs of the most vulnerable groups should be considered. A vulnerability analysis could help to identify specific needs and particular forms of vulnerabilities determined by social differences (ETC/CCA, 2018). Coping approaches can also be an effective way to address some elements of inequality (see also Box 2.1). For example, making flood insurance obligatory (and supporting those least able to afford it), ensuring heat and flooding alerts are understandable and reach those most at risk (e.g. the elderly and families with children) or subsidising or building grey water systems (that harvest rainwater) to build climate resilience while reducing the costs for the economically vulnerable.

Another key challenge is how to build resilience while accounting for potential interactions between climate adaptation and mitigation measures. A poorly coordinated policy mix may lead to undesirable trade-offs, while there are benefits in linking adaptation and mitigation when designing and implementing climate-related activities (Kongsager, 2018). Improving communication and integration of actions between local administration departments can help avoid trade-offs and save resources for dealing with unwanted consequences.

Certain adaptation options, particularly those related to 'grey' infrastructure, may make greater demands on energy and material resources and increase GHG emissions (EEA, 2016a). In addition, physical infrastructure projects can create lock-ins. This occurs when cities invest heavily in into solutions that are not long-term sustainable solutions for urban resilience. An example would be investing in urban energy and transport infrastructure that lock the city into unsustainable energy generation and travel choices. Such lock-ins are typically costly or politically difficult to change. However, coordination of adaptation and mitigation action is yet to be widely established across European cities. Just over a quarter of European cities explicitly consider the synergies and co-benefits between adaptation and mitigation in their climate change action plans (Aguiar, 2018).

Synergies between adaptation and mitigation policy are found where policies and investment to reduce GHG emissions also help to manage climate change impacts and vice versa. For example, reforestation programmes to stabilise degraded soils at risk of landslides and erosion can also sequester carbon. Creating synergies through combined measures can increase the cost-efficiency of actions and make them more attractive to stakeholders, including potential funding agencies.

Although adaptation is key for urban climate resilience, without mitigation the growing pressure from climate change in the long term will undermine cities' efforts to remain resilient. Cities across Europe are seeking to reduce or prevent GHG emissions through a range of strategies. Cities can shift to renewable energy sources, retrofit buildings to make them more energy efficient, develop more sustainable transport systems, and promote more sustainable uses of land and GI. Economic (e.g. costs, incumbent interests) and social (e.g. existing behaviours, equality) factors can make the implementation of such measures challenging (Hendrickson et al., 2016). Citizen engagement through participative decision-making may be key in designing measures and in ensuring local buy-in and uptake. The COVID-19 pandemic has shown that some transformative changes can be implemented much faster than previously assumed. When facing a deep crisis, cities have shown that they can radically transform how they operate and how people operate within them.

Table 2.1 Overview of challenges and actions for achieving climate resilience in cities

Example challenges	Example actions to address challenges
• Weak institutional capacity and lack of cross-sectoral integration acting as a barrier to building adaptive capacity and reducing vulnerability.	• Seek to build institutional capacity, e.g. by engaging with city networks on climate change (e.g. Covenant of Mayors) and training or recruiting staff. • Improve communication and integration between different departments of local administrations.
• Lack of technical expertise in and knowledge of the range of climate change adaptation approaches (e.g. incremental and transformative) and specific measures that should be implemented.	• Adopt incremental approaches that maintain the essence and integrity of systems by going beyond existing actions to deal with natural variation in climate and with extreme events. • Adopt transformative approaches that offer longer-term solutions to deal with climate impacts.
• Insufficient financial resources to design and implement adaptation measures.	• Explore funding mechanisms available at national and EU level. For example, at the EU level, financial support for adaptation interventions can be accessed through the LIFE programme, ERDF and EIB, e.g. through their financial support for integrated, sustainable urban renewal programmes.
• Inadequate awareness of and insufficient accounting for social inequalities in relation to climate impacts and solutions.	• Engage local citizens (including vulnerable groups and those less likely to engage in 'traditional' citizen participation processes) through participative decision-making on the choice and design of adaptation and mitigation options to ensure local buy-in and secure uptake. • Perform specific vulnerability analysis to understand needs and identify vulnerabilities determined by social differences. • Design climate adaptation and mitigation interventions to address the needs of the most vulnerable groups. • Adopt coping approaches such as making flood insurance obligatory, providing heat alerts for most vulnerable people, harvesting rainwater and using less water-intensive sanitation techniques as short- and medium-term solutions to deal with climate impacts.
• Lack of accounting for potential interactions between climate adaptation and mitigation measures to avoid undesirable trade-offs/maximise synergies.	• Explicitly consider the synergies and co-benefits between adaptation and mitigation in city climate change action plans to reduce GHG emissions and help manage climate change impacts. • Link adaptation and mitigation policies and investments to maximise synergies.

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2.2.1 Example assessment of interlinked actions: managing urban flood risk by using nature-based solutions

How do nature-based solutions manage urban flooding fit within the climate resilience nexus?

Nature-based solutions as a flood risk management strategy will:

- require spatial planning policy that protects existing, or supports the creation of new, open and green spaces and facilitates their use for flood management;
- can replace or reduce the need for built infrastructure such as culverts and drainage;
- can be designed and implemented to help meet the need for green infrastructure in a city by providing green spaces that benefit biodiversity and people.

Climate change is expected to increase the intensity and frequency of extreme rainfall, which is one of the main drivers of urban flooding (Hammond et al., 2013). Flood risk in cities is exacerbated by the extent of impermeable land surfaces, coupled with housing and commercial development in river floodplains (EEA, 2016b). The main cause of urban flooding is the increase in soil sealing (resulting in a limited land area for water absorption or storage) that increases the pressure on drainage systems that often lack the capacity to handle intense rainfall events (Warhurst et al. 2014; Ochoa-Rodriguez, 2021).

Urban flooding can lead to physical, economic, social and environmental impacts. In the short term, these can include human health risks (physical and mental), property damage and losses, and failure of infrastructure such as transport and electricity networks. In the longer-term, the disruption caused by flooding can have economic impacts that extend beyond the immediately affected city (Hammond et al., 2013).

Possible policy responses and interventions

A range of measures could be used to address urban flood risk. However, there is increasing attention on the potential of NbS, which may include creating and enhancing GI in a city and smaller-scale actions such as installing green roofs. NbS aim to help societies address a variety of environmental, social and economic challenges. They are actions inspired by, supported by or copied from nature (EC, 2015a). NbS use the features and system processes of nature in order to achieve desired outcomes. For example, by using natural processes to reduce urban run-off and increase urban water storage (e.g. tree planting, creation of reed beds and ponds for temporary water storage), NbS can mitigate flood risk. The approach therefore emphasises that maintaining and enhancing natural capital is of crucial importance, as it forms the basis for solutions (EC, 2015a).

NbS have the potential to provide multiple co-benefits beyond enhancing resilience to urban flooding (EEA, 2016b; IEEP, 2021). For example, the use of GI (e.g. restoring wetland areas and floodplains) can also have human health benefits by improving air quality and providing space for recreation. GI will also have environmental benefits from providing a buffer for habitats and species and climate mitigation benefits from carbon sequestration (EEA, 2017a; IEEP, 2021). NbS also potentially avoid the potential trade-offs arising from implementing grey infrastructure solutions to flood protection, such as increased GHG emissions during construction or operation.

Maximising co-benefits and limiting trade-offs while using NbS requires the interactions between various policy areas to be considered (EEA, 2016a). For example, coordination between water and other policy areas (e.g. land use planning, transport) to reduce flood risk at the local level (EEA, 2016b). Long-term urban spatial planning is particularly important to maximise co-benefits and limit trade-offs (EEA, 2020a). It can account for future climate change impacts and for the changing needs of a city. Decision-makers also need to consider collaborations and harmonisation of policy responses and interventions across administrative boundaries and scales. For example, a city may be able to address some flood risks, such as local stormwater discharge, but cannot on its own reduce the risk from upstream river flooding (EEA, 2016a).

Box 2.2 Example policy response: blue-green infrastructure mitigating urban flooding in Copenhagen, Denmark

Following multiple heavy rainfall events, Copenhagen developed a cloudburst management plan. It addresses the eight central city catchments and includes 300 separate projects that are expected to run over the course of the next 20 years. These projects are designed to increase the city's blue-green infrastructure and enhance its resilience to flooding.

Copenhagen concretisation masterplans were developed for a number of these catchment areas. These integrated, multidisciplinary plans bridge the gap between planning and site-specific solutions. This was achieved through the application of a cloudburst formula — a six-step procedure designed for integrating blue-green infrastructure solutions. The cloudburst formula is shaped by investigation, modelling and mapping, analysis of the cost of doing nothing, planning and designing of multifunctional and flexible solutions, public participation and cost-benefit analysis.

Using this procedure helps to identify integrated flood resilience solutions. For example, one of the options for a priority catchment area included the lowering of the level of a local lake to create a new cloudburst storage are. This option combines a blue-green and a grey solution (i.e. use of pipes), resulting in an integrated and balanced approach between infrastructure and green space.

Source: Oppla (2021a).

Box 2.3 Example policy response: urban river restoration: a sustainable strategy for stormwater management in Lodz, Poland

During industrialisation, the majority of the many city's urban streams were canalised and transformed into culvert pipes, contributing to an increase in surface run-off and in the speed of water outflow and causing frequent flooding in parts of the city during storms. In response, the city developed, in the context of the Switch project, a holistic approach to urban planning based on a blue-green network concept, which aims reduce flood risk and improve the microclimate, thereby contributing to better quality of life. The approach was tested in a demonstration project on the Sokołówka river, where hydraulic rehabilitation measures, wetlands and three stormwater reservoirs (completed in 2006, 2009 and 2010) and a sequential sedimentation
bio-filtration system for stormwater purification (completed in 2011) were planned and implemented. The Sokołówka river restoration project has contributed to resolving a series of climate-related challenges:

- reduction in urban surface flooding and extreme flows;
- increase in groundwater levels, improving the city's drought resilience;
- improvement in water quality;
- increase in the quality of life and health of city residents.

The demonstration project in the Sokołówka valley triggered follow-up actions by private investors, who implemented, for instance, solutions for stormwater retention on their premises. It also attracted interest from civil society. The experience has convinced the Lodz authorities and water professionals of the value of replicating these solutions for other rivers across the city.

Source: Climate-ADAPT (2020a).

Box 2.4 Example policy response: water retention reservoir in Podutik, Slovenia

A flood reservoir in Podutik was redesigned into a multifunctional flood reservoir, resulting in a broad range of ecosystem services being provided through the integration of nature-based solutions. Through a collaborative process involving a wide range of stakeholders (i.e. local council, national government agencies, academics, private sector and local communities) the project aimed to develop a new approach to water management and flood prevention. The Podutik reservoir follows policy set out in the Seventh Environmental Action Programme (2014-2020), the Water Framework Directive and the Floods Directive. Establishing a multifunctional flood reservoir had two main objectives: firstly, to improve and maintain a good ecological status in the nearby watercourses and, secondly, to mitigate floods in the settlements near the city of Ljubljana.

The Podutik reservoir is an example of good practice, as it has led to multiple benefits, including an increase in local biodiversity, the mitigation of water pollution and establishing a strong identity for the area. Among the key lessons for successfully planning and implementing this policy response is the importance of an integrated approach to planning, as well as strong engagement from stakeholders.

Source: Oppla (2021b).

2.3 Lessons for achieving climate resilience in cities

The challenges of predicting the timing, scale, frequency and intensity of climate change impacts highlights the importance of informed, coordinated planning with a long-term perspective, for example integrating spatial planning and built environment policies to ensure that GI is used to address multiple aspects of climate resilience (e.g. overheating, flooding). This and other examples presented in this nexus highlight the potential for a range of co-benefits to accrue from adaptation interventions to build urban climate resilience. The selected assessment example illustrates that, apart from reducing flood risk and urban overheating, NbS and GI can provide multiple social (e.g. health and QoL), environmental (e.g. biodiversity, reduced pollution, reduced urban heat island effect), climate mitigation (e.g. carbon sequestration) and economic (e.g. reduced energy consumption) benefits.

There is a need for a coherent policy framework and consistency among the policy areas forming this nexus. One challenge is that the EU has no formal authority for spatial planning; however, in 1999, the EU Member State ministers responsible for regional planning signed the European Spatial Development Perspective (ESDP) (EC, 1999). The ESDP has influenced spatial planning policy in European regions and Member States and put the coordination of EU sectoral policies on the political agenda. Actors such as the Covenant of Mayors for Climate & Energy also have an important role in supporting cities to take a coordinated approach to tackling the mitigation of and adaptation to climate change.

Cities are increasingly at the forefront of efforts to address climate change in Europe. In practice, achieving climate resilience can prove challenging. Despite the interconnected nature of climate impacts, the planning and implementation of adaptation and/or mitigation measures tend to be concentrated in one policy department (e.g. planning, environment). This can lead to undesirable trade-offs that can further accelerate climate change. Developing a joint adaptation and mitigation plan in cities can help to address the issue of trade-offs and identify and realise co-benefits. Mainstreaming mitigation and adaptation into existing sectoral policies can also help ensure that synergies are identified and represents an efficient and effective use of available resources (Bertoldi et al., 2018).

Crucial knowledge gaps and limited financial resources may restrict cities' ability to take the necessary actions (Guan et al., 2017). For example, the transport and building sectors are illustrative of the transformation required to achieve climate resilience. The development of climate-resilient infrastructure and measures to reduce GHG emissions requires huge investment. Thus, cities may need support from the EU and national governments in the form of funding, capacity building, knowledge and data to support local adaptation and mitigation measures. New sources of finance may be available to cities, such as through the Next Generation EU recovery package ([11]).

Ensuring horizontal coordination of governance is important for climate resilience in cities, as mitigation and adaptation policies may be the responsibility of different departments in municipal authorities and may require the cooperation of a wide range of stakeholders. Mitigation is dominated by a relatively small number of sectors (e.g. energy, transport) that often have governance oversight at a national level, or in large private sector companies. Adaptation tends to represent a broader mix of actors and sectors (e.g. water, health, biodiversity) and is managed more disparately, ranging from individuals to national agencies.

There is also a significant existing knowledge base available for cities to help inform decision-making and action to achieve climate resilience. For example, numerous studies have provided the tools and data for identifying where the risks of flooding exist (e.g. Copernicus European Flood Awareness System ([12])). In addition, there are well-established cases of how cities can mitigate and adapt to climate change (e.g. Climate-ADAPT case studies ([13]) and resources and support from the Covenant of Mayors ([14])). It is now up to the decision-makers to take action and implement the necessary measures to enhance urban climate resilience.

The COVID-19 pandemic has highlighted the importance and urgency of cities building resilience to large shocks. The crisis induced by COVID-19 has enabled cities to learn lessons for increasing their resilience to climate change, as it has many characteristics in common with climate impacts on society. For example, rapid emergence, global spread and a disproportionate impact on vulnerable groups are some of the characteristics shared by both phenomena (EEA, 2020a). It is important that the negative economic impact of the pandemic does not distract or discourage local authorities from building resilience to climate change.

([11]) https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940
([12]) https://www.efas.eu/efas_frontend/#/home
([13]) https://climate-adapt.eea.europa.eu/knowledge/tools/case-studies-climate-adapt
([14]) https://www.covenantofmayors.eu/support/adaptation-resources.html

2.4 *Existing networks and sources of information*

Various networks of cities have been established to take collective action against climate change. By engaging with member cities, these networks seek to collaborate and share knowledge with policymakers to effectively enhance urban climate resilience. Existing networks and information sources relevant to this nexus include:

- **TheResilient Cities Network** ([15]). This network focuses on sharing best practices, networking and collective learning and problem solving to create a global practice of resilience building in cities. Its various publications focus on different domains to enhance climate resilience in cities (e.g. buildings, transport, water and sanitation).

- **Climate Alliance** ([16]). This network coordinates a working group on climate change adaptation and shares practical experiences, advice and knowledge on the issue with its members.

- **Connecting Delta Cities network** ([17]). This network supports coastal delta cities to address climate change-related spatial development, water management and adaptation. It provides a knowledge portal that includes a good practice guide and publications on urban resilience and climate adaptation strategies.

- **Global Cool Cities Alliance** ([18]). This network supports cities to reduce the impact of the urban heat island effect.

- **Covenant of Mayors for Climate & Energy** ([19]). Case studies on good adaptation practices and other resources developed by partner organisations and EU-funded projects are shared through a resource library.

- **EuroCities**. This network gathers information on adaptation plans and strategies developed by member cities as good practice examples to inspire their peers ([20]).

- **ICLEI** ([21]). The International Council for Local Government Initiatives (also known as Local Governments for Sustainability) collates materials and information related to climate change adaptation and urban resilience.

- **Making Cities Resilient Campaign (United Nations Office for Disaster Risk Reduction)** ([22]). This network works with local authorities to increase their overall resiliency to disasters by implementing risk reduction strategies.

- **EU Climate-ADAPT platform** ([23]). This platform provides access and shares data and information related to urban adaptation to climate change in Europe. The collated information addresses the following: expected climate change in Europe; current and future vulnerability of regions and sectors; EU, national and transnational adaptation strategies and actions; adaptation case studies and potential adaptation options; and tools that support adaptation planning.

- **Future Cities international network** ([24]). This network cooperates to develop, apply and improve the assessment criteria for climate change-proof cities in urban regions in north-western Europe. One of the network's aims is to develop joint action plans for adaptation measures for its regions and involve stakeholders to promote proactive adaptation.

- **Oppla platform** ([25]). This platform provides an overview of and information and case studies on NbS. It includes a 'knowledge marketplace', where the latest thinking on natural capital, ecosystem services and NbS is brought together.

- **Urbact good practices database** ([26]). This database showcases case studies across European cities and includes topics such as climate adaptation, capacity building and urban planning.

- **Urban Flooding Network** ([27]). This network aims to assist cities to address the impacts of flooding in urban spaces.

([15]) https://resilientcitiesnetwork.org
([16]) http://www.climatealliance.org/en/municipalities/the-network.html
([17]) http://www.deltacityofthefuture.com
([18]) https://globalcoolcities.org/partnership-with-c40
([19]) https://www.covenantofmayors.eu
([20]) http://www.eurocities.eu
([21]) http://www.iclei-europe.org/topics/climate-change-adaptation-urban-resilience/newsletter-archive
([22]) http://sdmi-resilient-cities.com
([23]) https://climate-adapt.eea.europa.eu
([24]) http://www.future-cities.eu
([25]) https://oppla.eu/about
([26]) https://urbact.eu/good-practices/home
([27]) https://www.c40.org/networks/urban-flooding

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David Holland, My City

3 Quality of life nexus

3.1 What is quality of life and why is it important in an urban context?

In many respects, quality of life (QoL) has improved in European cities in the past 50 years. However, there are aspects (e.g. physical and mental health) that have stagnated or worsened. The disproportionate exposure of lower socio-economic groups to air pollution, noise and other negative environmental impacts tends to affect urban areas more than rural areas (EEA, 2018a). Addressing the challenges of inequality of opportunity and QoL is therefore of growing concern for most European cities.

The European Commission recognises that the qualities of the natural and physical environment are key determinants of QoL (Eurostat, 2016). Four out of five Europeans see environmental issues as having a direct effect on their daily life and health (Eurobarometer, 2017). Previous work by the EEA has established environmental quality as a fundamental issue for social wellbeing and urban QoL (EEA, 2009).

The term QoL is widely used in the policy literature but lacks a clear and unambiguous definition. It can be highly subjective and dependent on people's individual circumstances — although there is a broad consensus that a good QoL is a universal desire for almost everyone. A list of material (e.g. food, water and energy security) and non-material dimensions (e.g. equity, freedom of choice, enjoyment of natural beauty) have been proposed among existing definitions of and approaches to QoL. These dimensions also explicitly link QoL to the natural world. Together they contribute to achieving the inclusive goal of good quality of life (IPBES, 2019).

Conversations around QoL in cities have long been dominated by international rankings such as the Economist Intelligence Unit 'Global Liveability Index' ([28]) and the 'Mercer quality of living' ([29]) city ranking. Such rankings tend to place a greater emphasis on the economic and social aspects of life in cities. This has somewhat devalued the strong link between QoL in cities and the quality of the natural environment. Research is increasingly highlighting that these two outcomes are inextricably linked (Stessens et al., 2020; Jones, 2021).

The evidence strongly suggests that a greater focus on urban environmental quality is key to developing policy responses that aim to enhance liveability in cities.

If a better QoL is realised in cities, this is likely to support progress in other nexuses, in particular:

- **Sustainable buildings** — through well-built, well-insulated and well-ventilated housing and improvements in the wider built environment.
- **Urban accessibility** — through the creation of safer and more walkable streets and building high-quality efficient public transport systems.
- **Environment and health** — through sufficient and biodiversity-rich green spaces that are accessible to all.

3.1.1 The quality of life nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response

The COVID-19 pandemic and the resulting social distancing and lockdown measures are having a substantial impact on a range of urban systems that have further affected people's QoL. The significant reduction in motorised traffic as a result of the travel restrictions imposed across European cities initially led to a drastic reduction in noise and air pollution levels (EEA, 2020b), although the easing of restrictions partially reversed this positive trend. For example, air pollution levels have rebounded in several European cities (e.g. Athens, London, Paris) driven by an increase in traffic and congestion (EEA, 2020c). To sustain the positive impacts on QoL, longer-term recovery plans need to actively avoid a return to 'business as usual'. One of the major risks is an increase in private motorised traffic as people continue to avoid public transport. Ensuring that some of the infrastructure changes that were put in place to encourage more active travel (e.g. new segregated cycle lanes, wider pavements, traffic calming measures) become permanent will help to ensure a healthier and more sustainable mobility system in future.

([28]) https://www.eiu.com/topic/liveability
([29]) https://mobilityexchange.mercer.com/Insights/quality-of-living-rankings

The local lockdowns also highlighted the link between access to high-quality green spaces and QoL, especially for those living in cramped housing conditions without access to private outdoor space. During the lockdowns people became more acquainted with their immediate neighbourhoods and local green spaces, and there is some evidence that this has led to an increased appreciation of the importance of nature (Rousseau and Deschacht, 2020).

Longer-term implications as cities draw up and implement COVID-19 recovery plans

The COVID-19 pandemic has laid bare and exacerbated the huge inequalities that persist when it comes European urban residents' QoL. Local lockdowns disproportionately affected the poorest urban residents, with ethnic, racial and religious minorities, migrants, elderly people, people with disabilities and other marginalised groups particularly affected. Those with the lowest household incomes have been less able to work from home and also experienced much higher rates of unemployment. This has been compounded by poor housing conditions, including higher exposure to air pollution, crowded living conditions, poor thermal insulation and no outdoor space, all of which increase the risk of COVID-19 infections (Ahmad et al., 2020) while negatively affecting long-term QoL. To reverse some of the devastating impacts on the QoL of the most vulnerable urban groups, recovery planning needs to understand and address existing social inequalities within local communities. This includes investing in better housing, reducing air pollution and improving access to high-quality public green spaces and other urban amenities in low-income neighbourhoods.

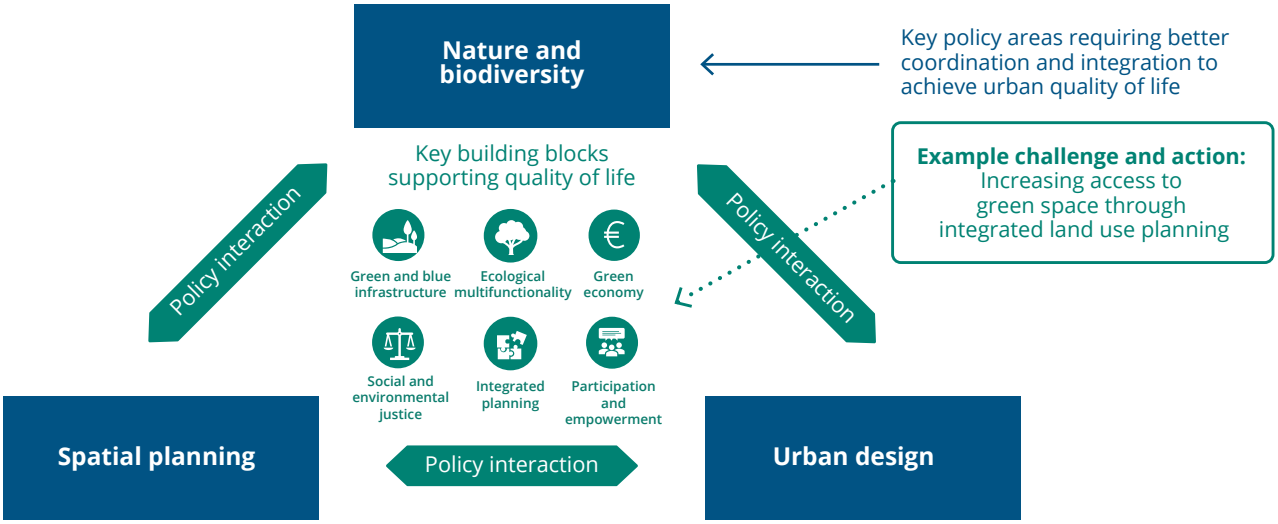
3.2 Interlinked policy areas contributing to urban quality of life

There are many important policy areas that can contribute to achieving the urban QoL nexus. This nexus recognises the essential but often neglected role of the natural environment as our life support system and the way that it is integrated with the built environment in cities. The QoL nexus therefore focuses on the need for coordinated policy related to spatial planning, urban design, and nature and biodiversity (see Figure 3.1).

Together, the natural and built environments create conditions that either improve or worsen social, economic and cultural elements of QoL. The focus is in particular on better coordination of the nexus policy areas. The following sections explore some of the key challenges for urban QoL and how coordinated action can improve it. An overview of these challenges and actions to address them is provided in Table 3.1. Integrating these policy areas could also have co-benefits, such as enhanced amenity value for people and increased biodiversity. This nexus analysis also provides case studies illustrating good practice in European cities.

The assessment then discusses in more detail an example illustrating how coordinated action can contribute to QoL: increasing access to green space through integrated land use planning (Section 3.2.1). This was selected by viewing the nexus through the green city lens. Viewing the nexus from the perspective of different lenses may provide other entry points into the wide-ranging and interdisciplinary policy challenge of achieving urban QoL. For example, viewing the QoL nexus through the inclusive city lens might identify actions to reduce the inequality in people's access to green spaces.

Figure 3.1 The quality of life nexus: key policy areas and building blocks



Challenges of and actions for achieving urban quality of life

One key challenge to successfully improve QoL in cities is associated with the methodological issues in determining what good QoL looks like. This is exacerbated by the heterogeneity of individual cities and individual's needs and desires. A European Commission survey on perceptions of urban QoL showed that satisfaction varied considerably both within cities across different social groups and between European cities (EC, 2016a).

While a universal definition of QoL may seem impossible, understanding the causal links between underlying common urban challenges (e.g. physical and mental health, pollution, crime) and specific policy measures (e.g. implementation of green infrastructure, improved public space) can help to identify transferable policy responses targeted at improving QoL. Some of these links are fairly well documented and already have indicators to measure progress (e.g. the health impacts of greater urban green space). Others are harder to measure and address because of feedback loops and indirect costs (e.g. how the environmental impacts of individual housing choices affect QoL).

The complex interaction between the many determinants of QoL means that efforts to promote one element can have unexpected impacts elsewhere. This is complicated by the fact that there is a tension between individual short term QoL improvements (e.g. private transport) and collective, longerterm needs for sustainable development (e.g. reducing traffic congestion) (EEA, 2009).

The trade-off between individual and community outcomes needs to be addressed as part of any actions aiming to promote QoL in cities. This is why actions to improve QoL need to take a systemic view and consider distributional impacts. The benefits of measures to improve QoL (e.g. increased green space, improvements in the environment) always need to be carefully monitored to ensure that trade-offs (e.g. increased property values and the resultant gentrification and social displacement) are taken into consideration (Wolch et al., 2014; Maantay and Maroko, 2018).

Achieving satisfactory QoL in cities is also hindered by poor sectoral policy and governance integration at various scales (e.g. national, regional, local). This integration is essential to ensure that QoL can be effectively mainstreamed into urban decision-making processes including public and private stakeholders (e.g. developers, city government, citizens).

The benefits of urban life often go hand in hand with negative outcomes. These may include poor environmental quality and pollution, lack of access to green space, congestion, crime and inequality that can affect the QoL of urban dwellers, including their physical and mental health (Eurostat, 2016; EEA, 2018a). As QoL is a broad topic, there are a range of actions that could improve QoL in cities. The specific policy measures will depend on the current conditions in individual cities. The following types of action that are explicitly linked to the environment and sustainability could be considered to improve urban QoL:

- **Nature-based solution (NbS)**. According to the final action plan of the EU urban agenda Partnership for Sustainable Land Use and Nature-based Solutions, both sustainable land use and NbS can provide sufficient, efficient and biodiversity-rich green spaces that enhance people's QoL. The COVID-19 pandemic has also highlighted the value of green areas for people's QoL. In addition, a city with more green and blue infrastructure will be less susceptible to the urban heat island effect and improve residents' thermal comfort overall for during the warmer months.

- **Traffic reduction measures**. Policies to reduce traffic in cities can play a significant role when it comes to improving QoL. Common measures include reducing speed limits, restricting vehicles' access to certain areas or reallocating road space to other uses. Such actions have the potential to reduce air pollution and noise and can also free up spaces previously used by cars to increase green space, which can increase urban biodiversity and climate resilience. As shown by the COVID-19 pandemic, creating safer and more walkable streets, with more opportunities for exercising and socialising, can often have health and social cohesion co-benefits with far-reaching positive impacts on QoL. Given that poorer communities tend to be located next to more major streets and urban highways, such measures also have the potential to address inequalities in health and well-being (Lee and Sener, 2016; Marshall and McAndrews, 2016).

- **Improvements in housing and the wider built environment**. Most urban dwellers in Europe spend around 90 % of their time indoors, meaning that housing quality is crucial to overall QoL (WHO Europe, 2014). The lockdowns imposed in response to the COVID-19 pandemic have further increased the time people spend indoors. Well-built, well-insulated and well-ventilated housing has better indoor air quality, reduces exposure to noise, protects against heat and cold and thus has tangible QoL benefits while also reducing fuel poverty in low-income families. Rooftops can be used for vegetation (reduces run-off and risk of flooding) or for energy production, which improves the overall resilience of the built environment and has long-term benefits for QoL (WHO Europe, 2014; Streimikiene, 2015; UK Green Building Council, 2016).

Table 3.1 Overview of challenges of and actions for achieving good urban quality of life

Example challenges	Example actions to address challenges
• Methodological issues in defining and measuring QoL and determining what good QoL looks like. • The tensions between individual needs and short-term QoL improvements and desires and collective, longer-term needs for sustainable development.	• Understanding the clear causal links between specific policy actions and QoL improvements, e.g. by using established indicators to measure the health impacts of greater urban green space. • Taking a systemic view and considering distributional impacts when implementing measures to improve QoL.
• Poor sectoral policy and governance integration hindering effective mainstreaming of QoL into urban decision-making processes.	• Defining a clear and measurable set of QoL indicators that can be used to assess urban policies to track improvement over time.
• Complex interactions between many determinants of QoL mean that efforts to promote one element can result in unwanted/unexpected impacts on other QoL element(s).	• Careful monitoring of any new measures to improve QoL to ensure that trade-offs are carefully considered and the distributional impacts of different policies on all sectors of society are considered.
• Poor environmental quality (e.g. air, water, noise) and lack of access to green space negatively affecting physical and mental health of urban dwellers. • Excessive motorised traffic causing pollution, community severance and discouraging safe active travel options. • Housing and built environment quality that is not meeting the needs of residents, leading to high fuel costs and an uncomfortable living or working environment.	• Implementing NbS that provide biodiversity-rich green spaces that enhance people's QoL (see Section 3.2.1). • Implementing traffic reduction measures to reduce air and noise pollution which have health and social cohesion co-benefits. • Improving housing and the wider built environment by insulating housing, using sustainable heating/cooling sources that reduce air pollution and greenhouse gas emissions, and using rooftops for vegetation, all of which have tangible health benefits while also reducing fuel poverty and improving resilience.

3.2.1 Example assessment of interlinked actions: increasing access to green space through integrated land use planning

How does increased access to green space through integrated land use planning fit within the quality of life nexus?

- Access to high-quality green space has been reliably shown to improve people's satisfaction with where they live, while it is also linked to improved health outcomes and promoting physical activity, which in turn improves quality of life.
- Land use planning that ensures that people of all income groups have access to green space can have a transformative effect on quality of life, especially for low-income communities.
- Improving green spaces has many co-benefits beyond the immediate amenity value it provides to people. It can enhance urban biodiversity, improve air quality, improve soundscapes, act as a carbon sink, reduce the urban heat island effect and absorb stormwater.

This policy and action area focuses on the link between land use planning and high-quality urban green spaces and their role in mitigating the negative outcomes arising from living at higher densities, and making compact cities attractive, safe and sustainable places to live.

Green areas in cities can fulfil a variety of functions, including far-reaching economic, environmental and social benefits that can enhance QoL. The challenge lies in identifying ways of introducing green space into cities without inadvertently causing negative feedback loops associated with urban dispersal or gentrification. There may be inevitable trade-offs regarding green areas, although these will generally be relatively minor. For example, when planning green areas cities should consider the economic costs of their maintenance and management. Trees and plants may have negative health impacts arising from pollen, and their roots and branches may damage roads and pavements. If not carefully planned and well managed, these spaces may deteriorate in quality and become unsafe for users, thus undermining QoL. Perhaps most importantly, there is always a trade-off when it comes to alternative land uses, and cities have to strike a balance between the benefits of green space and other urban uses.

Urban expansion is still often falsely perceived as the best path to improving QoL by providing urban dwellers with more affordable and greener places to live. Yet urban sprawl and the road building and increased transport demand that accompanies it can increase emissions and contribute to climate change, and it also leads to further deterioration and fragmentation of natural areas. This results in reduced biodiversity, loss of ecosystem services and loss of agricultural land (EEA, 2016c).

All of this has long-term impacts on the QoL of all Europeans, meaning that uncontrolled urban expansion is incompatible with a sustainable urban future. Living at higher densities can be a solution, but it needs to be carefully planned and managed to ensure that it maximises the social, economic and environmental benefits without leading to more congestion, pollution, exposure to noise and insufficient access to green space for inner city residents (Bart, 2010).

Possible policy responses and interventions

Many European cities already have an existing urban fabric that can be regenerated and reconfigured to increase access to green space. This can be achieved by using urban land use planning tools that place a greater emphasis on promoting green space. Even in dense and relatively 'grey' cities such as Paris, significant improvements in access to green space can be achieved. In recent years the city has demonstrated this by pedestrianising and greening the banks of the Seine, converting a disused railway line into an elevated linear forest, and installing 70 ha of new green infrastructure and rooftop gardens (C40 Cities, 2015).

Despite this potential, 'green recycling' (whereby previously developed grey infrastructure is redeveloped as green areas) remains a marginal phenomenon. It accounts for only 0.2 % of total land consumption (EEA, 2018b). The EU aims to achieve 'no net land take by 2050' in line with the United Nations Sustainable Development Goals. Today, land recycling and densification account for only 13 % of new developments, and land take continues to be a major challenge. Europe's urban planners will need to play a key role in limiting urban expansion by designing integrated mobility and land use policies that allows sufficient space for green areas while also thinking about how the wider green infrastructure network can connect green spaces both within and beyond individual cities (EEA, 2019b).

Increasingly, new developments are being planned so that they include a sufficient amount of high-quality green space. An increasing number of municipalities in Europe are using the Green Space Factor (GSF) developed by the city of Malmö to determine green infrastructure requirements for new developments before planning permission is granted (Kruuse, 2011). The GSF was adapted from the Berlin Biotope Area Factor, which is used as a guideline for new developments in the German capital.

Another important strategy that can provide access to high-quality green spaces while significantly preserving natural environments is using urban containment boundaries. These create 'hard' edges between the city and the countryside to ensure that development is not allowed to sprawl into intact natural habitats (Schulze Bäing, 2010). This not only ensures that existing natural spaces and biodiversity is preserved and cities' growth remains compact but also allows people access to wild areas in close proximity to the city. Urban containment boundaries have significant health and well-being benefits when compared with fragmented and artificial green areas associated with suburban developments.

Policies that contain urban expansion and those that focus on regenerating and greening existing brownfield sites can have impacts on land values. This happens when certain areas are made more attractive to live in and space for new housing developments is constrained. Cost of living is one of the main factors that shapes QoL, and ensuring that people have access to affordable housing is an essential component of this. Land use policies that promote biodiversity and green space therefore need to carefully monitor how investment in greening existing urban spaces affects low-income residents in order to avoid 'green' gentrification. Such policies should also ensure that the benefits of green space are experienced by a diverse range of people irrespective of their socio-economic background (Maantay and Maroko, 2018).

Box 3.1 Example policy response: a focus on compact development and green spaces to promote well-being in Ljubljana, Slovenia

In 2007 the city centre of Ljubljana was closed to all motorised traffic as part of an urban 'ecological zone' that today covers more than 100 000 m^2. Cycling and other forms of sustainable mobility are promoted in the zone and formerly derelict brownfield sites have been transformed into new green spaces.

The Ljubljana urban master plan, which forms part of the city's 2025 development vision, ensures that 83 % of new development will be focused on existing brownfield sites to preserve green spaces and regenerate the urban core in order to enhance the quality of life of local residents. An essential element of the city's strategy has been the ecological restoration of the River Ljubljanica, including renovated river banks with improved vegetation to create new high quality public spaces.

Between 2009 and 2016 the city created more than 90 ha of new public green areas on former brownfield or degraded land. (This, among other factors, led to its selection as European Green Capital in 2016.) Today, almost 75 % of the city surface is green areas. 80 % of the green areas are on the outskirts of the city and are connected to the historical centre by green wedges and riparian corridors that link city centre parks and gardens. This includes a 34-km-long circular green corridor popular for sports and leisure. Investments in urban gardening and urban beekeeping have further enhanced residents' ability to connect with nature in meaningful ways while enhancing local biodiversity.

Source: Oppla (2021c).

Box 3.2 Example policy response: green ventilation corridors to address urban heat islands, air pollution and quality of life in Stuttgart, Germany

Stuttgart is a pioneer in using intelligent land use planning to protect and enhance the green spaces surrounding the city. The city has developed green ventilation corridors and implemented construction bans in strategic locations to allow the winds from the surrounding hills to be channelled into the valley where the city lies. This helps to combat the urban heat island effect but also significantly improves local air quality and has had the co-benefit of protecting natural areas and enhancing local biodiversity. With the support of local climate maps (Climate Atlas) that inform the planning process, Stuttgart has stopped planned construction totalling 60 ha in recent years. On the basis of the Climate Atlas, the city established an environmental office tasked with evaluating the effect of new buildings on the local climate and green space. In addition, the following principles guide the planning process:

- Green spaces are to surround buildings and larger interconnected green areas are to be protected and enhanced.
- Valleys, hills and hillsides are not to be built up.
- Urban sprawl is to be avoided.
- All trees in the urban core over a certain size are protected.
- Green roofs are subsidised (the city now has 300 000 m^2 of green roofs).

As a result of these approaches, more than 60 % of Stuttgart's total land area is green space and more than 39 % is protected — the highest percentage in any German city. The different green areas of the city have also been linked up, connecting the central royal gardens with the forests on the city's edges. Combined with investments to enhance biodiversity, restore river systems and provide cycle paths and other leisure activities that allow people to actively use these spaces, Stuttgart has considerably improved the quality of life of its residents.

Source: Climate-ADAPT (2020b).

3.3 Lessons for achieving good urban quality of life

While individual cities may have achieved a high QoL for parts of their population, on the whole people's lifestyle choices are still putting their future well-being and that of the next generation at risk. It is important to find ways to align demands for higher QoL with demands for a good-quality environment and a safe climate. From environmental and sustainability perspectives, implementing NbS, and also measures to reduce traffic and improve the quality of housing and the built environment, are examples of the actions that potentially address many challenges related to the QoL nexus.

Thinking about the way in which cities are planned and designed, and how the built environment and the natural environment interact, appears to be a good place to start. Developing policy responses integrated between spatial planning, urban design, and nature and biodiversity is likely to significantly contribute to improved QoL within cities. To enhance the QoL, this sectoral integration should be guided by the intention to enhance environmental quality as well as to achieve social equity and sustainability.

Many of the relevant policy interventions that support QoL have already been implemented in some cities. The question is how these successful approaches can be replicated and adjusted to different types and scales of sectoral and city governance and to specific city contexts (i.e. spatial, cultural, geographical). To achieve transferable good practices, short-term, sectoral and siloed governance approaches need to be transformed to facilitate more collaborative, integrated, holistic and long-term solutions. This would enable adequate responses to the complexities associated with achieving equitable and sustainable QoL improvements (EEA, 2009). It appears that this is a shared European policy objective that has the potential to incentivise true horizontal and vertical integration in policymaking.

New technologies are likely to play an essential role when it comes to ensuring that urban environments promote greater satisfaction with life by being greener, healthier and more accessible places to live. However, in the post-pandemic world changes in priorities at the individual, societal and governmental levels in relation to what constitutes a good QoL will be even more fundamental. This means addressing questions of urban lifestyles and consumption patterns and imagining alternative urban futures in which we shift away from an individualistic perspective towards policies that promote good QoL for all.

While exact definitions of QoL may differ between individuals, cities and countries, there are a number of commonalities. This suggests that achieving good urban QoL would benefit from knowledge exchange between European cities and partnerships across different levels of government, civil society and the private sector. It is therefore essential that the EU sets the correct framework conditions that provide cities with the tools to confidently tackle the challenges posed by the QoL nexus without compromising environmental objectives. This includes good data and new indicators to measure QoL and allow cities to benchmark themselves against their peers.

3.4 Existing networks and sources of information

Existing networks and sources of information relevant to this nexus include:

- **Clever Cities — a Horizon 2020 project** ([30]). This network promotes and enables the uptake of NbS in urban planning worldwide and includes case studies from across Europe.
- **Covenant of Mayors for Climate & Energy** ([31]). The world's largest movement for local climate and energy action.
- **ICLEI** ([32]). The International Council for Local Government Initiatives (also known as Local Governments for Sustainability) collates materials and information related to NbS, urban biodiversity and urban resilience.
- **Oppla platform** ([33]). This platform provides an overview of and information and case studies on NbS. It includes a 'knowledge marketplace', where the latest thinking on natural capital, ecosystem services and NbS is brought together.
- **City Biodiversity Index** ([34]). Also known as the Singapore Index, this is a self-assessment tool allowing cities to evaluate and monitor the progress of their biodiversity conservation efforts against their own individual baselines.
- **Green City Accord**. A new initiative from the Directorate-General for the Environment to better engage local governments in delivering EU environmental policy objectives in the areas of air quality, noise, water, waste management, nature and biodiversity, sharing best practices and promoting dialogue between cities and the Commission.

([30]) http://clevercities.eu
([31]) https://www.covenantofmayors.eu
([32]) http://www.iclei-europe.org/topics/biodiversity-nature-based-solutions
([33]) https://oppla.eu/case-studies
([34]) https://www.cbd.int/subnational/partners-and-initiatives/city-biodiversity-index

- **Green Surge initiative** ([35]). This initiative provides case studies of projects that focus on planning, creating and managing urban green spaces while strengthening their biodiversity and making them accessible and available to all groups of society.

- **ThinkNature platform** ([36]). The ThinkNature project is part of Horizon 2020, the EU Framework Programme for Research and Innovation and has received funding under a grant agreement. The objective of the ThinkNature project is the development of a platform that supports the understanding and the promotion of nature-based solutions (NbS).

- **Urban green infrastructure indicators and map viewers** ([37]). These maps illustrate several facets of the GI for selected cities demonstrating some analytical options as explored by the EEA.

- **Urban Nature Atlas** ([38]) from Naturvation contains 1 000 examples of NbS from across 100 European cities.

Further reading

On access and equity of access to green space:

- Poelman, H., 2018, A walk to the park? Assessing access to green areas in Europe's cities. Update using completed Copernicus Urban Atlas data, Working Paper No 1/2018, European Commission (http://ec.europa.eu/regional_policy/sources/docgener/work/2018_01_green_urban_area.pdf) accessed 7 June 2021.

- Mears, M. and Brindley, P., 2019, 'Measuring urban greenspace distribution equity: the importance of appropriate methodological approaches', International Journal of Geo-information 8, 286 (https://doi.org/10.3390/ijgi8060286).

- Whyte, B., 2019, 'Indicating the importance of children's access to greenspace, Urban Big Data Centre, 7 February (https://www.ubdc.ac.uk/news-media/2019/february/indicating-the-importance-of-children-s-access-to-greenspace) accessed 7 June 2021.

- Fields in Trust, 2021, Green Space Index: analysing Great Britain's publicly accessible park and green space provision' (http://www.fieldsintrust.org/green-space-index) accessed 7 June 2021.

- Scottish Government, 2021, 'Access to green and blue space in Scotland' (https://nationalperformance.gov.scot/access-green-and-blue-space) accessed 7 June 2021.

- Davis, M., et al., 2018, Defining key concepts and associated indicators to measure NbS impact on urban regeneration within CLEVER Cities (http://clevercities.eu/fileadmin/user_upload/Resources/D1.1_Theme_4_impact_indicators_ECOLOGIC_12.2018.pdf) accessed 7 June 2021.

([35]) https://greensurge.eu/about
([36]) https://www.think-nature.eu
([37]) https://eea.maps.arcgis.com/apps/MapSeries/index.html?appid=42bf8cc04ebd49908534efde04c4eec8%20&embed=true
([38]) https://naturvation.eu/atlas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4
Urban accessibility nexus

4.1 What is accessibility and why is it important in an urban context?

Accessibility is generally understood to mean the ease with which people can reach goods, services and activities and connect with one another (Litman 2007; Rode et al., 2019). Based on this definition, urban accessibility is considered high when households can reach a wide variety of destinations in a short time and at a low cost per unit of travel (Duranton and Guerra, 2016).

It is well established in the EU that providing accessibility for everyone, at the lowest cost to the environment, should be the key objective of any transport policy (EEA, 2000). Even so, many European cities continue to confront major accessibility challenges. This is because decades of transport and land use planning have locked cities into prioritising a car-centric urban development model.

Moving towards better urban accessibility is also increasingly seen as a fundamental precondition for a range of urban environmental sustainability objectives. It leads to reduced carbon dioxide (CO_2) emissions from transport, improved air quality, reduced noise, preservation of green space and reduced habitat fragmentation. This is because there is a strong link between a more compact urban form and reduced transport demand. Denser cities generally increase accessibility through proximity of urban functions and services, while reducing resource consumption and negative environmental impacts (Rode et al., 2014). Studies have shown that higher densities can reduce vehicle-kilometres travelled per capita by 40 % (Ewing, 2008). Shorter distances also encourage active travel such as walking and cycling, which has a positive impact on health outcomes (Duncan and Kawachi, 2018).

High-quality and efficient public transport systems are essential for improving urban accessibility. Traffic congestion remains a significant issue for all major EU cities, costing nearly EUR 100 billion, or 1 % of the EU's gross domestic product (GDP) per year (EC, 2017). Yet to date only five European cities have introduced congestion charging. Despite recent technological advances in fuel efficiency and electric mobility, emissions from transport across EU Member States actually increased by 28 % between 1990 and 2017 (EEA, 2018c). Across Europe, road safety also continues to be a major challenge, with more than two thirds of all road accidents happening in urban areas. The external costs of road accidents in Europe have been estimated at 1.7 % of GDP (EC, 2018a).

The urban accessibility nexus recognises that enabling people to access work, education, shopping or leisure in an equitable and efficient manner is an essential component of economic and social development and one of the key reasons we have cities to begin with (Simpson, 2004; Duranton and Guerra, 2016; Gutman and Tomer, 2016; Cervero et al., 2017; Rode, 2018).

If better urban accessibility is realised in cities, this is likely to support progress in other nexuses, in particular:

- **Environment and health** — through measures that reduce car use and traffic and establish multifunctional green spaces that facilitate active transport and reduce air and noise pollution.
- **Climate resilience** — through the development of more sustainable transport systems and infrastructure that reduces or prevents greenhouse gas emissions.
- **Quality of life** — by reducing the distances between urban services, creating more liveable streets and improving access to green space and other urban amenities.

4.1.1 The urban accessibility nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response

The need for immediate social distancing measures to contain the spread of the virus led to rapid changes in travel behaviour in most cities, with far-reaching consequences for urban accessibility. Public transport systems were either partially closed or operating at reduced capacity in many cities, especially at the beginning of the pandemic. For many travellers reducing the risk of infection has become the main criterion for choosing transport modes, overtaking even time to reach the destination and the price of the trip in importance (McKinsey Center for Future Mobility, 2020). As a result, many European cities saw a significant increase in the number of people walking and cycling for leisure and as a means of transport. To accommodate these new sustainable travel behaviours, and to prevent an increase in private motor vehicle trips, many cities

responded with rapid infrastructure changes, including pop-up bicycle lanes, pavement widening and closing parts of the city to cars. For example, Paris built 50 km of temporary cycle lanes by taking space away from motor vehicles, whereas in Rome the creation of 150 km of new cycle lanes has been approved (Zafra, 2020).

The reduction in economic activity and increase in the use of active transport had an immediate and positive impact on congestion and air quality in many cities across Europe (EEA, 2020d), although, as lockdown restrictions were eased, some of these gains have been reversed. The drastic reduction in public transport use and the increase in operational expenditure on additional health and hygiene measures has also led to a collapse in revenue for many public transport operators (Lozzi et al., 2020). This has required central government support to keep services running and potentially endangered the long-term sustainability of public transport networks in some cities. City governments quickly recognised the importance of making public transport safe and attractive even during the pandemic. To restore passenger confidence cities have introduced new safety protocols, including cleaning surfaces, requiring the wearing of face masks, installing dividers between passengers and drivers, and installing contactless payment systems.

A significant increase in home working (for people with office-based jobs) also led to an overall reduction in travel demand. The widespread adoption of technologies that facilitate virtual connectivity may cause companies to rethink the necessity of maintaining large and expensive inner-city office space (Deloitte, 2020), and this may lead to people moving further away from traditional employment centres. At the same time, local travel increased in residential areas, as people spent more time in their immediate neighbourhoods.

Longer-term implications as cities draw up and implement COVID-19 recovery plans

In their pandemic recovery plans many cities have started to recognise that there can be no return to 'business as usual' and are proposing new strategies that are likely to fundamentally affect urban accessibility. These may include investment in active travel infrastructure; improved public transport safety and accessibility; changes in traffic regulations to increase safety; and pricing policies such as congestion charges to prevent an increase in car use. For example, Dublin started to develop a 'living' framework of mobility proposals together with the National Transport Authority. This plan proposes to provide additional space for pedestrian areas and safe cycling facilities. It also suggests implementing the various bus route changes that will be required to implement cycling and walking measures while maintaining a strong public transport network (OECD, 2020).

As a result of the pandemic, many employers are looking at new ways of operating. Working from home and shorter working weeks are both considered viable long-term options that could emerge as alternatives to a mass return to offices (BBC, 2020). If proximity to one's job becomes less of a factor in deciding where to live for many office workers, it could lead to a shift in demand for housing away from urban centres and traditional commuter belts. This trend might be exacerbated by a growing demand for bigger houses and access to private gardens. A long-term decline in daily commuting and a preference for suburban living could have significant implications for urban economies and land use. For example, the high street retail sector might relocate closer to its more dispersed customer base, which could lead to urban sprawl (Chait, 2020). A reduction in demand for centrally located office space may enable the construction of affordable housing in the inner city, or at least provide opportunities for more mixed-use developments. At the same time, an increase in e-commerce may also lead to an erosion of 'bricks and mortar' stores, an increase in urban freight movement and a potential loss of our vibrant high streets.

There is some evidence that the idea of a '15-minute city', in which people are able to meet all of their daily needs within a short walk or cycle from their homes, is gaining some traction among policymakers. If prioritised in response to COVID-19, this approach could increase accessibility in a way that preserves economic vitality and supports a low-carbon transition (Martínez Euklidiadas, 2020). New global initiatives have also emerged to ensure a sustainable urban mobility transition as part of the recovery from the pandemic. For example, the Transformative Urban Mobility Initiative has developed the avoid-shift-improve framework to implement a sustainable mobility in cities in response to the COVID-19 pandemic (TUMI, 2020).

In the longer-term, if there is an overall replacement of physical connectivity with more virtual connectivity, this could lead to reductions in the need for travel, without necessarily sacrificing accessibility. However, the impact of these changes is likely to be unequally distributed across different population groups, and cities will have to think very carefully about how their recovery policies can ensure that the most vulnerable groups do not experience a decline in their ability to access urban opportunities. To help policymakers with the long-term sustainable mobility transition, a new foresight project, 'European urban mobility 2050', supported by the EEA, will provide the narratives that they need to make the transition in the right direction.

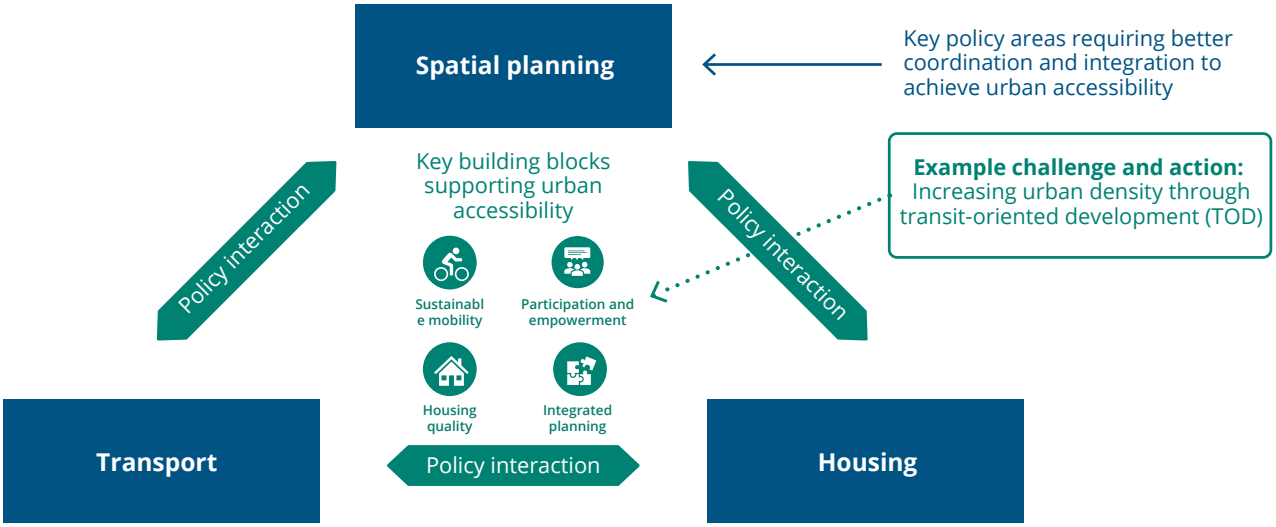
4.2 Interlinked policy areas contributing to urban accessibility

Moving towards better accessibility for all requires strong cross-sectoral collaboration across a range of policy domains. This nexus focuses on coordination between transport policy (which determines the transport options available), spatial and land use planning (which determines where different resources are located within the city and relative to one another) and housing policy (which determines questions of equity and inclusion) (Rode, 2018). Exploring the 'space' between these three policy areas in more detail should help to identify solutions that address accessibility while optimising integration and strengthening outcomes in each area (see Figure 4.1).

The following sections explore some of the key challenges of and potential actions for achieving urban accessibility, considering in particular the need for coordination across the selected policy areas. The overview of the challenges and actions to address them is provided in Table 4.1. We then discuss in more detail an example illustrating an integrated approach to addressing an accessibility challenge: using transit-oriented development to increase urban density (Section 4.2.1).

The assessment example was selected by viewing the nexus through the inclusive city lens. The nexus could be viewed from other perspectives, which would help to identify other potential areas of action. For example, viewing the urban accessibility nexus through a healthy city lens might lead to prioritising actions to reallocate road space and make non-car transport modes safer and more available and attractive. This would incentivise changes in travel behaviour that could improve people's health and well-being while also having environmental benefits.

Figure 4.1 The urban accessibility nexus: key policy areas and building blocks



Challenges of and actions for achieving urban accessibility

European cities face the challenge of how to enhance mobility, ensure accessibility to key urban opportunities, and create high-quality and efficient transport systems at the same time as reducing congestion, pollution and accidents. Although accessibility has been moving up the urban policy agenda for some time, many cities continue to struggle to tackle these interlinked policy areas comprehensively and move towards accessibility-based urban development. This is in large part because the traditional transport policy and land use model has been unable to address, or has even exacerbated, these concerns (Hajer and Kesselring, 1999; Vasconcellos, 2001; World Bank, 2002; Litman, 2011). A legacy of outdated spatial and transport planning models has locked cities into prioritising car-centric urban development. Both existing infrastructure and existing urban form are likely to be shaped significantly by the COVID-19 pandemic. Huge reductions in public transport use, renewed investment in walking and cycling infrastructures and, at the same time, an increase in the use of private cars

will potentially have significant implications for environmental sustainability and land use change.

Transport, housing and spatial planning at times function as separate worlds, with their own institutions, disciplinary and cultural backgrounds, planning procedures and concepts (Rode et al., 2014). In most countries, dedicated transport departments remain responsible for administering transport policies at national and local levels. These are often separate from spatial planning and housing policy, although their actions directly affect urban development. This siloed decision-making structure and poor cross-sectoral integration of policy and governance (i.e. across different governance levels — national, regional, local) has led to wide-ranging socio-economic and environmental costs and challenges. These include urban sprawl, congestion, poor road safety and poor transport connectivity (i.e. both within cities and between cities and their hinterlands). These challenges have undermined the sustainable growth of many European cities.

Policymakers recognise these impacts, but the narrow remit to simply anticipate and address demand often prevents them from considering the broader implications of their actions. Thus, in their efforts to facilitate movement, transport departments may unwittingly make choices that reduce accessibility (Rode et al., 2019). A common example of this is a focus on expanding road capacity and parking spaces to deal with increasing rates or motorised transport. Rather than alleviating congestion, such policies reduce accessibility for both car and non-car users by increasing circulation rates and leading to more congestion (Venter et al., 2019). Governance of accessibility has a multi-level dimension, as cities do not function in isolation and are connected with their hinterlands. For cities to ensure accessibility for intercity commuters, freight, and national and international tourists, they will need to work with other scales of governance (e.g. supranational, national, regional). Better alignment of policy frameworks at different governance scales and across sectors is an important component of this process, as it can help to eliminate or at least mitigate unintended barriers to urban accessibility. The cascading impacts of the COVID-19 pandemic have highlighted this, and travel restrictions are having far-reaching consequences for cities.

Defining the exact meaning of accessibility, and then measuring it accurately, is another challenge for policymakers. The high level of heterogeneity in cities means that accessibility is often unevenly distributed, something that was highlighted very clearly by the COVID-19 pandemic. Certain groups are more likely to experience accessibility-related disadvantages. Low-income groups, women, elderly and disabled people, and (more generally) households without a car are the most affected by a lack of access (Fol and Gallez, 2014). Questions of who has access to opportunities, at what times and at what cost are therefore an important additional component of ensuring that accessibility for all becomes the driving force of urban planning policy. This requires agreement about what type of accessibility should be promoted and how this access is distributed across the wider population. Generally speaking, diversifying transport modes as much as possible tends to ensure that the greatest number of people can reach the greatest number of destinations in ways that meet their needs.

There are many different policy interventions and governance reforms that can support a transition towards better urban accessibility. Transport policy reforms are an obvious place to start. Tackling unsustainable trends in this sector requires a recognition that car-based journeys in urban areas are generally the least optimal. The logical consequence of this is therefore to shift resources away from cars and towards walking, cycling and public transport. With the emergence of the COVID-19 pandemic, European cities have changed their priorities to invest in active transport infrastructures and limit the number of journeys people take. An important way of maximising the impact of such policies is to bring municipalities together to coordinate transport across the wider metropolitan area (Rode et al., 2019).

There are various interventions that can ensure more sustainable mobility, including:

- imposing regulations that require compliance (e.g. restrictions on parking, speed limits, low-emission zones);
- creating economic incentives (e.g. road pricing, congestion charging, budget support for public transport projects);
- using information and service provision to encourage behaviour change (e.g. public awareness campaigns, or guidance for local transport planners that promotes accessibility-focused approaches, bike sharing schemes, park and ride schemes, integrated mobility apps).

At the spatial planning level, a better spatial mix and distribution of economic activities, services and amenities and a focus on compact and mixed-use development can make a major difference to accessibility. Housing tends to be most expensive in the inner city (where accessibility to jobs and other services is highest), with low-income groups pushed to the outskirts, where housing is more affordable but the ease of accessing employment and other opportunities may be reduced. Transit-oriented development, whereby new developments are clustered around existing (or new) bus routes or railway or metro lines, can play a major role in ensuring greater accessibility for all.

Developments in telecommunications and e-commerce may progressively reduce the need for conventional transport and provide a different form of accessibility. The COVID-19 pandemic has shown that homeworking is a viable alternative to office-based work for many people. As companies begin to rethink the need for office space in urban centres, this could have a significant impact on land uses and existing transport networks.

Table 4.1 Overview of challenges of and actions for achieving urban accessibility

Example challenges	Example actions to address challenges

• Poor spatial, housing and transport planning practices including:
  • poor policy integration across sectors and different governance levels (i.e. supranational, national, regional, local).
  • lack of long-term planning and narrow focus on directly addressing demand rather than solving underlying accessibility issues (e.g. expanding road capacity rather than reducing road use).
  • legacy of outdated spatial, housing and transport planning models.
	• Ensure better alignment of policy frameworks at different governance levels and across sectors to eliminate unintended barriers to urban accessibility.
	• Ensure a better spatial mix and distribution of economic activities, services and amenities at the spatial planning level (see Section 4.2.1).
	• Implement transport, housing and spatial planning policy reforms (regulatory, economic, information based) which recognise that car-based journeys in urban areas are the least optimal.
	• Build and expand high-quality efficient public transport systems and infrastructure that promotes active travel.

• Lack of understanding of the exact meaning of accessibility and how to measure it accurately. • Lack of recognition that certain groups are more likely to experience accessibility-related disadvantages and have different accessibility needs.	• Develop clear metrics to measure progress towards accessibility (e.g. PTAL (public transport accessibility level). • Agree what type of accessibility should be promoted within a city and how this access is distributed across the wider population. • Diversify transport modes as much as possible to ensure that the greatest number of people can reach the greatest number of destinations in ways that meet their needs.

4.2.1 Example assessment of interlinked actions: increasing urban density through transit-oriented development

How does transit-oriented development fit within the urban accessibility nexus?

- Transit oriented development creates a strong link between transport and land use planning by encouraging the clustering of jobs, housing and other services in relatively constrained areas around transit hubs.
- Proximity to mass transit tends to lead to increases in land values around stations, which encourages higher density development.
- This concentration creates vibrant communities with high-quality public areas and shorter commuting distances — increasing access and making cities more liveable in the process.

Urban density and mixed use tends to be strongly correlated with greater accessibility. In this context, urban planning that aims to reduce passenger travel demand is an important component of accessibility-focused urban development (Ahlfeldt and Pietrostefani, 2019).

Urban sprawl has increased rapidly in Europe in recent decades. It is characterised by dispersed and segregated land uses. Urban areas have been expanding even in countries where the population has not been growing (EEA, 2016c). In addition to undermining accessibility objectives, urban sprawl is associated with a number of long-lasting and negative ecological, economic and social externalities. Some of these include the loss of fertile farmland, landscape fragmentation and higher infrastructure costs for transport and other services (Cárdenas Rodríguez et al., 2015; EEA, 2016c; OECD, 2018). Poorly managed urban growth not only has severe negative consequences, but it can also create 'lock-in', limiting options in the future.

While compact urban development has proven to have great potential for the sustainable growth of our cities, it is not without its detractors. If not carefully managed, greater urban densities can lead to increased traffic congestion and air

pollution, accelerate gentrification and increase house prices, thus exacerbating urban inequalities (Salat and Ollivier, 2017; Dingil et al., 2018). It can also reduce access to urban green spaces, which are essential for human health and well-being (Kabisch et al., 2015), provide space for nature and have a role in managing climate risks. Liveable urban density therefore relies on the concurrent development of excellent public and active transport infrastructures, as well as social policies to pre-empt the potentially detrimental effects of compact urban development. This will ensure that the benefits of greater density can be fully realised to enhance accessibility and quality of life for everyone.

Possible policy responses and interventions

There is a range of policy responses that can promote urban density. Some of them include urban containment policies, such as green belts, minimum density requirements for new developments and regenerating existing neighbourhoods (OECD, 2018). One of the policy interventions that has shown itself to provide significant social, economic and environmental co-benefits is transit-oriented development (TOD). TOD builds on well-established European precedents of concentrating urban development along railway lines, metro routes and other public transport routes (e.g. trams, buses). At its heart is the idea that transport, land use and economic growth can all be managed more efficiently if planned in an integrated way (Salat and Ollivier, 2017). This is because high-quality public transport and compact urban development mutually reinforce each other. Mass transit can support the large passenger flows that come with high-density development, while the concentration of jobs and housing around stations helps make public transport financially viable.

Well managed TOD measures can create important co-benefits beyond mitigating urban sprawl and shaping more accessible polycentric cities. These include relieving congestion and shifting to more sustainable transport modes, improving air quality, boosting economic growth, improving the quality of places, and increasing physical activity levels (Gouldson et al., 2018; Linton and Bray, 2019).

The following examples demonstrate that TOD can take many different forms and can be adapted by cities to suit their context and needs. The transport infrastructure can be retrofitted to improve accessibility for existing high-density developments. It can also be used to encourage densification around existing stations or to encourage new urban developments.

Box 4.1 Example policy response: regional transport and land use integration in the Randstad, the Netherlands

The Zuidvluegel (south wing) of the Randstad is one of the densest areas in Europe. The settlement structure is polycentric with roughly 65 minor municipalities spread out over the area and two major cities, namely Rotterdam and The Hague. In the early 2000s a transit-oriented development (TOD) strategy was developed called Stedenbaan (Cities Line). It focuses on existing but underused railway stations, aiming to densify urban development around the stations and increasing local train frequency to facilitate this. In 2011, the Stedenbaan agreement was revised and extended to 47 cities. This new agreement, called StedenbaanPlus, set the ambitious goal of building 80 % of newdwellings around all railway stations and key transit nodes, with a distinction between different types of stations, which correspond to different TOD solutions.

Stedenbaan is a slightly different approach to TOD, shifting the focus from the city to the region, involving stakeholders across administrative sectors and levels, and creating cooperative rather than competitive relations between local municipalities. While the initial motivation was to unlock the economic potential of the wider region, there are significant environmental and social co-benefits and the project has allowed many municipalities to rethink their long-term urban development strategies.

The Stedenbaan approach may provide an interesting model for other cities in the EU, as a lot of European cities already have significant rail infrastructure that is often underused either because of a lack of mixed-use developments in proximity to stations or because of insufficient service frequencies).

Sources: Balz and Schrijnen (2016); Staricco and Brovarone (2018).

Box 4.2 Example policy response: using transit-oriented development to develop new neighbourhoods in Copenhagen, Denmark

Copenhagen is a pioneer of transit-oriented development, initiated in its 1947 Finger Plan, which designated five corridors of urban development along existing or planned suburban railway lines, which would be electrified to provide rapid rail transit services to Copenhagen's central business district. Every station would be the focal point for high-density housing and contain local shopping facilities.

Building on this legacy, Copenhagen started developing Ørestad new town on a strategic piece of reclaimed land owned jointly by the city (55 %) and the Danish government (45 %). In 2000, a new bridge was built connecting Copenhagen to Malmö in Sweden. Leading up to this, the city identified the area between the city and the new bridge as suitable for high-density housing. Ørestad is designed to be highly accessible by public transport and bicycle. Car parking within Ørestad is restricted for both residents and visitors and is largely confined to multi-storey car parks. The Ørestad Development Corporation created a masterplan and provided critical infrastructure, including the new Copenhagen metro, before selling plots along the line to developers. The finance captured from land sales was then used to pay for a significant chunk of the metro's development.

Ørestad has helped to improve Copenhagen's international competitiveness by expanding its central business district and developing highly accessible sites for office, media, retail and leisure activities. The large investment in mass transport infrastructure in the central parts of Greater Copenhagen has increased its accessibility and encouraged commuting from a much wider area, including more than 20 000 commuters a day from the Malmö area. (This is an interesting example of a case where better accessibility has led to an increase in overall transport demand, which will have to be studied further to see if the benefits of greater accessibility outweigh the costs of the increased number of trips.)

Sources: Knowles (2012).

Box 4.3 Example policy response: Vienna's Aspern Seestadt, a transport-oriented development area still under development

With the transformation of the former airfield Aspern, the city of Vienna plans to establish a new urban centre to the east of Vienna. The masterplan envisages the development of a multifunctional district with a mix of residential, office, scientific, research and educational uses. In 2028, 240 ha of land will be developed, accommodating around 20 000 residents and a similar number of workplaces. Aspern Seestadt is expected to reduce the existing lack of jobs in the eastern part of Vienna, resulting in considerable commuter flows into other districts of Vienna. The development of Aspern Seestadt is accompanied by an integrated mobility strategy that seeks to transform the mobility patterns of incoming residents by prioritising walking, cycling and public transport. The new city district will be connected to Vienna's public transport network and the wider metropolitan region through the metro, light rail and heavy rail, as well as the tram and bus networks. The new metro line was opened in October 2013, before the residential areas were developed. A management group has been established with the aim of maximising the attractiveness of streets and public spaces, in which a broad choice of shops, restaurants and other services are provided. The highest densities in Aspern Seestadt are to be found around the two metro stations. Aspern Seestadt can be considered both a single-node and a corridor transit-oriented development.

Sources: Nordregio (2016); Aspern Seestadt (2020).

4.3 Lessons for achieving better urban accessibility

A key lesson for cities is that policies that explicitly aim to achieve better accessibility have the benefit of addressing a multitude of interlinked urban challenges. These go far beyond the environmental burden of excessive motorised transport in cities and have the potential to fundamentally reconfigure how we live, work and interact with each other. Implementing transport policy reforms that promote walking, cycling, public transport and other forms of sustainable mobility can play an important role. However, these need to be linked to spatial planning and housing policies to achieve real urban accessibility. In order to be truly effective, questions of equity and social inclusion will have to be central to any policy responses. This will ensure that a move towards greater accessibility does not come at the expense of the most vulnerable urban residents.

Lack of integration and collaboration across the different governance levels (i.e. national, regional, local) and policy sectors that characterise this nexus can lead to wide-ranging socio-economic and environmental costs and challenges (e.g. urban sprawl, congestion, poor road safety) and can be an obstacle to accessibility-based planning. However, each sector's role is fairly well defined and differentiated, and those sector-specific remits are robustly embedded into the institutional frameworks of most countries (Rode et al., 2019). Thus, while governments work towards integrating key institutions and policies, they can already implement sector-specific actions to advance urban accessibility. This is good news for cities, as it means that there are many actions that do not have to wait for fundamental reforms to the policymaking process or to existing institutional arrangements. The extent to which city governments can effectively implement accessibility policies will depend on the specific institutional and governance context and the overall decision-making powers that have been devolved to them. This can vary significantly from one EU country to the next.

The EU has significant limitations in developing policies on urban planning, since land use policies are mostly a national, regional or local competence. This presents a challenge for achieving greater policy coherence around accessibility at the EU level. At the same time, the EU can play an important role in several ways: for example, by developing clear standards and guidelines that focus on public transport access requirements for new developments and that stipulate desirable urban densities. The EU can also promote knowledge sharing and peer-to-peer exchange, which ensures that important lessons to promote urban accessibility are disseminated. Another opportunity would be the development of mandatory sustainable urban mobility plans — already a requirement for cities in France and the United Kingdom. These new planning instruments that consider accessibility are increasingly being mainstreamed into decision-making processes. However, cities are still learning how to use them effectively to ensure that they meet the objectives of specific policy interventions.

Defining and measuring accessibility currently presents a major barrier. It can mean different things to different people, and accessibility disadvantages are likely to affect some social groups more than others. To ensure equity, city governments need to agree what type of accessibility should be promoted and how this access should be distributed across society. Addressing the urban accessibility nexus might require new cross-sectoral metrics, analysis and appraisal methods and the introduction of (as far as possible) standardised measurement indicators. These will have to acknowledge the difference between transport-related terminologies that are often used interchangeably: for example, traffic (focus on level of service of roads and vehicle speeds), mobility (focus on multi-modal, door-to-door movement), connectivity (focus on ease of exchange between fixed locations) and accessibility (focus on travel costs and time to reach destinations) (Venter, 2016; Litman, 2017). Finally, it will be critical to ensure that new disruptive technologies — from automation to smart mobility — enhance urban accessibility rather than undermine it. This will require the creation of an agile regulatory environment that can respond proactively to these rapid changes.

The COVID-19 pandemic has highlighted the urgent need for cities to rethink their transport policies to change the focus from mobility to accessibility. By investing in TOD and active transport infrastructure, cities can build resilience to future pandemics while also ensuring significant environmental and health benefits

4.4 Existing networks and sources of information

Examples of existing networks and sources information relevant to this nexus include:

- **Civitas** ([39]) initiative. A network of cities dedicated to cleaner, better transport in Europe and beyond. Since it was launched by the European Commission in 2002, the Civitas initiative has tested and implemented over 800 measures and urban transport solutions as part of demonstration projects in more than 80 'living lab' cities Europe-wide. The knowledge garnered through these practical experiences is complemented, and supported, by several research and innovation projects (Eccentric, Portis and Destinations), also run under Civitas.

- **ELTIS** ([40]). The European Commission's urban mobility observatory has guidance and best practice case studies, including advice to support cities with the development of their sustainable urban mobility plans.

- **ICLEI** ([41]). The International Council for Local Government Initiatives (also known as Local Governments for Sustainability) collates materials and information related to mobility and transport and case studies from member cities.

- **Partnership on Urban Mobility** ([42]). Set up under the urban agenda for the EU.

- **International Transport Forum** ([43]). This Organisation for Cooperation and Development (OECD) network publishes a wide range of research on transport policy in OECD countries. Together with the European Commission it has developed a new accessibility framework benchmark for access in European cities by different transport modes and for different services.

- **Pep** ([44]). Transport, Health and Environment Pan-European Programme.

- **Urban Atlas** ([45]). As part of the Copernicus land monitoring services, Urban Atlas provides comparable, high-resolution land use maps for 785 functional urban areas, in support of urban monitoring services ([46]).

Further reading

- Poelman, H. and Dijkstra, L., 2015, Measuring access to public transport in European cities, European Commission Regional Working Paper 01/2015 (https://ec.europa.eu/regional_policy/sources/docgener/work/2015_01_publ_transp.pdf) accessed 10 June 2021.

- EC and UN-Habitat. 2016, The state of European cities 2016. Cities leading the way to a better future (Chapter 5) (https://ec.europa.eu/regional_policy/en/policy/themes/urban-development/cities-report) accessed 10 June 2021.

- EEA, 2017, Perspectives on transitions to sustainability, EEA Report No 25/2017, European Environment Agency (for an example of socio-technical system for (land-based) transport).

- EEA, 2019, Sustainability transitions: Policy and practice, EEA Report No 9/2019, European Environment Agency.

([39]) https://civitas.eu
([40]) https://www.eltis.org/mobility-plans
([41]) http://iclei-europe.org/topics/mobility-transport
([42]) https://ec.europa.eu/regional_policy/en/policy/themes/urban-development/agenda
([43]) https://www.itf-oecd.org/benchmarking-accessibility-cities
([44]) https://thepep.unece.org
([45]) https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-urban-atlas
([46]) https://land.copernicus.eu

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5
Environment and health nexus

5.1 What is environment and health and why is it important in an urban context?

Urban areas are often unhealthy places to live, characterised by heavy traffic, pollution and noise. In 2013 the European Commission introduced the clean air policy package to reduce the health and environmental impacts of air pollution by 2030 (EC, 2019c). With the launch of the urban mobility package, the European Commission reiterated measures to address these issues (EC, 2020a).

Human health is closely linked to the state of the environment. Although emissions of air pollutants have declined in recent years, almost 20 % of the EU's urban population lives in areas where air pollutant concentrations exceed at least one EU air quality standard (EEA, 2019a). For example, approximately 8 % of the EU's urban population is exposed to fine particulate matter ($PM_{2.5}$) concentrations that exceed the EU limit value (EEA, 2019c). Urban mobility contributes as much as 70 % of air pollutants (other than carbon dioxide, CO_2) from transport (EC, 2019d). Noise pollution is also a major environmental health concern in cities, especially from road traffic (EEA, 2019d, 2019e). For example, regular exposure to noise pollution can trigger elevated blood pressure and heart attacks and causes approximately 12 000 premature deaths each year (EEA, 2019d, 2019f). An estimated 82 million people in European cities are exposed to noise levels in excess of 55 dB from traffic during the day-evening-night period (EEA, 2019d). Light pollution also has impacts on the environment, for example disrupting photosynthesis or the activities of insects and animals (Falchi et al., 2011). More than 99 % of the EU population lives in areas where the night sky is affected by light pollution ([47]) (Falchi et al., 2016). In urban areas it affects both flora and fauna as well as human health (Falchi et al., 2011; Škvareninová et al., 2017; Coogan et al., 2020).

Exposure to environmental stressors differs between social groups in cities. As a result, the health of some groups (e.g. low-income groups and ethnic and racial minorities) is more affected by the state of the urban environment than others (Brulle et al., 2006; EEA, 2013, 2018a). This is because of the unequal distribution, quality and maintenance of urban infrastructures and services, such as transport systems and high-quality green spaces (Barnes et al., 2018). For these communities the risks are often exacerbated by factors such as unemployment and poor access to health services.

In addition, the quality and accessibility of urban green spaces are considered important elements of healthy urban communities (Bertram et al., 2015; Edwards et al., 2018; EEA, 2019f). These dimensions can be addressed through urban design and policies related to public transport, walking and cycling infrastructure. Together these can contribute to improvements in environmental quality, human health and social equity and justice issues. Achieving high-quality urban environments that enhance health for all citizens should thus be a priority for urban policymakers.

If environment and health is improved in cities, this is likely to support progress in other nexuses, in particular:

- **Quality of life** — through planning and measures to improve green infrastructure (GI) and prioritise access and multifunctionality to enable active transport, social meeting places, and the enhancement and maintenance of biodiversity.

- **Climate resilience** — through the creation and enhancement of green areas that can incorporate measures to manage climate impacts and extreme weather events such as floods and heat waves.

Enhanced environment and health can also contribute to other nexus outcomes, including 'food security', through the creation and enhancement of GI that can provide communities with space to grow nutritious and healthy food, and 'urban accessibility', through urban design and policies to improve public transport and to provide walking and cycling infrastructure.

([47]) Light pollution is defined as when artificial brightness accounts for more than 10 % of the night's natural light.

5.1.1 The environment and health nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response

The pandemic has highlighted the importance of the environmental quality in cities for people's physical and mental health. For example, continued exposure to poor air quality leads to increased mortality risk from respiratory diseases such as COVID-19. The strict travel restrictions imposed across European cities during the height of the lockdown led to a significant reduction in motorised traffic. This reduction had an immediate and positive impact on air quality, with emissions from cars and motorcycles falling by 88 % compared with pre-pandemic levels (EEA, 2020d; OECD, 2020). Concentrations of particulate matter (PM_{10}) and $PM_{2.5}$ across European cities were variable and, where reductions in these pollutants were observed, the decrease was less pronounced than that for nitrogen dioxide (NO_2) (EEA, 2020e). Noise pollution was also reduced across many European cities. There are also reports that wildlife was thriving during the height of the lockdowns, with some species (e.g. wild bees) benefiting from the reduced air and noise pollution (Stokstad, 2020). However, the easing of some COVID-19 restrictions in late summer 2020 saw air and noise pollution levels rebound across European cities (EEA, 2020c).

As a result of the ban on non-essential travel many cities experienced a rapid decrease in tourist arrivals. Although this raised concern for local economies, it also resulted in reduced environmental pressures, including water pollution and impacts on local habitats, in coastal tourism destinations.

The need for social distancing to reduce the risks of spreading COVID-19 meant that public transport systems were closed or run at limited capacity. This was mainly because of the health risk posed by the confined space and resulting difficulty in social distancing. To encourage more active travel and provide space for social distancing many cities set up temporary cycling and pedestrian infrastructure.

During the pandemic, a huge increase in the use of personal protective equipment has led to increased plastic pollution in the environment. Individual choices during lockdowns are also increasing plastic demand. Packaged take-away meals and home-delivered groceries became increasingly popular during the lockdowns. This puts extra pressure on regular waste management services, potentially leading to inappropriate and illegal waste management strategies, including illegal dumping and local burning (Adyel, 2020).

Longer-term implications as cities draw up and implement COVID-19 recovery plans

The pandemic has provided cities with an opportunity to reconsider mobility with an emphasis on active travel, improved local environments and human health benefits. In their pandemic recovery plans many cities have proposed long-term and permanent strategies including investments in an active mobility infrastructure; improved safety and accessibility of public transport; changes in traffic regulations to increase safety; and pricing policies such as congestion charges.

Public green spaces should play a key role in the green recovery. Local policymakers need to prioritise the provision of safe and accessible green space. It is especially essential in areas of deprivation or where there is poor or unequal access to green space.

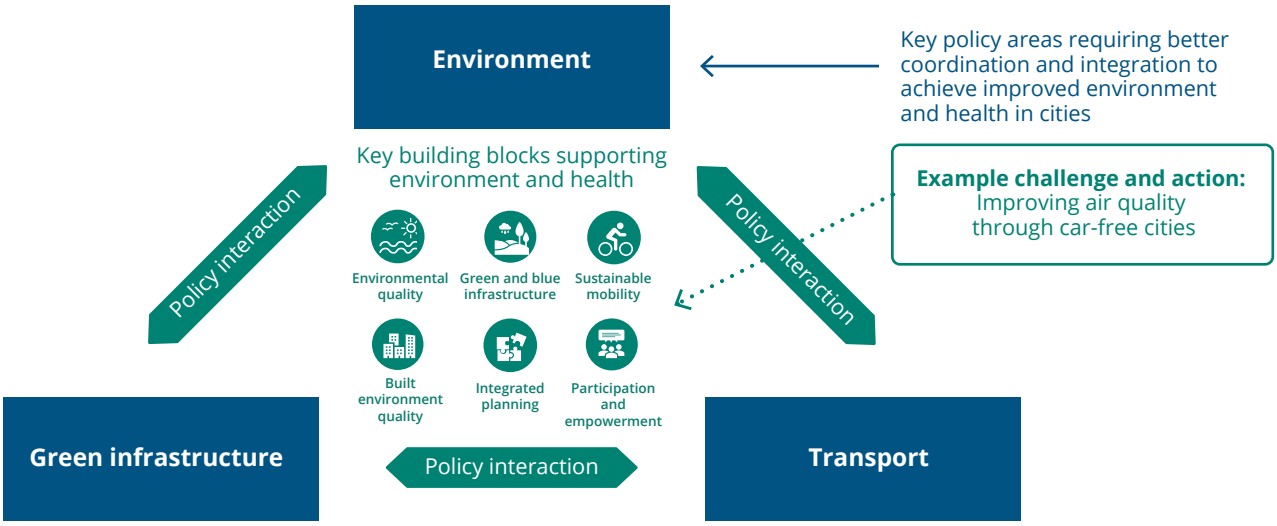
5.2 Interlinked policy areas contributing to environment and health in cities

There are many important policy areas that can contribute to improving the environment and human health in cities. Given their relative importance for human health, this nexus focuses on the need for coordinated policy related to transport, GI and the environment (Figure 5.1).

The following sections explore some of the key challenges to achieving good environmental quality and health in cities and how coordinated action can improve it. Table 5.1 then provides an overview of the challenges and actions to address them. The assessment also discusses in more detail an example illustrating coordinated action: improving air quality through car-free cities (Section 5.2.1).

The assessment example was selected by viewing the nexus through the healthy city lens. The nexus could also be viewed from other perspectives, which would help identify other potential areas of action. For example, viewing the environment and health nexus from the inclusive city perspective might identify action related to community involvement in local schemes to improve environmental quality. This could involve establishing multifunctional green spaces that provide a range of health benefits, as well as meeting other community needs such as providing meeting spaces, facilities for leisure and active transport routes.

Figure 5.1 The environment and health nexus: key policy areas and building blocks



Challenges of and action for achieving improved environment and health in cities

Improving environment and health in cities is a multi-dimensional challenge. It requires coordinating action on air quality, mobility and access and the quantity and quality of green spaces among other things. However, cities often lack coordinated policy approaches that consider mobility, GI, and environmental and air quality together. At the same time poor-quality urban design and form can limit options for, or provide little space for, community activities, green space, biodiversity and active transport. The pandemic has highlighted the need to focus on cross-cutting policy approaches that can deliver sustainable outcomes for each of these issues. This could include redesigning urban public and open spaces to improve GI and prioritise multiple uses and multifunctionality, including environmental quality and active transport but also social meeting places and areas for biodiversity conservation. Cities could implement these actions as part of their green recovery from the pandemic.

Some research suggests that multifunctionality can compensate for the quantitative lack of green areas in compact cities (Haaland and van den Bosch, 2015). The Green Space Factor is one way of determining GI requirements for new developments (Kruuse, 2011; Massini and Smith, 2018). It is used in the policies of many municipalities to set requirements that developers must agree to before planning permission for a site is granted. The aim is to ensure that, in creating places, GI is included in the planning at the earliest stages.

Many European cities experience high levels of congestion and associated environmental health concerns, including air and noise pollution. Well-established but unsustainable transport patterns and behaviours are common, including the dominance of motorised transport (especially cars) even for short journeys and commuting within urban areas. However, as highlighted by the pandemic, urban areas have the highest potential to shift from motorised transport to more active modes of transport such as walking and cycling (Interreg Europe, 2019). Overcoming such challenges requires the coordination of policy and action in a range of areas. These outcomes can be realised through the introduction of policies that reduce car use and traffic and promote active transport (e.g. improved frequency and availability of public transport, subsidised public transport and incentives for cyclists, reducing speed limits, restricting access and reallocating road space) to reduce air and noise pollution (see example assessment of interlinked actions in Section 5.2.1). Promoting teleworking and flexible working can also play a role by reducing the number of people commuting to work overall or during certain periods of the day. To some extent this has already taken place as a result of the COVID-19 pandemic, as more people are working from home out of choice or following national or local guidance. A shift to active transport can have a range of co-benefits, contributing to improved health and reduced noise and emissions of air pollutants and greenhouse gases (GHG).

Cities often have high levels of social inequality. There is strong evidence that vulnerable communities experience higher rates of morbidity and mortality due to the cumulative effects of exposure to environmental stressors (EEA, 2018a). At the same time access to and experience of GI significantly differs depending on socio-economic status. More deprived populations also often have poorer access to and lower-quality GI in their vicinity than groups with higher incomes living in more affluent urban areas (EEA, 2010). Addressing this inequality in environment and health outcomes requires participatory working with community (including minority) groups and citizens in deprived areas in order to understand them and help to ensure that the needs of all are considered in planning and policymaking. Collaborative creation of policy and interventions with communities can also help to improve outcomes. The creation and enhancement of GI could also be focused in areas with the lowest current levels of access, as well as in areas of economic and social deprivation (recognising that people living in these areas may also be less likely to have access to private outdoor space and gardens). City governments can better understand how deprived and minority groups are affected by environmental stressors by incorporating deprivation and equality measures in spatial (mapping) of air and noise pollution, access to green space and active transport routes, etc.

The policy actions taken to improve human health in cities can also create a range of co-benefits that also contribute to this goal (EEA, 2018a). For example, GI can be planned to contribute to climate resilience (e.g. by incorporating flood management) and food security (e.g. by providing space for communities to grow food).

Table 5.1 Overview of challenges of and actions for achieving improved environment and health in cities

Example challenges	Example actions to address challenges
• Lack of cross-cutting and coordinated policy approaches that consider mobility, access, green space and air quality among others together.	• Working across policy areas, in particular transport/mobility, land use planning (especially for green space), nature/environment, air quality, health and equality to achieve coordinated outcomes and co-benefits. • Adapting existing policies to create co-benefits and improve human health in cities, e.g. GI can be planned to contribute to climate resilience and food security.
• Poor existing urban design and form, which limits options for or provides little space for active transport, community and green space.	• Redesigning urban form and space to improve GI and prioritise multiple uses, including environmental quality and active transport but also social meeting places and areas for biodiversity conservation.
• Current unsustainable transport patterns, especially the dominance of motorised transport (cars) even for short journeys and commuting. • Existing infrastructure does not support or enable active travel.	• Introducing policies that reduce car use/motorised traffic and promote active transport to reduce air and noise pollution (see Section 5.2.1). • Promoting teleworking to reduce the number of people commuting during the busiest periods of the day.
• High levels of social inequality: vulnerable communities, including ethnic and racial minorities, experience higher rates of morbidity and mortality due to the cumulative effects of exposure to environmental stressors; and more deprived populations often have poorer access to and lower-quality GI in their vicinity than groups with higher incomes.	• Working with community groups and citizens to ensure that the needs of all are considered and to collaboratively create policy and interventions. • Focusing action to create and enhance GI in areas of economic and social deprivation seeking to ensure equality of access in all areas of a city. • Ensuring monitoring of environmental drivers of health outcomes (e.g. air quality, noise, access to green space) also includes social and economic equality measures.

5.2.1 *Example assessment of interlinked actions: improving air quality through car-free cities*

How does improving air quality through car-free cities fit within the urban health and well-being nexus?

- Air quality is a key indicator of the health of a city, and air quality is typically poor in congested cities that are not well planned and do not have ample green space.
- Exposure to air pollution has an unequal impact on vulnerable citizens.
- Car-free cities have co-benefits in addition to improving human health and quality of life.

Over 400 000 premature deaths each year in the EU are linked to air pollution (EEA, 2020f), and the health impact of road traffic emissions alone costs EUR 67-80 billion a year (CE Delft, 2018). The high population densities found in many cities exacerbate these impacts (Wang and Moriarty, 2018). Thus, one of the best overall 'indicators' of a healthy city is its air quality. Air pollution levels are typically low in well-planned cities with good transport systems, walkable streets and ample green space. In contrast, air pollution levels soar in urban settings that prioritise road transport over pedestrians and cyclists and that allow uncontrolled sprawl (WHO, 2018).

Not all urban citizens are equally exposed and equally vulnerable to air pollution. The urban poor, elderly people and children are considered most vulnerable to air and noise pollution, particularly in the southern and eastern regions of Europe, where exposure is highest (EEA, 2018d). These socio-economic differences mirror unequal income and unemployment patterns. In Germany, for example, children aged 3-14 years old from families of low social status more frequently live next to main roads with heavy traffic, a pattern seen elsewhere in Europe. Consequently, they are worse affected by road traffic noise (11 %) than children from families of medium and high social status (3 %) (EEA, 2013). Car-free cities have the potential to create multiple co-benefits for both the environment and human health. Reducing traffic congestion in urban areas has had notable impacts on air quality. It can also reduce GHG emissions such as CO_2.

Possible policy responses and interventions

Most sources of outdoor air pollution are well beyond the control of individuals. Addressing air pollution demands concerted action by local, national and regional level policymakers working in sectors such as transport, energy and urban planning (WHO, 2018). When cities take action to reduce air pollution, they can achieve good progress. Almost half of all cities monitoring air pollution in high-income countries reduced air pollution levels by 5 % between 2008 and 2013 (WHO, 2018).

In relation to transport, a wide portfolio of policies is needed to support car-free cities. These include improved frequency and availability of public transport, improved infrastructure for cyclists and pedestrians, shared car and bicycle programmes and access for emergency vehicles and delivery trucks. Cities can provide incentives and build capacity among start-ups for business and community-based innovation projects that enable ride sharing or alternative modes of transport. However, policies must be carefully considered. The popularity of electric scooters in European cities has demonstrated that some alternative forms of transport can raise both environmental and safety concerns (Tapper, 2019).

Some cities have subsidised public transport, and others have established incentives for cyclists. For example, Portugal has established an e-bike subsidy scheme to encourage cycling in urban environments (Georgieva, 2019). However, initiatives that promote car-free cities may be contested by businesses and interest groups that feel that it will create economic disadvantages for a particular sector. Car-free cities may also be opposed by those who are sceptical to policies aimed at reducing GHG emissions. An emphasis on co-benefits is thus important, and this includes human health (EEA, 2018d).

Another policy option is to promote teleworking, which involves working remotely and reducing the number of people commuting during the busiest periods of the day. According to the Organisation for Economic Cooperation and Development's (OECD's) International Transport Forum (2019), the percentage of the population teleworking is highest in Denmark (34 %), Finland (32 %) and the Netherlands (29 %).

Box 5.1 Example policy response: encouraging sustainable mobility habits to reduce air pollution in Cornellà de Llobregat, Barcelona, Spain

Air pollution is one of the main public health problems in the metropolitan area of Barcelona, where Cornellà de Llobregat is located. This issue is mainly caused by motorised traffic. In 2016, Cornellà de Llobregat municipality, in collaboration with the Área Metropolitana de Barcelona, launched the Cornellà Natura project, which has shaped the city's strategic plan for 2016-2026. The project aims to increase and improve green areas in the municipality and encourage sustainable mobility habits to improve urban liveability by 2026. It focuses on three main goals that provide the focus for all interventions:

- achieve a green municipal infrastructure;
- promote sustainable mobility;
- improve environmental quality.

Many of the actions promoted within the project are aimed at reducing air pollution levels and encouraging sustainable mobility habits. For example, these include reducing the speed limit to 20-30 km/h, traffic restrictions during weekends and the expansion of the bicycle network. A key objective is to have more than 50 % of all journeys made on foot or by bicycle by 2026, with public transport accounting for another 30 %.

The COVID-19 pandemic has accelerated the implementation of some of the actions within the project. The initial lockdowns enabled the municipality to test closing streets to traffic and improving the public transport service. These measures have now been consolidated and new streets will be calmed by increasing the green infrastructure and creating more space for pedestrians.

Sources: EC (2019c); Cornella de Llobregat municipality (2017).

Box 5.3 Example policy response: a multi-pronged strategy to shift on transport use behaviour in Oslo, Norway

Oslo has succeeded in reducing the number of its inhabitants exposed to high levels of pollution from 190 000 to 10 000 since 2015, and the city's emissions have decreased by over 20 % since 2009. This has been achieved by adopting a multi-pronged strategy, firstly by encouraging the uptake of electric cars through reduced taxes, provision of charging stations, and free parking and travel on toll roads and public ferries for electric cars. In 2020 electric vehicles accounted for 22 % of the total number of cars in the city.

Oslo City Council has also increased tolls for vehicles with diesel and gasoline engines, with 93 % of the toll revenue to be set aside for developing the public transport system. The sale of all fossil fuel-powered automobiles will be phased out by 2025 in Norway. The centre of Oslo has also been redesigned by improving the infrastructure for cyclists and pedestrians, supporting bike-sharing schemes and electric cargo bikes, increasing car parking fees, and introducing car-free zones in the city centre.

Together, these measures and improvements have achieved a shift in transport behaviour. The council estimated that in late 2018 there were nearly 500 000 fewer cars entering Oslo each month than there were in 2017, and the aim is to reduce vehicle traffic by one third and for all private cars to be emission free by 2030. Eventually, Oslo is aiming to make the transition to a totally car-free city.

However, there has been strong opposition to several of these initiatives, in particular increased tolls, with the emergence of a new political party to fight them and 43 % of the population feeling negative about them in 2020. This highlights the need to consider carefully **how** car-free initiatives are implemented to avoid polarisation.

Sources: Oslo Kommune (2017, 2020, 2021a, 2021b); Klimaetaten (2020); Statens Vegvesen (2021).

Box 5.3 Example policy response: the role of experimentation and evaluation in reducing urban traffic

Autonomous vehicles have been promoted as a force for people-centred design of transport systems. According to one estimate (Strategy&, 2017), almost half of all vehicle-kilometres in the EU could be travelled in self-driving cars. Although promoted as an environmentally sound solution with considerable road safety benefits, the consequences of automated vehicles are ambiguous and contested. For example, in 2019 the Ministry of Infrastructure and the Environment in Netherlands opened public roads to large-scale tests with self-driving passenger cars and trucks. However, despite their readiness in terms of policy and legislation, technology and innovation, infrastructure and consumer acceptance, the integration of autonomous driving has proven difficult in dense urban areas because of safety issues, perceptions and the strong cycling culture. As a result, critics argue that autonomous vehicles will not be a sustainable or acceptable solution in urban areas and will have to be kept separate from other transport modes. Furthermore, autonomous vehicles may result in a rebound effect from the potential increase in their use and the number of users. This case provides an example of the importance of both experimentation and evaluation when it comes to interventions aiming to reduce urban traffic.

Source: Government of the Netherlands (2021).

5.3 Lessons for improving environment and health in cities

While urbanisation has contributed to an overall decline in poverty (subsequently improving human health), some environmental challenges (e.g. air, noise, light pollution) put the health of people in cities at risk (Chen et al., 2019). As shown by the COVID-19 pandemic, a better understanding of the linkages, dynamics and complexities of urban environments is needed (InterAcademy Partnership, 2021). Policies must prioritise both the health of people and the quality of the environment. Recognising the many potential co-benefits between improving environmental quality and improving human health, these two objectives can be considered intrinsically related and thus should be considered together. Strategies for urban sustainable development must therefore recognise people as part of urban environmental systems.

National-level interventions (e.g. legislative frameworks) should encourage local authorities to integrate transport better within their health and environment policies (Flausch, 2016). Cities have a key role in improving the environment and health through coordinated policy actions. Transport networks and GI are good examples of the complex sub-systems in cities that interact with each other and significantly affect human health in positive and negative ways. Considering this example of interlinked issues, to maximise health outcomes local authorities should develop and implement policy that reduces the use of cars by enhancing public and active transport options, including by creating multifunctional spaces and improved GI.

Many of the examples presented in this nexus depend on collaboration across diverse stakeholder groups, in particular those from deprived, low-income and minority groups who are often most exposed to environmental stressors (e.g. air and noise pollution) and have poor access to high-quality GI. The articulation of co-benefits may be critical in reaching a consensus. For example, there is considerable synergy between efforts to reduce air pollution and climate mitigation and adaptation measures (Wang and Moriarty, 2018).

In terms of indicators, those that capture the quality of human-environment connections can provide a good picture of human health in cities, especially when combined with indicators of deprivation and inequality. Good-quality urban green spaces can provide a restorative environment to mitigate the impacts of urban stressors such as air and noise pollution (Payne and Bruce, 2019). When multiplied by the thousands of people who use it, green space can have a large positive cumulative public health impact (Gilbert, 2016). However, it also should be noted that trees themselves can act as obstacles to airflow, decreasing air exchange and leading to large concentrations of pollutants. It is important that urban planners consider local meteorological conditions (e.g. wind direction and speed) and building layouts when developing tree-planting policies to ensure substantial air quality improvements (Jeanjean et al., 2017). The COVID-19 pandemic has highlighted the urgency for cities to reimagine the way their infrastructure supports environment and health for all. By investing in infrastructure that encourages active transport and improves access to green space, cities can contribute to a green recovery and achieve multiple co-benefits for both the environment and human health.

5.4 Existing networks and sources of information

Examples of existing networks and sources information relevant to this nexus include:

- **C40 Cities** ([48]). C40 is a network of the world's megacities, committed to addressing climate change. C40 supports

([48]) https://www.c40.org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cities to collaborate effectively, share knowledge and take meaningful, measurable and sustainable action on climate change.

- **Connecting Nature** ([49]). An EU-funded project, a partnership of 31 organisations co-working with local authorities, communities, industry partners, non-governmental organisations (NGOs) and academics. It involves 16 European countries, Brazil, China, South Korea and the Caucasus (Georgia and Armenia), that are investing in a large-scale, multi-million euro implementation of nature-based projects in urban settings.

- **EuroCities** ([50]). The network of major European cities. that brings together the local and municipal governments of over 140 of Europe's largest cities and over 45 partner cities. The network works through six thematic forums, working groups, projects, activities and events to share knowledge and ideas.

- **Green Surge** ([51]). A collaborative project between 24 partners in 11 countries funded by the European Commission's Seventh Framework Programme. Green Surge will identify, develop and test ways of linking green spaces, biodiversity, people and the green economy. Its aim is to meet the major urban challenges related to land use conflicts, climate change adaptation, demographic changes, and human health and well-being.

- **ICLEI** ([52]). The International Council for Local Government Initiatives (also known as Local Governments for Sustainability) is a global network of more than 1 750 local and regional governments committed to sustainable urban development. Active in over 100 countries, ICLEI influences sustainability policy and drives local action for low-emission, nature-based, equitable, resilient and circular development.

- **Interreg Europe** ([53]). A network that helps regional and local governments across Europe to develop and deliver better policy. It offers a platform for regional and local public authorities across Europe to share ideas and experience on public policy in practice and includes resources and case studies on active transport and GI among many other topics.

([49]) https://connectingnature.eu
([50]) http://www.eurocities.eu
([51]) https://greensurge.eu
([52]) https://www.iclei.org
([53]) https://www.interregeurope.eu
([54]) https://cinea.ec.europa.eu/cinea-data-hubs_en

- **LIFE programme** ([54]). Various projects are funded by the LIFE programme, the EU's funding instrument for the environment and climate action.

- **Nature4Cities** ([55]). Horizon 2020 EU-funded project creating a comprehensive reference platform for nature-based solutions (NbS), offering technical solutions, methods and tools to empower decision-making in urban planning.

- **Naturvation** ([56]). This 4-year Horizon 2020 project, whose name comes from 'nature-based urban innovation', involves 14 institutions across Europe in the fields of urban development, geography, innovation studies and economics. It aims to develop our understanding of what NbS can achieve in cities. The project also examines how innovation can be fostered and contribute to realising the potential of NbS.

- **Oppla** ([57]). The EU repository of NbS. Oppla is an open platform designed for organisations and individuals from science, policy and practice and from the public, private and voluntary sectors.

- **Perfect project** ([58]). 'Planning for environment and resource efficiency in European cities and towns' is a project supported by Interreg Europe. It aims to integrate the many benefits of GI into the planning and investment for the future of urban and rural areas. The project also seeks to influence the policymaking process by raising awareness of the social, environmental and economic potential of GI.

- **SPAcE** ([59]). 'Supporting policy and action for active environments' was a project that ran from January 2015 to December 2017. It aimed to integrate active transport programmes (e.g. walking to school, cycling to work schemes) into public policy across the EU. SPAcE was a collaboration between regional governments, higher education institutions and NGOs across Europe.

- **Urbact III (2014-2020)** ([60]). An EU cohesion policy instrument, co-financed by the European Regional Development Fund, the 27 Member States, Norway, Switzerland and the UK. It aims to foster sustainable integrated urban development in cities across Europe.

- **Urban agenda for the EU** ([61]). A multi-level working method promoting cooperation between Member States, cities, the European Commission and other stakeholders. Its aim is to stimulate growth, liveability and innovation in the cities of Europe and to identify and successfully tackle social challenges.

([55]) https://www.nature4cities.eu
([56]) https://naturvation.eu
([57]) https://oppla.eu
([58]) https://www.interregeurope.eu/perfect
([59]) http://activeenvironments.eu
([60]) https://urbact.eu
([61]) https://ec.europa.eu/futurium/en/urban-agenda


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6
Food security nexus

6.1 What is food security and why is it important in an urban context?

Food security is defined as the physical, social and economic access to safe, sufficient and nutritious food for all individuals at all times (FAO, 2003). It also refers to the ability of a nation to provide such access for its people, through its food production systems, self-sufficiency and stable trade agreements and networks.

The demand for food and evolving tastes (e.g. for out-of-season produce) in cities has outgrown the supply capacity of their hinterlands. As a result, reliance on imported food continues to grow. Any disturbance (e.g. climate risks, food prices, pandemics) to these supply chains could lead to social inequality in terms of access to affordable nutritious food in cities. Food security is an urban policy issue as much as a national and rural one. Yet European policy to date has not had a transformative effect on urban agriculture and food security, as it mainly views food production as a rural activity. Social innovation and experimentation is rapidly emerging in cities. This can range from community-supported agriculture schemes and farmers' markets to the creation of urban food policies. EU and national policies are often ill equipped to encourage this type of experimentation. For example, food system initiatives in cities are ineligible for common agricultural policy funding (De Schutter et al., 2019).

Food security is critical to urban environmental sustainability. It is estimated that 80 % of Europeans will live in cities by 2050, compared with 74 % today (EEA, 2019a). This means that the demand for food in cities will increase. Larger urban populations may lead to increased density and urban sprawl with impacts on the availability of land for urban and peri-urban agriculture (EEA, 2016c). This will also have a negative effect on the quality and quantity of biodiversity. Increasing awareness of environmental and sustainability issues among urban residents is also shaping the growing demand for new types and qualities of food. For example, the increasing number of people choosing to eat plant-based diets will have important implications for livestock and agricultural production (EC, 2018b).

Enhanced urban food security can reduce the environmental footprint of the increased demand for food. It can also decrease reliance on external food provisioning systems and imports. Both issues are critical within the context of climate change and any future pandemics. Access to and affordability of fresh, nutritious food for all urban citizens can be supported through diverse and innovative forms of urban food production. It could also be supported by reducing food waste and creating closer relationships between urban residents and the food they consume.

If enhanced food security is achieved in cities, this can help to support progress in other nexuses, in particular:

- **Quality of life** — through ensuring access to healthy, fresh and affordable food for all to improve diet and health.
- **Environment and health** — through measures supporting urban food production and changes in people's diets (e.g. towards more plant-based diets).
- **Closing the loop** — through improving management of food waste in households and service industries.

Enhanced food security can also contribute to other nexus outcomes, including 'sustainable buildings', for example through the use of rooftops and balconies for food production.

6.1.1 The food security nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response in cities

The COVID-19 pandemic has increased awareness of the nature and vulnerability of the food system and food production, supply and distribution chains. The initial responses to COVID-19 caused significant disruption to food systems, including those in urban areas. This posed several challenges, including rapid changes in food demand, availability, accessibility and affordability.

During the height of the pandemic many supermarket shelves across European cities were empty as a result of spikes in demand and a reliance on long and complex supply chains and just-in-time delivery. This meant, in the short term, that it was not possible for supermarkets to restock quickly enough to meet demand. Closed borders, grounded planes, missing ship containers and a reduced workforce led to disruption of supply chains, particularly those for fresh produce (EC, 2020b). In some communities and households there was a shift away

from supermarkets towards local, small-scale provision of and self-sufficiency in certain goods and services, including food. This has forced local food shops to adapt to increased demand.

Longer-term implications as cities draw up and implement COVID-19 recovery plans

As a result of the pandemic, more municipal and city authorities are realising the value of growing local, organic and more seasonal food (e.g. fruit and vegetables) in and around urban areas (EC, 2020c; IPES, 2020). For example, Paris is planning to move part of its food production more locally. The aim is to reduce the average distance travelled by food from producer to consumer, which is currently 660 km. In Valencia there are plans to use the urban green belt as an immediate and direct source of fresh food for the city (OECD, 2020). There is a risk that those from the lowest-income households will not be able to afford locally grown and organic food, as it tends to be more expensive than food found in supermarkets. The pandemic-induced economic recession is also likely to have an impact on vulnerable households, further reducing their ability to purchase healthy, nutritious and locally grown food.

In their green recovery plans cities could plan for a diversity of green spaces, including urban agriculture. This could have several co-benefits, for example increased biodiversity, reductions in the urban heat island effect and a reduced risk of flooding and soil erosion (OECD, 2020). However, there may also be trade-offs with other land uses, such as for housing or commercial development. Achieving these co-benefits and limiting trade-offs will require coordinated policy and action in relation to urban agriculture, spatial planning and social policy.

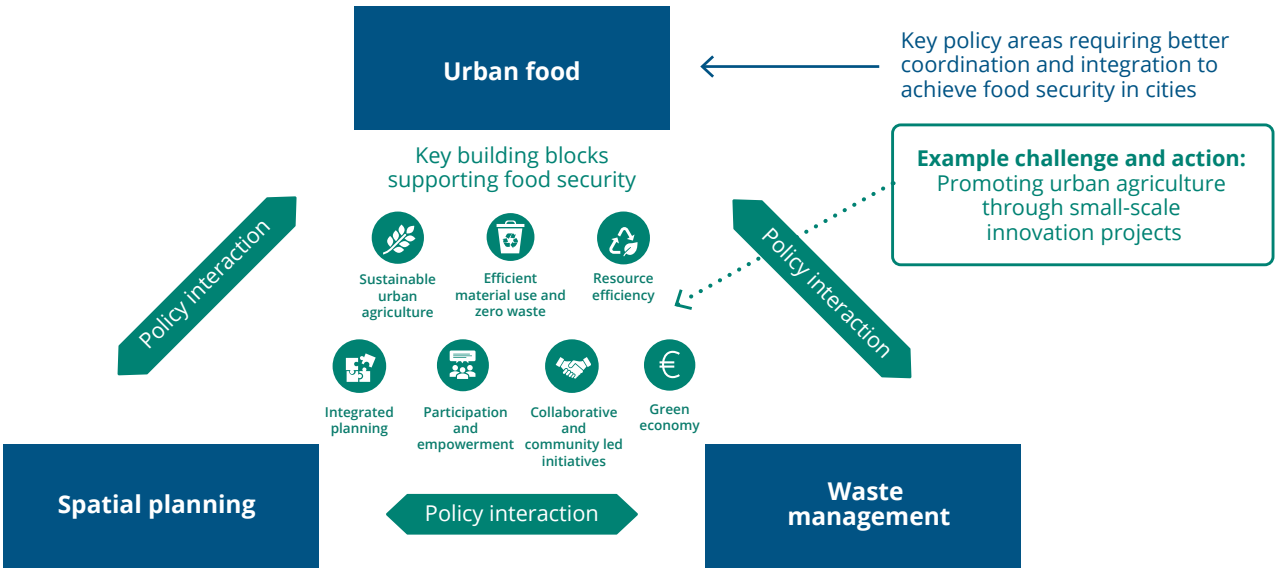
6.2 Interlinked policy areas contributing to food security in cities

The focus of the food security nexus is on achieving secure and sufficient access to food for the growing urban population today and in the future. Achieving food security for all requires coordination between a range of policy areas. This nexus focuses on coordination of policy and action in relation to urban food, waste management and spatial planning (see Figure 6.1).

The following sections explore some of the key challenges of enhancing food security in cities and associated policy and practical actions. The focus is on better coordination of the nexus policy areas. Table 6.1 then provides an overview of the challenges of and actions for addressing them. The assessment also discusses in more detail an example illustrating how coordinated action can contribute to food security: promoting urban agriculture through small-scale innovation projects (Section 6.2.1).

The assessment example was selected by viewing the nexus through the resilient city lens. The nexus could be viewed from other perspectives, which would help to identify other potential areas of action. For example, viewing the food security nexus from the circular city perspective might identify action related to stakeholder cooperation to reduce food waste by applying circular economy principles. This could include the wider adaptation of both composting and anaerobic digestion to divert bio-wastes from landfill and to ensure that nutrients and energy are recovered from food waste.

Figure 6.1 The food security nexus: key policy areas and building blocks



Challenges of and actions for achieving food security in cities

Climate change impacts are already affecting food systems globally. For example, droughts can trigger local food crises and have cascading systemic consequences such as spikes in international food prices (World Economic Forum, 2016). Urban areas are not immune to these impacts, and urban food systems may have low resilience levels, in particular where climate impacts coincide with pressures from a growing urban population. The main elements of urban food systems (e.g. food distribution and supply chains, transport and food storage) can all be affected. The COVID-19 pandemic has highlighted the vulnerability of these elements, particularly of the production, supply and distribution chains. Any significant disruption in these elements will have implications for urban food security and the resilience of urban food systems (IUFN, 2016).

Growing urban populations and social disadvantage can present additional challenges for food security (Maggio et al., 2015). Food security for all depends on sustainable and fair food access and food pricing and collaboration across diverse groups of stakeholders. This could include engaging the private sector (e.g. supermarkets, local convenience shops and food distributors), charities and non-governmental organisations (NGOs), community groups and urban residents to understand food access challenges and to support or encourage the provision of affordable, healthy and fresh food in deprived areas (Wang et al., 2018). Urban authorities can also play a role in encouraging and supporting local food cooperatives and community shops in low-income communities and deprived areas.

Food often plays an important cultural role in urban areas. It can increase community cohesion and support the integration of new residents. For example, urban community gardening and farming projects can help new immigrants and refugees build social ties. It also enables them to celebrate and maintain their cultural traditions, as well as fostering resilience and boosting mental health (MacKenzie, 2016).

Variations in import supply and availability, costs and quality could be offset by increasing urban agricultural production. It encompasses a wide range of practices, ranging from household and community gardens to rooftop, vertical and indoor farms. By helping a city become partially self-sufficient, these practices decrease reliance on external supplies. An EU briefing on urban agriculture in Europe uses case studies to assess its potential (McEldowney, 2017). For example, in Bologna, it is estimated that, if all rooftop gardens were used, they could provide approximately 77 % of residents' vegetable needs.

High levels of food waste and how to reduce it is a central challenge for both urban sustainability and food security. It is estimated that approximately 88 million tonnes of food are lost along the supply chain or wasted at the household level each year in the EU, at an annual cost of EUR 143 billion (EU Fusions, 2016; EEA, 2019a). Innovative solutions for the redistribution of surplus food supplies within urban areas are emerging. For example, social entrepreneurs use technology (e.g. donation-matching software) that provides real-time information about available food. This enables local organisations to arrange efficient routes and pick up small amounts of food that otherwise would have been too expensive to recover (Link, 2019). A growing number of cities around the world have committed to 'zero-waste' food systems that aim, as part of a move to a more circular economy, to holistically integrate the food and waste sectors to increase overall resource efficiency. As part of this, there are new systems for the diversion and reuse of food waste. For example, the inedible fraction of wasted food is included in recycling processes in which it is converted into new products. Having been separated from the inedible fraction, the edible food fraction is reused in creative recipes or donated to people in need (Pleissner, 2018). The European Commission and Member States are committed to meeting the Sustainable Development Goal 12.3 target of halving per capita food waste at the retail and consumer level by 2030. They will also seek to reduce food losses along the food production and supply chains (EC, 2019f, 2021a). This will require policy action at national and EU levels to update existing legislation so that it enables and facilitates reducing food waste in European cities.

Policies related to urban land use and spatial planning can also contribute to food security. Changing land uses can help to create new relationships between urban residents and food production, consumption, nutrition and waste. Creating or allocating spaces for urban farming and new ways of experiencing agricultural production can contribute to a sense of connection with food, which can lead to a reduction in food waste, particularly if people feel that they have a stake in the production of food. Making food and the growing of food more accessible provides learning opportunities and creates spaces and platforms for new collaborations to emerge. Facilitating the participation and empowerment of stakeholders through land use planning can therefore contribute to both food security and community cohesion.

Table 6.1 Overview of challenges of and actions for achieving food security in cities

Example challenges	Example actions to address challenges
• Low resilience of urban food systems to various impacts, including those from climate change and a growing urban population. • Over-reliance on external food supplies.	• Increase urban agricultural production using practices ranging from household and community gardens to rooftop, vertical and indoor arms. • Establish initiatives to promote urban agriculture through small-scale innovation projects (see Section 6.2.1).
• Lack of fair access to nutritious food, particularly among low-income communities. • Lack of understanding of how the values and attitudes of all stakeholders can influence both the design and implementation of food systems.	• Engage citizens and stakeholders in land use planning to ensure that space is available for and communities are engaged in local food-growing initiatives. • Promote urban community gardening and farming projects to, for example, help new immigrants and refugees build social ties and increase community cohesion. • Work with the private sector (e.g. supermarkets, local convenience shops, food distributors), NGOs/charities, community groups and citizens to understand food access challenges and encourage the provision of affordable, healthy and fresh food in all areas. • Encourage and support local food-cooperatives and community shops in low-income communities and deprived areas.
• Reducing food waste.	• Provide incentives for and build capacity among start-ups and community-based innovation projects to reduce food waste. • Promote innovative solutions for the redistribution of surplus food supplies within urban areas, including by using technology.

6.2.1 Example assessment of interlinked actions: promoting urban agriculture through small-scale innovation projects

How does promoting urban agriculture through small-scale innovation projects fit within the urban food security nexus?

- Even in dense urban areas with limited green space, small-scale innovation projects can support food production with the right integrated approach and policy and institutional set-up.
- The development of urban agriculture requires systems to support its development as part of wider circular economy and resiliency efforts.
- Urban agriculture offers a range of co-benefits, including increased biodiversity, reductions in the 'urban heat island effect' and a reduced risk of flooding and soil erosion.

Urban agriculture faces several challenges, including:

- pressure on open space and farmland;
- barriers to cooperation with more traditional farmers;
- the need for training and support for urban agricultural entrepreneurs;
- environmental constraints such as urban air and soil quality.

As part of an integrated approach to food security, human health, social and economic inclusion and environmental quality, there are various factors that influence the viability of expanding urban agriculture. Some of these include the climate, existing urban layout, attitudes towards the use of urban space for food production, and the wider policy and institutional set-up. At the EU level, important barriers also remain in terms of how urban agriculture is defined and whether or not it falls under the common agricultural policy. There is also ongoing discussion about whether or not it should qualify for funding

through rural development programmes typically reserved for more conventional agriculture (McEldowney, 2017).

Recent research suggests that, globally, urban agriculture could produce as much as 180 million tonnes of food a year. This would represent up to 10 % of the global output of legumes, roots and tubers, and vegetable crops (Clinton et al., 2018). While there are no definitive figures on the percentage of food grown in urban areas across Europe, individual case studies suggest a significant potential.

There are also environmental benefits associated with urban agriculture, for example increased biodiversity, reductions in the 'urban heat island effect' and a reduced risk of flooding and soil erosion (Clintone et al., 2018). Urban agriculture does not require large amounts of land, as vacant plots or disused land can often be brought back into use. However, there might be trade-offs with other land uses, such as for housing or business development as a result of increasing urban populations. It can also be integrated into existing parks and private gardens. This can also improve biodiversity and local amenity value. Even in dense urban areas with limited green space, rooftops or vertical structures can support food production. This requires the right set-up and support from technologies such as hydroponics.

Possible policy responses and interventions

There are growing opportunities for cities to provide incentives for and build capacity among start-ups and community-based food-related innovation projects. Many cities have set up their own systems to support the development of urban agriculture as part of wider circular economy and resiliency efforts (GIZ and ICLEI, 2014). One successful example is London's Capital Growth network. It links more than 2 500 food-growing spaces in London. These range from small community and school food-growing efforts to small-scale commercial urban farms. It is one of the largest and most established urban food growing networks in the world, offering training, support and practical help for community growing projects (Mayor of London, 2021). Based on an analysis of land use, Rome is the most agricultural municipality in Europe. One of the best urban agricultural practices there is the Agricoltura Nuova multifunctional agricultural cooperative. It occupies some 250 ha and is selling all its food directly to local markets. The cooperative is also involved in the social integration of marginalised individuals (Cavallo et al., 2016).

Box 6.1 Example policy response: rooftop farming in Rotterdam, the Netherlands

The DakAkker rooftop urban farm, one of Europe's largest, is located on top of the Schieblock office building in the centre of Rotterdam. It was set up in 2012 as part of Binder Groenprojecten in collaboration with Environmental Centre Rotterdam. Binder Groenprojecten is a Rotterdam City Council 'City Initiative' project, which has support from several business partners. The farm produces fruits, vegetables and herbs, and honey from its own hives, and functions as a test site for experimenting with different ways of green roof farming in the city.

In addition, with 18.5 km^2 of flat rooftops in Rotterdam, the city has set a target of putting 1 km^2 of that space to good use by 2030. This will include greening the rooftops with plants and trees, adding solar panels and using them for recreation or even homes.

Sources: Rowling (2019); Luchtsingel (2021).

Box 6.2 Example policy response: urban farming in Berlin, German

TECF Farmsystems is a 1 800 m^2 aquaponic start up in Berlin's central Schöneberg district producing 30 tonnes of fish (tilapia) and 400 000 basil plants per year. The founders have created a symbiotic system in which basil plants are grown from seed using nutrient-rich water filtered from the fish-farming tanks by bacteria.

The system avoids the usual use of pesticides in producing basil and antibiotics in producing fish. In addition, 90 % of water is reused. Shorter transport routes for the fish and basil result in fresher food and lower emissions, especially because of the reduced need for refrigeration. Start-up finance of EUR 1.4 million came from private investors and the Investitionsbank Berlin, a state-owned development bank. The business employs three gardeners and two fish farmers and has a contract to supply basil to the Rewe supermarket chain throughout Germany.

Source: Rosenbach (2019).

6.3 Lessons for achieving food security in cities

The nexus analysis points to several key lessons for improving urban food security.

Understanding how climate change will affect the various interlinked elements of food systems should be built into all policy decisions and actions. Food security is closely linked to urban climate resilience; thus, urban food production, land use and waste programmes must be aligned with urban adaptation strategies.

There is also a need for structures and approaches that support effective and equitable collaboration between all stakeholders in the food system in urban areas and, where necessary, in the wider food system. This includes policymakers, producers, distributors, retailers and consumers, ideally involving the different cultural groupings and age cohorts that make up urban populations. This is especially important in the context of rising numbers of immigrants and refugees in some urban areas. There is also a need for a better understanding of how the values and attitudes of all stakeholders can influence both the design and the implementation of food systems. This would also help us to understand whether they are able to deliver economically, socially and environmentally sustainable outcomes. Policies that consider the needs of all people as a critical part of food systems can help optimise food security in urban areas.

A shift towards more integrated perspectives on urban food systems would require consideration of health and education — but also sectors and interests such as transport and logistics, disaster and emergency management, urban food networks for the urban poor, food infrastructure and greening local economies (Dowding-Smith, 2013). For example, in the 2013 Bonn Declaration of Mayors, city leaders committed to 'holistic ecosystems-based approaches for city-region food systems that ensure food security, contribute to urban poverty eradication, protect and enhance local level biodiversity and that are integrated in development plans that strengthen urban resilience and adaptation' (Mendle, 2015).

Thus, urban food security requires a cross-policy response, touching on several EU policy areas. These include agriculture, fisheries and food, business, sustainable development, climate action, employment and social rights, energy and natural resources, environment, consumers and health, regions and local development, and science and technology.

Cities are already starting to work on food issues in a comprehensive, interlinked way. There is growing recognition of the crucial role of (and opportunities for) urban authorities in the design and implementation of urban food policies. Key areas of focus include reconnecting food producers and consumers and involving different local stakeholders at different scales to co-create innovative solutions (Magarini et al., 2018). Strong urban-rural cooperation is important to ensure continued access to food and land for farming. Land use policies must be in place to manage an expansion of both urban farming and peri-urban agriculture. The types of policy tools available to cities to achieve this include citizen involvement and social innovation, innovative public procurement and collaboration with research.

The COVID-19 pandemic has shown how important it is for cities to take action to enhance food security by highlighting the vulnerabilities of food production, supply and distribution chains. The pandemic has also highlighted the disproportionate impact it has on food availability, accessibility, and affordability for socially and economically disadvantaged groups. The economic recession resulting from the pandemic is also likely to disproportionately affect these households, further reducing their ability to purchase healthy, nutritious and locally grown food. As part of their green recovery planning, cities can help address food security by expanding urban agriculture, introducing 'zero-waste' food systems and implementing measures that ensure accessible and affordable food for all.

6.4 Existing networks and sources of information

Examples of existing networks and sources information relevant to this nexus include:

- **#reducefoodwaste** ([62]). A competence network for food waste prevention and management.
- **Big Picnic** ([63]). Aims to generate debate around food-related topics such as food security, nutrition and adaptation to climate change. It comprises 19 partner organisations across 12 European countries and Uganda and brings together the public, scientists, policymakers and industry.
- **COST — Action: Urban Agriculture Europe** ([64]). Seeks to integrate the European context of its urban and landscape pattern, the important role of the common agricultural policy and the needs of European society. It aims to develop a definition of a European approach to urban agriculture.
- **EAT initiative:** ([65]). A science-based global platform for food system transformation. EAT is a non-profit organisation

([62]) http://www.reducefoodwaste.eu/network.html
([63]) https://www.bigpicnic.net
([64]) http://urban-agriculture-europe.org
([65]) https://eatforum.org

founded by the Stordalen Foundation, Stockholm Resilience Centre and the Welcome Trust to catalyse food system transformation.

- **FACCE-JPI** ([66]). The Joint Programming Initiative on Agriculture, Food Security and Climate Change brings together 24 countries committed to building an integrated European research area to address the interconnected challenges of sustainable agriculture, food security and impacts of climate change.

- **Food and Agriculture Organization of the United Nations (FAO)** ([67]).

- **Food Security Information Network** ([68]). A global initiative sponsored by FAO, the International Food Policy Research Institute (IFPRI) and the United Nation World Food Programme (WFP) to inform food security policies, programmes and projects. The network is a technical platform for exchanging expertise, knowledge and best practices on food security and nutrition analysis.

- **EU Fusions** ([69]). 'Food use for social innovation by optimising waste prevention strategies' was a project that worked towards achieving a more resource-efficient Europe by significantly reducing food waste. The project ran for 4 years, from August 2012 to July 2016. It was funded by the European Commission's Framework Programme 7. It comprised 21 project partners from 13 countries, bringing together universities, knowledge institutes, consumer organisations and businesses.

- **Scalibur project** ([70]). Leading waste management companies, technology developers and research organisations have teamed up with four European cities to demonstrate innovative solutions to transform urban food waste and sewage sludge into high-value-added products. These solutions also help cities to increase their recycling rates and create new circular economy business opportunities.

- **Slow Food** ([71]). A global, grassroots organisation, founded in 1989 to prevent the disappearance of local food cultures and traditions and to counteract the increase in the pace of life. Since its foundation, Slow Food has grown into a global movement involving millions of people in over 160 countries working to ensure that everyone has access to good, clean and fair food.

- **EU Platform on Food Losses and Food Waste** ([72]). Established in 2016, bringing together EU institutions, experts from EU countries and relevant stakeholders selected through an open call for applications. The platform aims to support all stakeholders in achieving the Sustainable Development Goal 12.3 target on food waste by defining measures needed to prevent food waste, sharing best practice and evaluating progress over time.

- **WRAP** ([73]). Waste & resources action programme is a UK-based non-profit organisation working with other organisations in the food and drink industry to create economic and environmental value by reducing food waste and tackling issues around water scarcity across the supply chain.

Further reading

- De Cunto, A., et al., 2017, *Food in cities: Study on innovation for a sustainable and healthy production, delivery, and consumption of food in cities*, European Commission (http://www.fao.org/urban-food-actions/resources/resources-detail/en/c/1070546/), accessed 3 August 2021

- Guilbert S., et al., 2016, *Enabling food waste reduction in potential urban environments* (https://hal.inrae.fr/hal-02801419/file/2016_etude-gaspillage-alimentaire-en-ville_1.pdf)) accessed 17 June 2021.

- iPES Food, 2017, *What makes urban food policy happen? Insights from five case studies* (http://www.ipes-food.org/_img/upload/files/Cities_full.pdf) accessed 17 June 2021.

- Silvennoinen, K., et al., 2019, 'Food waste case study and monitoring developing in Finnish food services', *Waste Management* 97, pp. 97-104 (https://doi.org/10.1016/j.wasman.2019.07.028).

([66]) https://www.faccejpi.net/en/faccejpi.htm
([67]) http://www.fao.org/home/en
([68]) https://www.fsinplatform.org
([69]) https://www.eu-fusions.org/index.php
([70]) http://www.scalibur.eu
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([73]) http://www.wrap.org.uk

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7 Closing the loop nexus

7.1 What is closing the loop and why is it important in an urban context?

Current, predominantly linear (take-make-dispose) consumption and production patterns are unsustainable. Recognising this, in 2015 the European Commission adopted 'Closing the loop — An EU action plan for the circular economy' (EC, 2015b). In 2020, on the back of the European Green Deal, the Commission followed up by adopting 'A new circular economy action plan for a cleaner and more competitive Europe' (EC, 2020d). The new urban agenda (UN, 2016) also commits to sustainable resource management and the transition to a circular economy. Partnership on a circular economy is also one of 12 thematic partnerships under the urban agenda for the EU (EC, 2016b).

Closing the loop refers to a circular model of resource management. It means keeping products, materials, built assets and land in use while maintaining their value. It also means minimising waste generation.

It is estimated that 80 % of Europeans will live in cities by 2050, compared with 74 % today (EEA, 2019a). As a result, much of Europe's production meets demand originating in cities as major consumers of resources and products. Cities have been called the 'engines of the [EU] economy' (Nabielek et al., 2016). They represent distinct systems that can be transformed (EEA, 2019a). Taking the example of land, at present, land recycling represents only 13 % of urban land development. Increasing this amount would help achieve the EU target of no net land take by 2050 (EEA, 2019a).

Urban areas also depend on land and production outside their boundaries to meet resource needs and dispose of their waste. This includes resources such as energy, water and food and the disposal of wastes, emissions and pollution (e.g. to air, water) (EEA, 2017b). At the same time, many environmental and social problems associated with the linear economy are focused in urban areas (e.g. unequal impacts of air pollution, climate change impacts, local unemployment). Through improved resource efficiency, closing the loop can 'decrease our reliance on imports and … reduce environmental pressures' (EEA, 2019a), including in cities.

Cities can benefit from the circular economy and, given their environmental and economic importance, act as 'centres for change' (Ellen MacArthur Foundation and ARUP, 2019).

Closing the loop is a relatively high-level nexus topic. If a more circular economy could be realised in cities, this would imply progress in other nexuses, in particular:

- **Sustainable buildings** — through improved management of construction waste and resource and material use in construction (e.g. reuse), as well as by applying circularity principles in relation to the use of buildings and land (EEA, 2019g, 2020g).

- **Clean energy** — through the development of more circular energy systems, in which energy use is reduced, waste energy is reused, and clean energy is generated on a small scale to meet local energy demands.

Closing the loop in cities can also contribute to other nexus outcomes, including 'environment and health', through improved resource management practices that reduce local pollution; 'quality of life', through improved environmental quality and the provision of urban resource centres that can act as community hubs; and 'food security', through local food initiatives to reduce food waste, which improve access to food.

7.1.1 The closing the loop nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response

The pandemic has highlighted the importance of supply chain resilience. At the height of the COVID-19-induced lockdowns many businesses across European cities were affected because of their reliance on long and complex supply chains and just-in-time delivery. This has led to increased interest in local goods and services, which may support more circular production and consumption (e.g. making reusing packaging easier and encouraging industrial ecology). There is a risk of social impacts, however, as low-income households may be less able to afford locally sourced and produced goods because they tend to be more expensive than those provided by global supply chains.

The effect of the COVID-19 pandemic on various waste management systems across European cities is still unclear. At the height of the lockdowns local authorities and municipal waste operators had to rapidly adapt their waste management systems. Recycling systems have also been under increased

pressure to continue providing services because of closure of recycling centres; an increase in home clearances; and an increase in plastic waste from personal protective equipment, take-away meals and home-delivered groceries. As noted in the environment and health nexus (see Section 5.1.1), this puts extra pressure on regular waste management practices and may lead to inappropriate and illegal waste disposal activities (Adyel, 2020).

Longer-term implications as cities draw up and implement COVID-19 recovery plans

The COVID-19 pandemic has provided cities with an opportunity to put the circular economy at the centre of a green recovery. By designing out waste and keeping products and materials in use, it could create opportunities for economic growth that also restore the environment, create jobs and benefit society. To be inclusive, recovery planning needs to understand and address existing social inequalities within local communities and ensure that the needs of the most vulnerable are met.

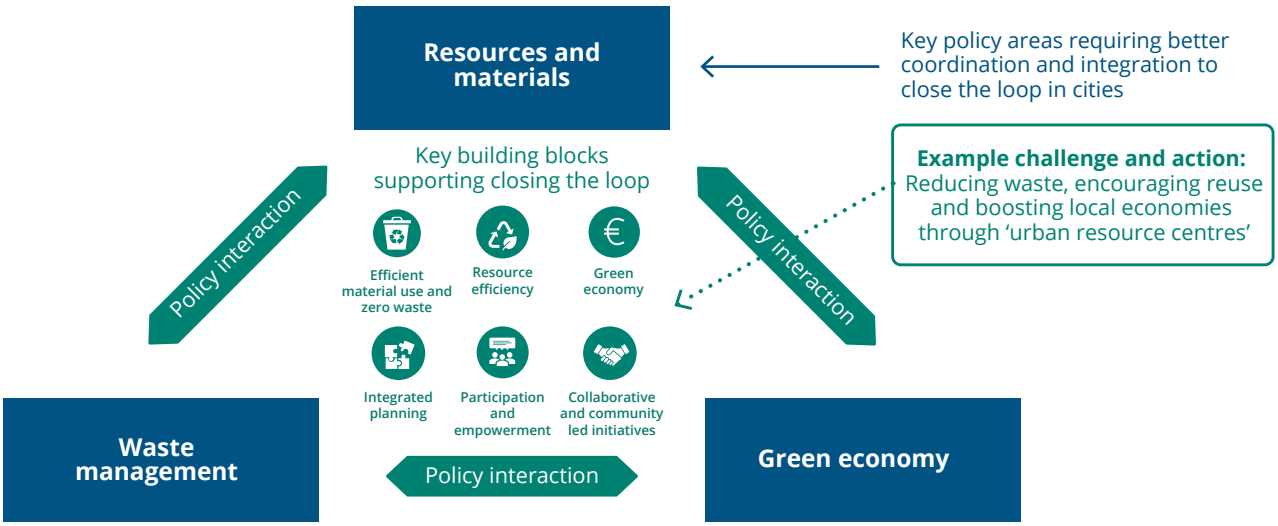
Following the pandemic, short supply chains may be considered more favourably than before, as the reliance on international supply chains may be seen as riskier than sourcing products and components locally. With support from city authorities this could help accelerate the move to more circular local economies. The pandemic has also significantly affected consumer behaviour, as hoarding and panic buying became more prevalent at the height of the lockdowns. The long-term effects on other aspects of consumer behaviour that affect the circular economy remain unclear. For example, there may be continued resistance to the concept of using products as a service and sharing of certain goods (because of real or perceived risks), which could undermine some efforts to encourage circularity.

7.2 Interlinked policy areas contributing to closing the loop in cities

Closing the loop implies moving to a more circular economy, which relates to a large range of policy areas. This nexus focuses on the need for coordinated policy in cities related to resources and materials, waste management and the green economy (see Figure 7.1).

Many challenges to closing the loop result from a lack of coordination between the three policy areas included in this nexus. For example, there is a risk that a waste policy that focuses on landfill and incineration misses out on opportunities to grow the green economy by using waste as a resource.

Figure 7.1 The closing the loop nexus: key policy areas and building blocks



Integrating these policy areas could also have co-benefits, such as through reducing pollution and creating local employment.

The following sections explore some of the key challenges of closing the loop in cities and associated policy and practical actions. The focus is in particular on better coordination of the nexus policy areas. Table 7.1 then provides an overview of the challenges and actions to address them. The assessment also discusses in more detail an example illustrating how coordinated action can contribute to closing the loop: reducing waste, encouraging reuse and boosting local economies through 'urban resource centres' (Section 7.2.1).

The assessment example was selected by viewing the nexus through the circular city lens. The nexus could be viewed from other perspectives, which would help to identify other potential areas of action. For example, viewing the closing the loop nexus from the inclusive city perspective might identify action related to community involvement in local schemes to reduce consumption, encourage reuse or reduce waste. This could involve establishing local 'libraries of things' to support sharing of some household items, or community initiatives to reduce food-waste.

Challenges of and actions for closing the loop in cities

Cities do not exist in isolation. Challenges to closing the loop in cities relate to wider governance of the transition to a circular economy and to city-level challenges. This nexus analysis focuses on challenges and actions at the city scale. A further challenge will be the scale of influence a city can have on the circularity of systems outside its direct control (e.g. the food system). Nonetheless, cities have a role, and circular city and city region initiatives are increasingly common in Europe (Gravagnuolo et al., 2019).

A fundamental challenge is that many cities or city regions lack comprehensive strategies or roadmaps for circularity. The urban agenda circular economy action plan (EC, 2018c) notes that most cities currently view the circular economy as being about waste management and that there is a need for detailed visions and strategies to move cities from urban waste management to resource management. This could include focusing on reuse, sharing and associated business models and on supporting businesses to help identify the value of waste and by-products as secondary resources. Establishing circular city strategic policy documents or roadmaps would address this challenge. Such roadmaps should be based on an understanding of local and regional contexts. The circular economy may look different in every city depending on local needs and resources. Therefore, 'copy-pasting' solutions from elsewhere will not necessarily be effective.

A shift to more sustainable consumption behaviours is needed if efforts to achieve circularity are to be effective (Gravagnuolo et al., 2019). There is a need for participation of citizens and communities and for social innovation ([74]). Yet the social and behavioural side of closing the loop is 'not adequately addressed at the local level' (EC, 2018c). Cities can address this challenge by engaging citizens, businesses and other stakeholders in setting strategy. They may also encourage cross-sectoral engagement and partnerships to catalyse cross-sectoral action. Alongside more collaborative working, cities can raise awareness and build capacity among citizens and businesses. This can help them understand and take advantage of the economic opportunities that a circular economy can provide (e.g. new jobs, resource efficiency, which can reduce costs, and supply security).

Alongside improved strategic action, there is a need to combine governance approaches with new technical knowledge and capacity. A range of actions could address this challenge, including setting up and working with networks to share scientific and applied knowledge in the field of the circular economy and to strengthen a strategic coordinated approach. Cities can also explore solutions to the complex problems associated with the transition to a circular economy through practical experimentation (testing approaches) and innovation. Bačová et al. (2016) recommend that cities will benefit from starting with small, experimental projects that can then be scaled up and translated into policy.

The way that waste and materials are managed in cities remains a challenge, as:

- There is limited focus in cities on waste prevention as the highest priority, as it is 'rarely an integral part of local waste management' (EC, 2018c). This means that holistic approaches to resource management are often missing, with a focus instead on 'waste management' from the perspective of dealing with materials once they have been discarded. The focus should be on preventing waste by changing consumption habits (e.g. using products as services, sharing products), encouraging repair and reuse and finding uses and value for waste as a resource (to the extent that cities can influence this).

([74]) Urbact's *Social innovation in cities* report defines social innovation as 'innovative solutions, new forms of organisation and new interactions to tackle social issues' (Urbact, 2015).

- Recycling rates often remain low because of insufficient administrative capacity; a lack of investment in separate collection and recycling infrastructure; and limited use of economic instruments (e.g. pay-as-you-throw). Excess capacity in the infrastructure for treating residual waste (e.g. through incineration) can also act as a barrier (EC, 2018c), which represents a technological and economic lock-in, in essence discouraging investment in waste prevention measures.

- There has been limited progress in closing the waste-material loop: connecting consumer behaviours with waste management practices while encouraging business to invest in and implement industrial ecology practices and make use of secondary raw materials (whose quality also needs to be assured). On average only 10 % of the EU demand for raw materials is met by recycled materials (EC, 2018d), although for some materials (e.g. copper, nickel) this figure is over 30 %. A lack of designated facilities to support waste prevention, reuse and repair, coupled with low levels of information and knowledge among consumers about repair and reuse services, also hamper more circular consumption behaviours (EC, 2018c).

One specific action to overcome these challenges is for cities to work with communities, civil society or the private sector to set up consumer repair and reuse hubs (see Section 7.2.1). Cities can also put in place local waste prevention plans, including long-term and short-term targets and provisions for regular monitoring (Dri et al., 2018). To give a specific example, the extended lifetime and delayed obsolescence of electronics is important for circularity. While the setting of design and labelling standards will need to be done at an EU or national level, local (including city) authorities can support such standards through public procurement strategy (EEA, 2020h).

Major disruptions in supply chains due to the COVID-19 pandemic have highlighted the importance of keeping resources within the value chain, minimising waste and maximising reuse and repair. This will require improved collaboration among all stakeholders in the value chain (ETC/WMGE, 2019). For a city this may mean organisational restructuring, infrastructure investment and training or upskilling of people working in waste management. The urban agenda circular economy action plan (EC, 2018c) states that city authorities will need to gain more insight into resource use characteristics and resource flows by mapping resource flows (e.g. quantities, flow rates, owners, quality); access or develop tools and capacities to broker supply and demand of secondary resources and help markets for secondary resources to develop; and monitor progress towards resource efficiency in the city through the use of appropriate indicators. City authorities may also have a role in encouraging industrial symbiosis and ecology. Business can be supported to integrate industrial wastes or by-products (e.g. heat, energy, water) into production processes. A specific example is described in Box 7.1.

Box 7.1 Example of public-private collaboration to support industrial symbiosis: Kalundborg symbiosis in Denmark

The Kalundborg symbiosis, established more than 40 years ago, is an industrial symbiosis, in which a by-product or residual product of one enterprise is used as a resource by another. Through local collaboration, public and private enterprises (both small and large) buy and sell residual products from one another. The success of this initiative has also led to the foundation of an industrial symbiosis centre, which seeks to identify and support similar initiatives in Denmark.

The reported benefits of the industrial symbiosis in Kalundborg include:

- cost reductions and reduced emissions;
- growth with less resources consumed;
- more competitive enterprises;
- more resilient societies and enterprises.

Source: State of Green (2017).

City authorities can also exercise their spending power through public procurement. A city authority's position as a large consumer can influence local markets and influence the use and flow of materials within the city. Cities can encourage circularity through the uptake of EU green public procurement criteria by (EC, 2016d):

- setting standards and criteria for use in the procurement of public goods and services;
- guiding investment into physical development and asset management;
- holding funding competitions to encourage new ideas, cooperation and innovation;
- focusing on areas where there is the most potential to influence the market.

For example the municipality of Almere (Netherlands) held a competition aimed at 'stimulating start-ups, companies and research institutes to develop business cases that not only introduce innovative solutions for upcycling of waste flows but also encourage collaboration to create a solid financial plan that makes actual economic activity possible'.

Table 7.1 Overview of challenges of and actions for closing the loop in cities

Example challenges	Example actions to address challenges
• Lack of comprehensive strategies and roadmaps for circularity at the city or city-region scale.	• Establishing circular city strategic policy documents or roadmaps. Such roadmaps should be based on an understanding of local and regional context to reflect local needs and resources. • Engaging citizens, businesses and other stakeholders in setting strategy.
• Inadequate understanding/addressing of the social and behavioural changes required to shift to more sustainable consumption behaviours. • Insufficient investment by businesses in industrial ecology practices for the use of secondary raw materials.	• Convening cross-sectoral engagement and encouraging partnerships in order to catalyse cross-sectoral action. • Raising awareness and building capacity among citizens and businesses. • Encouraging industrial symbiosis and ecology and supporting businesses in integrating industrial wastes or by-products into production processes, including brokering supply and demand of secondary resources and helping markets for secondary resources to develop.
• Understanding and making use of new technical knowledge and capacity.	• Establishing networks to share scientific and applied knowledge in the field of the circular economy. • Exploring solutions through practical experimentation (testing approaches) and innovation at a small scale before scaling up.
• Lack of holistic approaches to moving from 'waste management' to 'resource management'. Need to focus on waste prevention.	• Focusing efforts on preventing waste by reducing consumption, encouraging repair and reuse and finding uses for and value of waste as a resource (to the extent that cities can influence this). • Understanding resource use characteristics and resource flows by mapping resource flows (e.g. quantities, flow rates, owners, quality) and monitoring progress towards resource efficiency in the city, with the use of appropriate indicators.
• Recycling rates remain low because of insufficient administrative capacity; a lack of investment in recycling infrastructure; and limited use of economic instruments (e.g. pay-as-you-throw). • Excess capacity in infrastructure to treat residual waste represents a technological and economic lock-in. • Lack of designated facilities to support waste prevention, reuse and repair.	• Using city-level procurement to influence local markets for circularity, e.g. setting standards and criteria and holding funding competitions to encourage new ideas, cooperation and innovation. • Redesigning city-level waste management investment, processes and structures to keep resources in the value chain, minimising waste and maximising reuse and repair. • Working with communities, civil society or the private sector to set up consumer repair and reuse hubs (see Section 7.2.1).

7.2.1 *Example assessment of interlinked actions: reducing waste, encouraging reuse and boosting local economies through 'urban resource centres'*

How do urban resource centres fit within the closing the loop nexus?

Establishing urban resource centres will:

- provide facilities and enhance capacity for the reuse and repair of materials and goods that otherwise would end up as waste — related to the coordination of resources and materials and waste management policy areas;
- generate local economic benefits, for example by creating employment and serving as 'incubators' for social enterprises — related to coordinating waste management and resources and materials policy areas with policies to promote a green urban economy.

Coordination of these policy areas in the form of establishing urban resource centres can also result in co-benefits for communities and authorities by providing hubs for activities, awareness raising and training.

This policy and action area focuses on citizens as consumers and on their role in waste prevention. Closing the loop in cities will require citizens, as consumers of products and services, to make different choices that support a more circular economy. However, the ways in which citizens can be involved in this transition process is 'not adequately addressed' in cities (EC, 2018c). Furthermore, the European waste hierarchy (Figure 7.2), has prevention as the highest priority. However, prevention is rarely integrated into local waste strategies. There is also a lack of knowledge among consumers and of access to facilities that support them in waste prevention, reuse and repair (EC, 2018c).

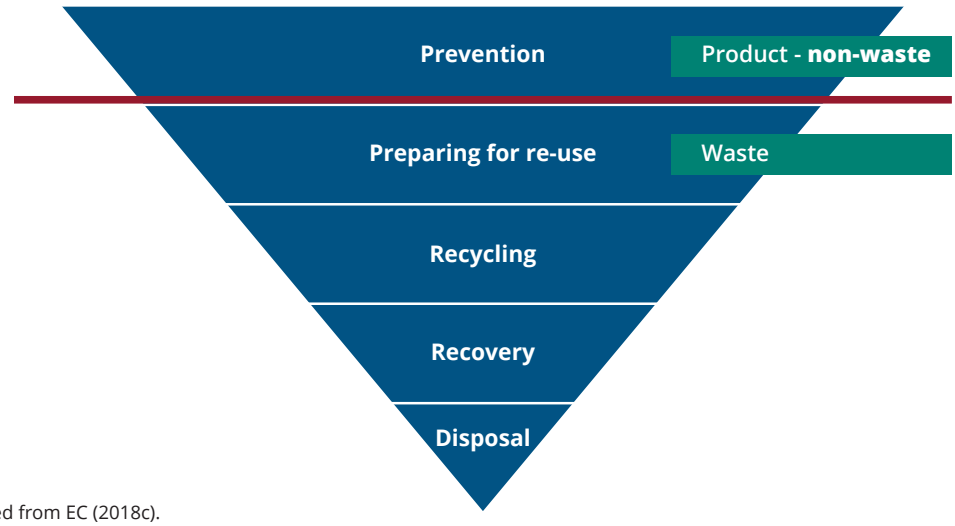
Possible policy responses and interventions

To enhance citizens' involvement in the circular economy, one solution is to create designated multifunctional places where waste prevention, repair and reuse can be promoted and practised (EC, 2018c). The urban agenda circular economy action plan (EC, 2018c) refers to these places as urban resource centres (Figure 7.3). They are physical spaces within a city that are easily accessed by the public. Such centres provide practical space in which products and materials can be repaired and/or reused or repurposed. They can also perform a range of roles to promote the circular economy, including:

- providing facilities and space for private and community activities, such as repair cafes and sharing food;
- creating a place where citizens, businesses and other stakeholders can find information about waste prevention initiatives, as well as a place for showcasing good practices;
- acting as centres for small-scale, local entrepreneurship, which in turn can create jobs and support the local economy and communities; involving non-governmental organisations (NGOs) and social entrepreneurs can help ensure that marginalised groups are also included;
- acting as incubators to provide space for new circular business models to emerge and support the local circular economy (EC, 2018c).

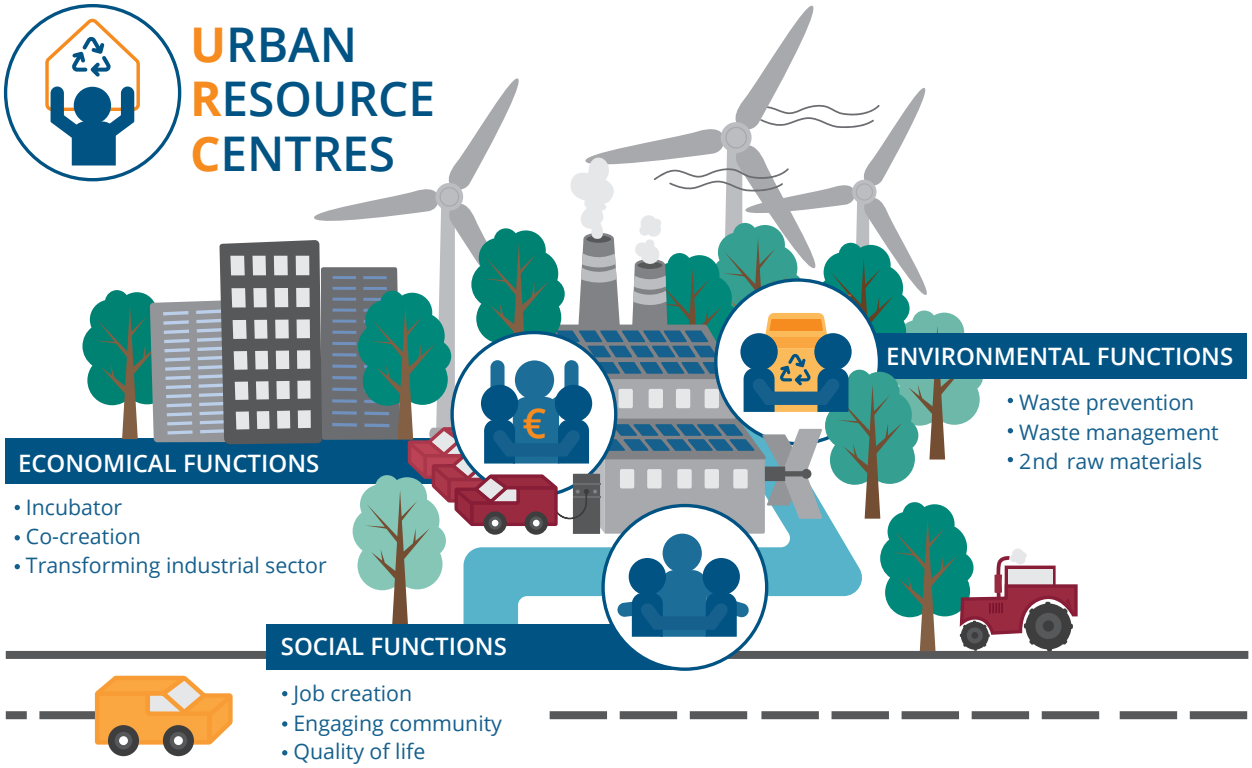
A recent report by the Circular Economy Partnership of the urban agenda for the EU (EC, 2019g) identifies numerous examples of urban resource centres in one form or another 'popping up' all over European cities, representing the innovative driver of cities striving for sustainable change at the local level. The report presents 12 case studies of good practice.

Figure 7.2 **The European waste hierarchy**



Source: Adapted from EC (2018c).

Figure 7.3 **Visualisation of urban resource centres' functions and benefits**



Source: EC (2019g).

Box 7.2 Example policy response: RLab in Porto, Portugal

TRLab is a centre for the repair and recovery of WEEE (waste electrical and electronic equipment), located in Porto and established in 2013. RLab is an initiative of the local municipal waste management authority (Lipor) with funding through public-private partnership. RLab provides space and facilities for the repair, reuse and, if necessary, recovery of WEEE, as well as providing professional training in repair for students through partnerships with local education institutions. RLab also promotes reuse and recovery and raises awareness of WEEE. Social (and local economic) co-benefits are achieved by donating repaired devices to local solidarity organisations.

The RLab project has three objectives:

- reducing WEEE generation and increasing reuse and repair;
- promoting education, through partnerships with schools;
- raising awareness among citizens of waste prevention and consumption.

Source: Good practice example included in EC (2019g).

Box 7.3 Example policy response: mini-recycling stations in Oslo, Norway

There are ten 'mini-recycling stations' in Oslo, managed by the Agency for Waste Management and focusing on waste reduction, reuse, repair and recycling. They aim to improve the quality of residual household waste by encouraging people to dispose of larger waste articles at these mini-stations. The stations are located centrally (in densely populated areas and accessible in by walking and cycling). At the stations Oslo's city authority encourages people to participate in repair workshops and sale and exchangedays, and promotes waste prevention activities and values through direct interaction with local people (e.g. through workshops, meetings and seminars). The stations include space for people to leave items and also to take reusable items for free.

In some areas of the city the mini-stations are combined with other council services and local activities, and they have become 'social arenas' for local communities.

The mini-recycling stations have contributed to increasing the overall level of reuse in the city. In 2016, more than 195 tonnes of reusable goods were exchanged at the stations, in addition to the 310 tonnes of waste collected for material recovery. By 2018 this had risen to 1 499 tonnes of reusable goods being exchanged at the centres.

Source: Good practice example included in EC (2019g).

Box 7.4 Example policy response: Alelyckan reuse park in Gothenburg, Sweden

Alelyckan reuse park, established in 2007, is a place where inhabitants can bring products to be recycled, donate reusable material or buy goods donated by others, which are often repaired or upcycled. The park is owned by the municipality, but it also houses specialised thrift shops that pay rent for the use of municipal facilities. All visitors are encouraged to donate or sell items for reuse, and the rest is sorted into waste fractions for material recycling or energy recovery. The initiative resulted in the reuse of 5.5 % of materials that otherwise would have been discarded.

Source: Good practice example from Bačová et al. (2016).

7.3 Lessons for closing the loop in cities

On the one hand a circular economy is a highly strategic aim, and a key lesson for cities is that achieving circularity will require the development of far-reaching and ambitious strategic plans and roadmaps that support coordinated policies and action across sectors. Many examples of such roadmaps exist, and a recent study for the European Economic and Social Committee (EESC, 2019) identified 33 existing circular economy strategies across 14 EU Member States, of which 17 were regional or local (including cities).

On the other hand implementing the circular economy requires an understanding of the local context (such as existing industries and materials flows) and quite specific, locally relevant actions. In many ways cities are uniquely suited to such actions and changes and therefore are well placed to be leaders in the transition to a circular economy.

Closing the loop in cities can boost local economies, create employment and reduce the environmental and social pressures associated with the linear economy. The closing the loop nexus highlights the importance of cooperation between a wide range of sectors and types of stakeholder (e.g. public, private, community). Cities will need to develop partnerships and seek new ways of working involving collaboration across public-private-social sectors. City authorities may need to act as facilitators and brokers, bringing businesses and stakeholders together. As cities sit within a wider economic and regulatory structure, the authorities may also need to work with EU, national and international partners to explore and implement changes needed to close the loop (e.g. in relation to value chains and fiscal measures).

The engagement of citizens is also key, as consumers of goods and services are participants in the circular economy (e.g. reusing or recycling). The social and behavioural side of closing the loop is considered to be 'not adequately addressed at the local level' (EC, 2018c). Addressing citizen involvement could include more collaborative working and the establishment of consumer repair and reuse hubs. Such hubs could also act as centres for capacity building for the circular economy, for example skills for repair.

The COVID-19 pandemic has highlighted the need for industries to rethink and transform their supply chain models. Cities should take advantage of this opportunity to accelerate the transition to a circular economy. This transition could offer investment opportunities that contribute to ensuring a more competitive and greenpost-pandemic recovery.

7.4 Existing networks and sources of information

Examples of initiatives, existing networks and information sources relevant to the closing the loop nexus include:

- **EU urban agenda Circular Economy Partnership** ([75]). Provides a library of resources and news, including the partnership's action plan and associated studies prepared by it.
- **EuroCities** ([76]). Provides a range of resources, including events, case studies and publications. EuroCities has also established a task force on the circular economy.
- **ICLEI** ([77]). The International Council for Local Government Initiatives (also known as Local Governments for Sustainability) provides online resources and information on projects related to waste and the circular economy.
- **OECD Re-Circle** ([78]). This Organisation for Economic Cooperation and Development project provides policy guidance on resource efficiency and the transition to a circular economy.
- **Association of Cities and Regions for Sustainable Resource management (ARC+)** ([79]). Provides a range of information on projects and good practice related to waste and the circular economy in Europe.
- **Ellen MacArthur Foundation** ([80]). Provides a range of resources, case studies and guidance documents on the circular economy in cities.
- **European Circular Economy Stakeholder Platform** ([81]). This European Commission platform includes space for cities.
- **Urbact** ([82]). Includes circular economies as an urban topic, and provides links to related networks, good practices, events and activities on this topic.
- **Zero Waste Europe (**[83]). Works with and represents European cities that have committed to reduce waste generation and improve separate waste collection.

Further reading

- EIT Raw Materials, 2020, *Policy instruments and incentives for circular economy — Final report* (https://eitrawmaterials.eu/project/police) accessed 17 June 2021. The project aimed to identify and describe the various policy instruments and incentives that influence, promote and boost the circular economy.
- ETC/WMGE, 2019, *Country factsheets on resource efficiency and circular economy in Europe*, ETC/WMGE Report 4/2019 (https://www.eionet.europa.eu/etcs/etc-wmge/products/country-factsheets-on-resource-efficiency-and-circular-economy-in-europe) accessed 17 June 2021. A set of 32 country factsheets that summarise policies and initiatives on the area of resource efficiency and circular economy.

([75]) https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/priority-themes-eu-cities/circular-economy-cities_en
([76]) http://www.eurocities.eu/eurocities/issues/circular-economy-issue&tpl=home
([77]) http://iclei-europe.org/topics/waste-circular-economy
([78]) https://www.oecd.org/regional/cities/circular-economy-cities.htm
([79]) http://acrplus.org/en
([80]) https://www.ellenmacarthurfoundation.org/our-work/activities/circular-economy-in-cities
([81]) https://circulareconomy.europa.eu/platform/en/scope/cities
([82]) https://urbact.eu/circular-economies
([83]) https://zerowasteeurope.eu

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8
Clean energy nexus

8.1 What is clean energy and why is it important in an urban context?

Fossil fuels still dominate primary energy production in the EU and are a key driver of climate change. In 2019 the European Parliament declared a climate emergency in Europe, part of the response to which would include a rapid transition to clean energy. In this declaration the Parliament urged the European Commission to address inconsistencies in current policies including those of energy and infrastructure investment. The EU also has an ambition to become carbon neutral by 2050. The European Commission has identified this as 'one of the greatest challenges of our time' (EC, 2019c). In 2016, the European Commission revised the EU's energy policy framework to focus on the transition to clean and fair energy. As part of this transition, the clean energy package for all Europeans includes various elements related to the EU's targets to reduce greenhouse gas (GHG) emissions (EC, 2019c). The Commission refers to this as a 'new energy rulebook', which is fundamental to the implementation of the energy union strategy adopted in 2015 (EC, 2015c). Supplying clean, affordable and secure energy is also one of the cornerstones of the European Green Deal (EC, 2019b).

Clean energy generally refers to energy from renewable natural resources such as wind, water ('hydro'), sunlight, geothermal heat and tides. Clean energy sources make less impact on the environment throughout their life cycles than their conventional counterparts (coal, petroleum, natural gas and nuclear energy). In particular, clean energy leads to lower emissions of GHGs and other pollutants (Bouman, 2020).

Urban areas are essential to transition to clean energy production and a carbon-neutral economy. They account for 60-80 % of global energy consumption and similar share of carbon dioxide (CO_2) emissions (IRENA, 2016; Sharifi et al., 2016; EC, 2021b). The projected increase in EU's urban population is likely to lead to rising energy consumption. A significant factor in this is growing electricity demand due to the electrification of transport, as well as the heating and cooling of buildings (EC, 2019h).

Meeting climate goals requires maximising the deployment of clean energy sources. In the light of the Paris Agreement on climate change and the 2030 climate target plan proposed by the European Commission, the EU has pledged to move further ahead and achieve GHG emission reductions of at least 55 % by 2030. In 2018, renewable energy accounted for 18.9 % of energy consumed in the EU-27 and the UK. This represented an increase of over six percentage points in just a decade (Eurostat, 2020). According to the International Renewable Energy Agency it would be cost-effective ([84]) for the EU to achieve a 34 % share of renewables in its energy mix by 2030. National- and city-level commitments and implementation are essential to meet this potential (IRENA, 2018).

If more clean energy is produced in cities, this is likely to support progress in other nexuses, in particular:

- **Climate resilience** — through a reduction in energy-related GHG emissions achieved by using clean energy sources in which no fuels are combusted.
- **Environment and health —** through reduced air and water pollution achieved by using clean energy sources**.**

Clean energy production in cities can also contribute to other nexus outcomes, including 'closing the loop', as clean energy is used to power the circular economy and is generated at a small scale to meet local energy demands; and 'sustainable buildings', through including clean energy sources in building design or retrofitting measures.

8.1.1 The clean energy nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response

The EU energy sector witnessed a fall in energy demand and supply amid the sharp reduction in air and road transport and industrial activity. During the first quarter of 2020 the share of

([84]) See the definition of cost-effectiveness in Section 1.1.3.

renewables in EU energy production reached an all-time high, with reduced generation from coal, gas and nuclear installations (IEA, 2020a). Although these trends indicated that the EU is likely to meet its 2020 renewable energy target, the COVID-19 pandemic slowed the progress of renewable energy projects in the first 6 months of 2020 (IEA, 2020b, 2020c). This trend has also been seen in cities, where many urban homeowners have been cancelling or postponing solar installations and renovation projects. Delays in construction (e.g. due to supply chain disruption), lockdown measures and social distancing guidelines, as well as financing challenges, have largely been responsible for the limited number of completed clean energy projects.

Although the implementation of renewable energy installations across European cities slowed in the first half of 2020, 'remote selling', using digital tools (e.g. Zoom, Microsoft Teams), became a common practice during the lockdown. This has enabled leaders in the renewables market to educate potential clients (e.g. homeowners) on the benefits of renewable energy. It has also allowed them to agree on a deal now and install the solar panels later (McElroy, 2020).

The pandemic has also had an impact on local authorities. The economic challenges facing cities has negatively affected the funds available for investing in clean energy. In particular, this has affected decision-making, granting permits and adopting spatial planning arrangements that allow for the construction of renewable energy projects (McElroy, 2020). The full impact of the COVID-19 crisis on renewables is yet to become clear. However, there have been encouraging developments, as the industry has been adapting quickly. Since June 2020 renewables have seen growth in the monthly additions to capacity, pointing to a faster than expected recovery in Europe. Globally, renewables accounted for almost 90 % of the increase in total power capacity in 2020 and are set to become the largest source of electricity generation in 2025 (IEA, 2020c).

Longer-term implications as cities draw up and implement COVID-19 recovery plans

In their green recovery plans cities acknowledge the need for investments in clean energy to reinvigorate local economies. For example, the mayors of the C40 Cities network have launched a green and just COVID-19 recovery plan. One of the key actions proposed in this plan is to invest in urban renewable energy programmes (C40 Cities, 2020a). The Next Generation EU recovery package is also prioritising investment in cleaner technologies, including those for energy. The green recovery investment in clean energy sources can also provide good value for money. For example, financing solar photovoltaic (PV) and wind energy installations ensure relatively quick delivery and provide immediate environmental gains. In addition, both of these sources are among the cheapest options for new generation of clean energy and have relatively short investment cycles.

The impact on local energy initiatives will depend on cities' approach to recovery. City governments choosing to focus on community-based recovery, self-sufficiency and the social economy could lead to increased interest in community energy schemes.

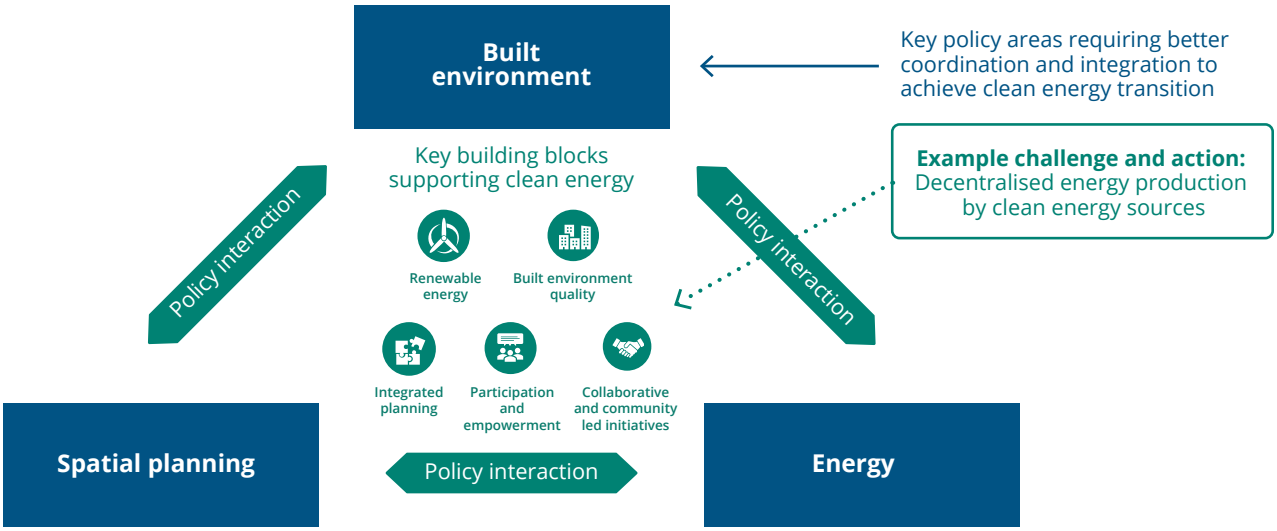
8.2 Interlinked policy areas contributing to the clean energy transition in cities

Supporting a clean energy transition in cities will require action across a range of policy areas. This nexus focuses on the need for coordinated policy and action in cities related to spatial planning, the built environment and energy (see Figure 8.1).

A lack of coordination between these three policy areas will undermine efforts to increase clean energy production in cities. For example, city governments will need to ensure that spatial planning and built environment policies consider the land use and infrastructure needs of new clean energy production and transmission.

Integrating these policy areas can also have co-benefits. For example, clean energy reduces carbon emissions and helps mitigate climate change. It can also reduce air and water pollution, resulting in benefits for the environment and human health (EEA, 2017c). The geographical spread and modular design of some renewable energy sources (e.g. wind, solar) can also enhance energy resilience: for example, resilience to severe weather events as a result of being less dependent on one large energy production source; to cyberattacks on the operating systems that control large power stations as a result of using small-scale operating systems; and to power outages as a result of being less vulnerable to large-scale failure. The continuity of clean energy supply can help ensure that essential services in cities are not disrupted (IRENA, 2019).

Figure 8.1 The clean energy nexus: key policy areas and building blocks



The following sections explore some of the key challenges of achieving clean energy transitions in cities and associated policy and practical actions. The focus is in particular on improved coordination between the nexus policy areas. Table 8.1 then provides an overview of the challenges and actions to address them. The assessment also discusses in more detail an example illustrating an interlinked area of policy and action relevant to cities: decentralised energy production by clean energy sources (Section 8.2.1). The assessment example was selected by viewing the nexus through the low-carbon city lens. Other examples of interlinked policy and action in this nexus could include:

- ensuring that built environment policies consider the physical infrastructure and technological challenges of cleaner energy (e.g. availability of transmission lines);
- integrating energy policy with spatial planning and policies for the built environment to ensure that sufficient space is available for the clean energy infrastructure;
- ensuring that energy policy supports partnerships (e.g. public-private) and community-led energy initiatives to help achieve a just transition to cleaner energy.

This nexus could be viewed from other perspectives, which would help to identify other potential areas for action. For example, viewing the clean energy nexus through the inclusive city lens might identify actions to enable all citizens to benefit from the transition to clean energy production (ensuring a just transition). It would also be important to consider how the transition to clean energy might affect the affordability of energy, especially for those in low-income groups.

Challenges of and actions for achieving clean energy in cities

Cities transitioning to clean energy and carbon neutrality implies a structural change in energy production, moving away from fossil fuels. Broadly this could be achieved in two ways. Cities could replace existing large energy plants with clean energy alternatives. Alternatively, cities could replace existing large plants with a more decentralised approach to power generation, in which there are many local producers of clean energy. A combination of these two approaches could also be used.

Whichever route to clean energy is chosen, cities face a range of complex challenges in decarbonising their energy production. The transition to clean energy may be hindered by bureaucracy and regulatory requirements. Planning restrictions and associated delays in the installation of clean energy infrastructure is an example of the administrative hurdles that can be encountered. A lack of coordination between different authorities and long lead times in obtaining authorisation further impact the clean energy transition (Richardson, 2019). Reducing administrative and regulatory hurdles could encourage new clean energy producers to enter the market (IRENA, 2016).

The installation of clean energy sources can be influenced by the ownership structure of buildings. Multi-owner residential buildings entail complex governance processes and rules regulating decision-making procedures. This could be a major barrier to investment in clean energy sources. The higher the share of publicly owned buildings in a city, the higher the potential for the installation of clean energy sources. Some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forms of clean energy (e.g. wind, solar) require a lot of space if they are to be able to make a substantial contribution to energy supply. Cities will need to find the space (e.g. in peri-urban areas) required for clean energy infrastructure (Seetharaman et al., 2019). A recent JRC study indicates that meeting the EU's total energy demand from clean energy sources would require 18 % of all land in the EU (EC, 2019i), although new and more effective technologies may reduce this figure.

Cities could take action to better coordinate energy policy, spatial planning and the construction of clean energy sources. Integrating spatial and energy planning could help city governments to find solutions to developing decentralised clean energy (see Section 8.2.1). For example, it could ensure that developments consider the orientation of and distances between buildings or the necessary width of streets (to avoid shadows) and alignments to optimise solar energy generation. This could result in a trade-off between avoiding shading of buildings to maximise clean energy production from solar PV installations and shading buildings as a measure to mitigate heat waves.

Given the interlinked nature of the energy transition challenges, a set of coherent and coordinated actions at EU, national and city levels are required. The clean energy transition is inherently linked to a range of policy areas, including:

- climate change (e.g. 2030 climate and energy framework; equivalent national and local policies or strategies);
- environmental protection (e.g. clean air for Europe; environmental, air quality, etc., strategies in cities);
- circular economy (e.g. EU action plan for the circular economy; local plans and initiatives for the circular economy);
- digital transition (e.g. digital single market strategy);
- economic development (e.g. EU sustainable development package; Next Generation EU recovery package; local economic development strategies and partnerships);
- mobility (e.g. low-emission mobility strategy; local transport plans);
- land use planning (e.g. local and regional land use policies).

Ensuring positive synergies between energy policy measures and each of these policy domains will be required to bring about the structural changes needed for widespread clean energy production. The interactions and need for coordination between these policy areas may be particularly evident in urban areas such as the conflicting and synergistic relationships between energy, land use planning, mobility, economic development and environmental protection.

The transition to clean and decentralised energy systems requires considerable initial investment, in particular for those cities with ageing energy infrastructures. Falling tax revenues and austerity measures in many cities in Europe may further delay the necessary investment. This may be further exacerbated by the economic recession following the COVID-19 pandemic. Other financial factors include lack of investors and continuing competition from subsidised fossil fuels (Seetharaman et al., 2019). Recently, the mayors of some of the world's largest cities (e.g. London, New York) urged their counterparts to divest their municipal assets from fossil fuels. Cities can also work with their local or regional pension funds to divest their assets in this way and support sustainable investments in energy production (C40 Cities, 2020b). Other important actions that cities can take include exploring private-public partnerships and providing guidance, recommendations, financial backing, land and assets for potential clean energy micro-producers. Cities can also be engaged more actively by becoming partners in clean energy micro-generation through cooperatives.

The transition to entirely clean energy power generation is a long-term process and requires major infrastructure changes. Often there is limited infrastructure (e.g. transmission lines) to connect clean energy plants to the main grid (Seetharaman et al., 2019). Extending existing energy grids is required to ensure the integration of emerging clean energy micro-producers. To achieve this, suitable policies are needed to provide a framework and incentives for investments. It is important for city authorities to plan and integrate clean energy generation within new infrastructure developments, as retrofitting them later will generally be more costly. The energy infrastructure investment decisions and choices of today will lock cities into a path for many years and in some cases several decades (EEA, 2017c). In their recovery from the COVID-19 pandemic, cities could take advantage of the available EU support mechanisms to lock themselves into a path to a clean energy future.

A lack of appropriate technologies might limit the capacity to harvest, store and transport clean energy (Power Technology, 2018). For city authorities to connect existing energy distribution and transmission networks to large offshore wind farms, for example, may require grid extension and grid capacity expansion. To improve energy storage from renewables, city authorities could also invest in the development of affordable battery systems and storage technologies such as underground storage for heat (Future Learn, 2018).

The transition from conventional to clean energy sources in cities may encounter public resistance and opposition. Loss of visual amenity and noise pollution from wind turbines are the main concerns for many communities (Schumacher et al., 2019; Seetharaman et al., 2019). To overcome this, city authorities can provide information to households and businesses (e.g. public awareness campaigns) on the social, ecological and financial benefits arising from the clean energy transition. In addition, early engagement with communities to understand their opinions, perceptions and fears about the development of new clean energy infrastructure can help to increase support (Bloomberg CityLab, 2019).

Alongside large clean energy schemes, communities can also play a role in achieving more decentralised energy production, through the establishment of small-scale community-owned generation installations (e.g. through energy cooperatives) and investments by individual households (e.g. depending on local context, geothermal, wind, micro-hydro or solar generation). Although energy cooperatives account for only a small share of the EU's renewable energy capacity, they are widely considered important stakeholders in the clean energy transition (Wierling et al., 2018). This is due to the strong participation of local stakeholders and citizens, their considerable co-determination rights and their frequently pioneering role (e.g. electrification of rural areas, fostering the transition to renewable energies) (Meister et al., 2020).

Community energy schemes can bring co-benefits such as lower energy costs, public acceptance and reduced fuel poverty. For community energy to play a role, cities and municipal authorities would need to support communities and individuals (e.g. owners, tenants) of all income levels in their efforts to make the transition to clean energy production. For many urban communities, the initial investment cost of these technologies is still considered too high. If clean energy production remains feasible for only a few prosperous communities and/or individuals, the role that communities can play in the clean energy transition is likely to be limited.

The knowledge and technical skills to engage with clean energy technologies may also vary within the community and among individuals. For some, this could act a barrier for adopting these technologies (Vezzoli et al., 2018). If community energy is to be a part of the transition to clean energy, city authorities will need to engage with micro-producers (e.g. communities, households) to provide, for example, information, best practice guides, training and support in terms of technical, financial, legal, regulatory and long-term management solutions. As has been shown by the pandemic, digital tools (e.g. Zoom, Microsoft Teams) are useful for educating homeowners on renewable energy production and its benefits.

Table 8.1 Overview of challenges of and actions for achieving the clean energy transition in cities

Example challenges	Example actions to address challenges
• The considerable initial investment needed in clean and decentralised energy systems, in particular for those cities with ageing energy infrastructures. • Insufficient infrastructure to connect clean energy plants to the main grid. • Lack of appropriate technologies limiting the capacity to harvest, store and transport clean energy.	• Divesting energy generation from fossil fuels in favour of clean energy producers. • Providing guidance and recommendations for potential clean energy micro-producers (e.g. communities, households). • Planning and integrating clean energy generation within new infrastructure developments to ensure that the orientation and spacing of new buildings allows for solar PV installations on roofs and walls. • Investing in grid extension and capacity expansion to harvest and transport energy from remote locations to cities. Also investing in the development of affordable battery systems and storage technologies.
• Bureaucracy and regulatory challenges, including complex regulations; lack of coordination between different authorities; planning delays and long lead times in obtaining authorisation; and planning restrictions on installing clean energy infrastructure. • The space required for some forms of clean energy infrastructure (e.g. wind, solar PV installations) to make a substantial contribution to the growing energy demand.	• Implementing a set of coherent and coordinated cross-sector actions at EU, national and city levels, given the interlinked nature of the energy transition challenges. • Reducing administrative hurdles and incentivising market entry for new clean energy producers. • Ensuring coordination and positive synergies between energy policy measures and a range of other policy areas, including climate change, environmental protection, circular economy, digital transition, economic development, mobility and land use planning. • Integrating spatial and energy planning to find solutions for decentralised clean energy development (see Section 8.2.1).
• Public concerns about and resistance to the transition from conventional to clean energy sources in cities, in particular due to loss of visual amenity and noise pollution from wind turbines. • Lack of affordability of clean energy transition for communities of all income llevels.	• Providing information (e.g. public awareness campaigns) of the social, ecological and financial benefits of the clean energy transition. • Engaging with communities to understand their sentiments, opinions, perceptions and fears about developing new clean energy infrastructures. • Ensuring that energy transition measures (e.g. incentive mechanisms, tax exemptions) are affordable for communities of all income levels.
• Inadequate knowledge and skills within the community or among individuals to interact with clean energy technologies.	• Engaging with communities/individuals to provide the knowledge and training required. • Sharing of best practice in terms of technical, financial, legal, regulatory and management solutions.

8.2.1 *Example assessment of interlinked actions: decentralised energy production by clean energy sources*

How does decentralised energy production from clean energy sources fit within the clean energy nexus?

Moving to clean energy through an increase in decentralised generation:

- requires long-term structural change in the energy system, including the investment in and construction of smart and clean energy infrastructure — related to the coordination of energy and built environment policy areas;
- requires integrated urban planning and alleviating issues over land use, noise and visual pollution — related to all three nexus policy areas: spatial planning, built environment and energy;
- relies on energy policies that reduce administrative hurdles and incentivise new clean energy producers to enter the market — related to rethinking energy policy in a city context.

The transition to a decentralised clean energy system requires long-term structural changes. The production of clean energy in a city will depend on geography and climate but is likely to rely on wind power, solar PV rooftop installations and hydropower (EEA, 2015a; World Economic Forum, 2018). A decentralised system can be more flexible and demand led. It can also represent a move away from the historical generation-led approach. Ultimately this calls for the creation of a decentralised and circular energy system that reduces energy use, reuses available waste energy sources, and generates clean energy at a small scale to meet the remaining local energy demand (Energy Transition Partnership, 2019).

Rapid technological progress (e.g. improved energy storage), cost reductions and the shift to electric mobility are key drivers of the growth in decentralised clean energy production in the last decade (Ecofys, 2014; Power Technology, 2018). However, the current energy market is considered unprepared for a more widespread decentralised clean energy model. Continued fossil fuel subsidies and increased taxes on self-consumption of energy disrupt local clean energy producers. Other issues preventing local clean energy uptake include changes in financial support, spatial planning barriers and long lead times for administrative and grid access procedures (IEA, 2017; EEA, 2018e).

Possible policy responses and interventions

Moving towards a decentralised clean energy system requires a range of interventions and measures. These include establishing coherent overall policy goals, developing institutional capacity, encouraging stakeholder buy-in and financial support.

A growing number of cities have already set targets to increase the share of clean energy in their energy mix. The effectiveness of these targets depends on political commitment and public or private support.

Supporting the dissemination of information among households and businesses and removing any legal barriers can incentivise investment in decentralised clean energy systems. To achieve ambitious clean energy targets, cities may need to explore opportunities in surrounding rural areas, which may be more suitable (e.g. because they have more land available for solar and wind power installations) (IRENA, 2016).

Integrated urban planning and design can help address issues related to land use and concerns about noise and visual amenity. Visual amenity could be addressed by, for example, integrating solar panels in rooftop materials. Energy policy measures could also ensure that clean energy infrastructure is designed in accordance with circular economy principles. This would enable the reuse and recycling of various components at their end of use (EEA, 2017c).

A transition to decentralised clean energy systems made up of small, localised grids can have a range of co-benefits, including (EEA, 2015a; IRENA, 2016; Lloyd, 2018; Power Technology, 2018; Vezzoli et al., 2018):

- climate mitigation by lowering carbon emissions;
- for the environment, by reducing emissions of harmful pollutants and improving air quality;
- enhancing resilience through a more secure energy supply and improved ability to respond to immediate needs;
- for the economy, by reducing transmission losses, offering more competitive prices in the long term and resulting in more stable costs;
- for local communities, by, for example, creating jobs in building and managing new energy infrastructure, as well as increasing their engagement in clean energy production and increasing their climate awareness.

However, this transition will inevitably bring some trade-offs, for example between the increase in decentralised clean energy systems and the availability of rare materials and land for development (EEA, 2017c; Giurco et al., 2019; Seetharaman et al., 2019). Another important trade-off is between clean

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energy production and unemployment in the conventional energy sector (Rivers, 2013). One of the goals of the EU Just Transition mechanism is to provide reskilling opportunities for those workers from carbon-intensive industries and to facilitate employment opportunities in new sectors and those in transition.

Box 8.1 Solar Thermal Ordinance in Barcelona, Spain

Since 2000 (upgraded in 2006), a Solar Thermal Ordinance (STO) has been in place in Barcelona, making it compulsory to use solar energy to supply 60 % of hot running water in all private and public buildings, including new and renovated buildings and regardless of their size or intended use. The Barcelona Energy Agency (BEA) was established to evaluate the planned installations provided when a building developer seeks approval for both the building design and construction permit. Building inspectors are then responsible for ensuring that construction meets the specified criteria.

The Barcelona STO is an example of the early adoption of such practices and is considered a success because it has achieved significant energy savings and reductions in carbon dioxide emissions since it took effect. By end of 2010, 87 600 m^2 of solar thermal panels had been installed. This initiative had also successfully popularised the use of solar thermal energy, both within the city of Barcelona and beyond its borders.

Stakeholder engagement and education on the use and maintenance of their solar panels were identified as the main factors in the success of this project. The BEA worked with the neighbourhood association and the body corporates of buildings to enable tenants and the public to measure their energy savings and check to ensure that the solar installations are working. In 2006 the principles of this STO were adopted in legislation at the national level and have since been followed by many municipalities in Spain.

Source: Center for Clean Air Policy (undated).

Box 8.2 Sustainable urban district of Vauban in Freiburg, Germany

In the late 1990s a mixed-use district of some 5 100 residents was built in Freiburg on the site of a former French military base. The energy and heat are generated by large number of solar collectors and photovoltaic modules and a highly efficient woodchip-powered combined heat and power (CHP) generator connected to a district heating grid. Many houses in the district are producing more energy than they use, and the surpluses are sold back to the city grid and the profits split between households.

The installation of photovoltaic panels and solar energy is encouraged through tax credits from the federal government and subsidies from the regional utility. As a result most of the electricity needed in Vauban is produced on site through CHP and photovoltaic installations.

Source: Thorpe (2019).

Box 8.3 Crowd investing in solar energy in Križevci, Croatia

The Green Energy Cooperative launched an initiative to install a solar power plant on the roof of Križevci Business Centre's administrative building. It was entirely financed by citizens — small investors who were attracted by the agreeable interest rate, higher than that provided by commercial banks.

The Green Energy Cooperative leased solar equipment to the Križevci Business Centre for 10 years. All investors signed a loan agreement with the cooperative for 6 years, for which annual interest on the funds accrued is anticipated. The business centre pays for the actual electricity consumed. The monthly savings are then used to return investment to the citizen-investors. This initiative is also supported by Križevci local authority, which will take over the ownership of the solar power plant after 10 years.

Source: Renewables Networking Platform (undated).

8.3 Lessons for achieving clean energy in cities

This nexus analysis highlights that integrating the built environment, spatial planning and energy policy areas can have a range of co-benefits including climate mitigation (e.g. reduced carbon emissions), environment and health (e.g. reduced pollution), and social and economic (energy resilience, reduced energy poverty, democratic participation, climate awareness) benefits. However, there are also trade-offs, for example between decentralised clean energy systems the and availability of rare materials and land for development.

The clean energy transition will require stakeholder cooperation across different sectors and spatial scales (EU, interregional, national and local/city). This should cover stakeholders across the end use (buildings, industry, and transport) and transformation (power and district heat) sectors. Stakeholders beyond the energy sector should also be engaged, including those from the urban planning, building design and construction domains (IRENA, 2016). Such integrated decision-making requires a deep understanding of planning processes across sectors and may include location-specific actions.

It is important that energy policy reforms recognise the critical interrelationships between the planning, built environment and energy sectors, bringing stakeholders together to explore optimal solutions for clean energy production. These reforms need to be adapted to local conditions and provide the necessary policy tools (e.g. green building codes, certification programmes and education campaigns). These reforms will also require effective policy and regulatory conditions to encourage private sector involvement. Cities are well placed to enable these conditions and lead the implementation of such reforms and thus be leaders in the transition to clean energy.

The clean energy transition could be further stimulated by reducing or removing subsidies in the conventional energy market. Although it is likely to be beyond the scope of cities to influence this, it would increase competition and drive innovation and price control, benefiting clean energy micro-producers (e.g. homeowners, industries, energy cooperatives) in cities (Energy Transition Partnership, 2019).

The EU supports cities in their transition to clean energy through various tools and policies. The energy union is one of

the 10 current political priorities of the European Commission. It is supported by other overarching policies, including those on the circular economy, the skills agenda and innovation. This political commitment is supported by EU funds (e.g. European Fund for Strategic Investment, European Regional Development Fund, Cohesion Fund) (EEA, 2017c). The Partnership on Energy Transition ([85]) has prepared an action plan that reflects the need for 'a more integrated, smarter, and more decentralised energy system' (Energy Transition Partnership, 2019). There are also several EU platforms and initiatives that provide advisory and financial support to local authorities (e.g. URBIS ([86]), European Fund for Strategic Investments ([87])). These can help to unlock, facilitate and accelerate investment in projects and programmes in urban areas, including clean energy schemes.

While many policies are still enacted at the national or regional level, cities are increasingly taking control of their own (clean) energy futures. Some EU cities have or are planning to bring municipal energy utilities back into local public and collective ownership, referred to as 'remunicipalisation' (Worldwatch Institute, 2016). This can empower cities to unlock the clean energy transition through a range of actions. These include target setting; use of local regulations; operation of municipal utilities (including energy utilities); clean energy consumption in public buildings, street lighting, etc.; financing; and advocacy work (IRENA, 2016). Coordinating these actions could help to 'lock in' a city's long-term energy production into a clean, smart energy system with greater levels of decentralisation.

The COVID-19 pandemic has had a significant impact on urban economies across Europe. Cities have acknowledged the need for investment in clean energy to reinvigorate local economies. It is important that national governments and multilateral agencies support cities' efforts towards the clean energy transition as part of their green recovery (C40 Cities, 2020a).

8.4 Existing networks and sources of information

Various examples of existing networks and sources information relevant to this nexus include:

- **C40 Cities** ([88]). A network ofsthe world's megacities committed to addressing climate change. Its Clean Energy Network supports cities' efforts to plan and implement initiatives to increase their low-carbon energy supplies.
- **Climate Alliance** ([89]). Through this network, some 1 700 member municipalities and districts covering 26 European countries, as well as a variety of regional governments, non-governmental organisations and other organisations, are actively working to combat climate change.
- **Covenant of Mayors for Climate & Energy** ([90]). This cooperative movement brings together local governments voluntarily committed to achieving and exceeding the EU's climate and energy targets. The signatory cities share a vision for accelerating the decarbonisation of their territories and for allowing their citizens to access secure, sustainable and affordable energy.
- **Directorate-General for Regional and Urban Policy (DG REGIO) project database** ([91]). This provides examples of projects (including clean energy) funded by EU regional policy programmes across the various programming periods.
- **Energy Cities** ([92]). A network of local governments aiming to transform energy systems and policies and to empower citizens to shape a decentralised and renewable energy future.

([85]) Urban agenda for the EU (agreed in 2016 through the Pact of Amsterdam).
([86]) https://eiah.eib.org/about/initiative-urbis.htm
([87]) https://www.eib.org/en/efsi
([88]) https://www.c40.org
([89]) http://www.climatealliance.org/about-us.html
([90]) https://www.covenantofmayors.eu/en
([91]) https://ec.europa.eu/regional_policy/en/projects
([92]) https://energy-cities.eu

- **European Energy Network (EnR)** ([93]). A voluntary network of European energy agencies that aims to promote sustainable energy good and best practice. EnR strengthens cooperation between members and key European stakeholders on issues concerning sustainable energy.

- **European Innovation Partnership on Smart Cities and Communities** ([94]). A European Commission initiative bringing together cities, industries, small and medium-sized enterprises, investors, researchers and other smart city stakeholders to exchange ideas and initiatives to develop solutions for joint challenges, including the clean energy transition.

- **ICLEI** ([95]). The International Council for Local Government Initiatives (also known as Local Governments for Sustainability) is a global network of more than 1 750 local and regional governments committed to sustainable urban development, which have collated materials and information on climate change adaptation.

- **International Energy Agency** ([96]). The website provides publications on fuels and technologies, as well as on a variety of energy topics with a focus on cities.

- **LIFE project database** ([97]). This provides examples of energy projects from the LIFE programme, including those focusing on the energy supply.

- **Open & Agile Smart Cities (OASC)**([98])**.** A non-profit, international smart city network that has the goal of creating and shaping the nascent global smart city data and services market.

- **Renewables Networking Platform** ([99]). A multi-level governance discussion project connecting relevant European, national, regional and local stakeholders to rethink, analyse, improve, redesign, refocus, and boost renewable energy policies.

- **Smart Cities Information System (SCIS)** ([100]). A knowledge exchange platform enabling cities to collaborate with a range of stakeholders (e.g. project developers, research institutions, industry, experts and citizens) to tackle urban sustainability issues. It also encompasses data, experience and stories from projects focusing on various thematic areas, including energy (e.g. energy system integration, sustainable energy solutions on district level).

- **Smart City Alliance** ([101]). An international alliance that brings together the frontrunners in the smart city approach. It especially promotes peer-to-peer learning and fosters collaboration within cities.

Further reading

- Gancheva, M., et al., 2018, *Models of local energy ownership and the role of local energy communities in energy transition in Europe*, European Committee of the Regions (https://cor.europa.eu/en/engage/studies/Documents/local-energy-ownership.pdf) accessed 4 November 2019. This report looks at different local ownership models and the enabling conditions for them and the obstacles/barriers they face. It also provides an analysis of existing EU legislation and how it addresses the operation of local energy communities.

- Wierling, A., et al., 2018, 'Statistical evidence on the role of energy cooperatives for the energy transition in European countries', *Sustainability* 10(9), article 3339. This paper provides evidence of activities by energy cooperatives in the field of renewable energy and highlights their role in the clean energy transition.

([93]) http://enr-network.org
([94]) https://eu-smartcities.eu
([95]) https://iclei.org
([96]) https://www.iea.org
([97]) http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.getProjects&themeID=7&projectList
([98]) https://oascities.org
([99]) https://www.renewables-networking.eu
([100]) https://smartcities-infosystem.eu
([101]) https://thesmartcityalliance.eu

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9
Sustainable buildings nexus

9.1 What are sustainable buildings and why are they important in an urban context?

All buildings (residential, public, commercial, industrial) require the use of large amounts of resources and energy throughout their life cycles. Recognising this, the Europe 2020 strategy stresses the need to improve resource efficiency in the building sector (EC, 2010). This is also reflected in the EU action plan for the circular economy (EC, 2015b). Under the European Green Deal, the European Commission has introduced a Renovation Wave initiative to encourage faster and deeper renovation (EC, 2020e). In partnership with industry, the Commission has also developed Level(s) ([102]): a voluntary reporting initiative for environmental performance in the built environment (EC, 2019j). *The European environment — state and outlook 2020* (SOER 2020) estimates that more than EUR 1 trillion will need to be invested in transport and buildings to achieve the EU's 2030 climate and energy targets (EEA, 2019a).

Sustainable buildings have high levels of energy and resource efficiency and reduce environmental impacts across their life cycles. Their users enjoy better health, well-being and productivity. In turn this translates into cost savings (EC, 2016c). The European Commission states that carbon emissions from the buildings sector could be reduced by around 90 % by 2050.

It is estimated that 80 % of Europeans will live in cities by 2050, compared with 74 % today (EEA, 2019a). Accommodating more people in cities is likely to require more buildings and retrofitting of existing buildings (e.g. homes, schools). This in turn may increase resource and energy demand throughout the life cycles of buildings (EC, 2019h). Construction and demolition waste accounts for over a third (36 %) of all waste generated in the EU. At the same time, households as a sector account for 12 % of total annual water use and 27 % of final energy consumption in the EU (EEA, 2019a; Eurostat, 2019).

The potential for energy and resource savings through sustainable buildings is clear, and this nexus explores the role that cities may have in realising this potential. This is a key priority given the need not only to ensure that buildings use more sustainable heating and cooling sources to reduce their associated greenhouse gas (GHG) emissions but also to ensure that they are designed to make them resilient to future climatic changes.

If more sustainable buildings are present in cities, this would support progress in other nexuses, in particular:

- **Climate resilience** — through using sustainable heating and cooling sources to help buildings adapt to a warmer climate and by reducing associated GHG emissions.
- **Closing the loop** — through improving the management of construction waste and resource and material use in construction.
- **Environment and health** — through well-insulated housing that has better indoor air quality and reduced exposure to outdoor noise and that protects against heat and cold.

Sustainable buildings can also contribute to other nexus outcomes, including 'clean energy', through using rooftops for clean energy production; and 'quality of life', through designing housing in which residents feel comfortable and safe and by reducing energy poverty in low-income families.

9.1.1 The sustainable buildings nexus and the COVID-19 pandemic

Immediate COVID-19 pandemic response

The COVID-19 outbreak has left office and commercial buildings in urban centres dormant for a period of weeks or even months as businesses closed and/or homeworking became the norm. An increase in homeworking has increased pressure to ensure that building standards provide enough suitable living and working space in residential buildings. Homeworking is also increasing pressure in terms of energy consumption. With employees spending more time at home, many homeworkers

([102]) Level(s) — a voluntary reporting framework that provides a common EU approach to the assessment of environmental performance in the built environment. It provides a set of core indicators for performance assessment. For more information, see: https://ec.europa.eu/environment/eussd/pdf/Level(s)_factsheet-EN-web.pdf

have seen an increase in their utility bills as a result of providing heating and lighting during the day when they would normally be at work. Energy use is also likely to increase, as many domestic properties are likely to have less efficient heating systems and poorer insulation than commercial buildings. Some national governments (e.g. Spain) have agreed with business leaders that employers must cover their employees' homeworking expenses during the COVID-19 pandemic.

The pandemic has had a disproportionally negative impact on socially and economically disadvantaged groups in cities. Housing is an important social determinant of health, with those using sustainable buildings enjoying better health, well-being and productivity. For those in poor-quality housing, lockdown means more time exposed to cold, damp and other hazardous conditions, which has consequences for both physical and mental health.

The COVID-19 pandemic caused significant disruption in construction supply chains. This has led to increasing interest in developing more sustainable and resilient supply chains by using locally sourced or recycled material and ensuring more efficient use of scarce resources.

Longer-term implications as cities draw up and implement COVID-19 recovery plans

The COVID-19 pandemic could result in significant changes in land use planning and building design and construction in future, including design for energy-efficient and healthy buildings. Such changes could include minimalist building design; flexible entrance areas and more balconies; views of local landscapes from windows and access to sunlight prioritised in planning; and more natural ventilation (including linear flow extraction, increased humidity control, heat and moisture recovery) (Pinheiro and Luis, 2020). Through land use planning, such changes could affect the green areas surrounding buildings; the size of homes; and the existing infrastructure (e.g. office buildings, transport networks) as a result of increased homeworking.

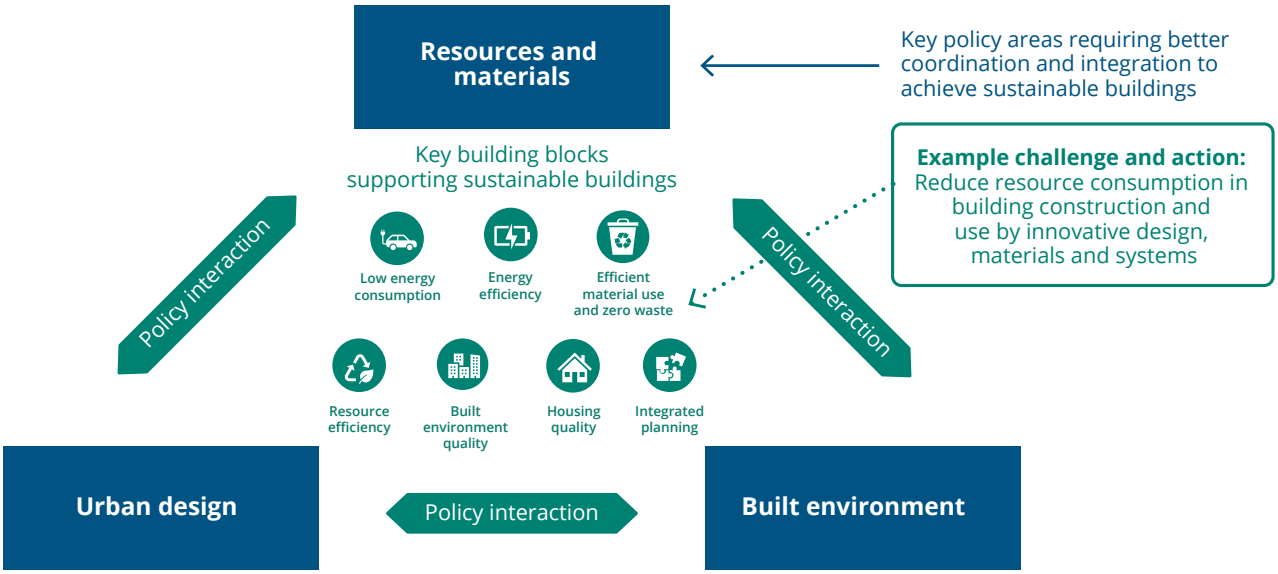
As part of their green recovery plans cities could take advantage of the Next Generation EU recovery package to invest in their ageing housing stock. Once it is available cities could use the funds to retrofit/renovate public buildings, to improve energy efficiency, reduce GHG emissions and to create green jobs that will kickstart the economy. Energy efficiency retrofits could provide another important opportunity for a green recovery by creating jobs. For the users of the buildings, this would also reduce energy costs and ensure healthier buildings as a result of improved indoor quality. In the longer term the pandemic is providing cities with an opportunity to establish and implement their own sustainability standards for their building stocks.

9.2 Interlinked policy areas contributing to sustainable buildings in cities

This nexus focuses on areas of policy and action through which cities can improve the sustainability of their building stock. This nexus looks in particular at policy and action related to resource and material use, the built environment and urban design (see Figure 9.1).

Many challenges in achieving sustainable buildings result from a lack of coordination between the three policy areas included in this nexus, for example, coordinating integrating sustainability principles in building design while ensuring that these principles are supported by policy relating to the use of resources and materials in a city. Integrating these policy areas could also have co-benefits, such as reducing building lifecycle costs (e.g. energy efficiency or material reuse) and creating healthier buildings.

Figure 9.1 The sustainable buildings nexus: key policy areas and building block



The sustainable buildings nexus focuses on the design, construction and use phases in the life cycles of residential, public and commercial (e.g. retail, office) buildings. Taken together these represent approximately 99 % of total building stock in the EU (Ecorys, 2014).

Through improved coordination of policy and action, resource and energy performance can be improved throughout buildings' life cycles. Examples include:

- improving housing quality and enabling energy efficiency, reduced material use, modularity and recycling in the design phase;
- reducing material and energy intensity in the extraction and transport phases;
- increasing energy efficiency and modularity in the construction phase;
- reducing energy and water consumption in the use phase;
- enabling recycling and material recovery in the demolition phase.

The following sections explore some of the key challenges that cities may face in seeking more sustainable buildings and the associated policy and practical actions. Table 9.1 then provides an overview of the challenges and actions to address them. The assessment also discusses in more detail an example illustrating how coordinated action can improve the sustainability of buildings: reducing resource consumption in building and construction through innovative design, materials and systems (Section 9.2.1).

This assessment example was selected by viewing the nexus through the circular city lens. The nexus could be viewed from other perspectives, which would help to identify other potential areas of action. For example, viewing the sustainable buildings nexus from the perspective of the low-carbon city might identify action related to reducing energy consumption throughout the life cycles of buildings.

Challenges of and actions for achieving sustainable buildings in cities

The main challenges for achieving sustainable buildings are associated with how, in practice, to reduce resource and energy use throughout their life cycles. For example, how do we ensure efficient material (e.g. metals, minerals, concrete and timber) and water use, minimise waste and maximise recycling in the construction, retrofitting and use of buildings? To overcome this challenge city authorities can work with building owners and building design and construction businesses (e.g. architects, contractors) to promote innovative building design and improve the management of construction materials (see example assessment of interlinked actions in Section 9.2.1). As part of the green recovery cities could take advantage of available funds and work with building owners on these issues to kickstart the economy. Collaborative working between all stakeholders (e.g. building owners, design teams, contractors, manufacturers, installers) can improve the coordination of building design and construction and the associated resource management. In turn, this can increase resource efficiency and help reduce buildings' lifecycle energy consumption and associated GHG emissions.

A range of actions can help to reduce resource and energy use throughout buildings' life cycles, including establishing local building codes and sustainable design and retrofitting standards that ensure greater ambition (Brilhante and Skinner, 2015; IEA, 2020d). Cities could implement these actions as part of their green recovery from the COVID-19 pandemic. Cities can also play a direct role in encouraging sustainable buildings: city authorities will often manage a sizeable building stock and can also lead by example in developing new buildings. Green public procurement is one of the tools available to cities. Through procurement, sustainability standards and criteria can be set for the suppliers of materials and services (e.g. the design and construction sectors), including the need for coordinated action.

There are already examples of standards for assessing the environmental design and use of buildings, such as the Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED). Such codes and standards ([103]) aim to ensure that energy efficiency, material use, and water and waste management are considered in the building design phase. This requires the design of, for example, closed cycles of water, waste and energy in buildings using easily applied solutions. Furthermore, ambitious design, construction and retrofitting standards can help reduce energy consumption in the use phase through better heating, ventilation and air conditioning systems and access of natural light and green infrastructure. Making effective use of space in buildings is important to ensure efficient use of resources, including building materials, energy and land. The size and shape of a building's envelope (i.e. design and construction of the exterior) are key factors in achieving these objectives. The design of a sustainable building in which compactness is a guiding principle can provide material and energy savings, limit heat gains or losses and limit sprawl (D'Amico and Pomponi, 2019). The requirement

([103]) BREEAM, for example, measures building sustainability against the following categories: energy; water; waste; materials; land use; pollution; health and well-being; transport; innovation; and management.

to practise modular construction, sustainable sourcing of resources and the use of smart energy-saving technologies could reduce energy use during construction. Water use and efficiency can also be included in construction specifications, including on-site water use. This may include eliminating leaks and recovering grey water for reuse in construction (WBDG, 2018). Such water efficiency practices will bring about cost-effective improvements in buildings' environmental performance (Clement et al., 2012).

Improving energy efficiency is a key issue for achieving sustainable buildings. Approximately 75 % of the existing building stock in the EU is considered energy inefficient (BPIE, 2017). The urgency of this issue has also been highlighted by the COVID-19 pandemic's disproportionate impact on those in poor-quality housing. Users of such buildings are exposed to conditions that have negative consequences for their physical and mental health. As more people work from home utility bills will increase, particularly for those living in poor-quality housing (e.g. with poor insulation). These buildings would benefit from retrofitting to incorporate energy-efficient technologies and approaches. Retrofitting may include thermal insulation, energy-efficient use of natural lighting, central mechanical ventilation systems, and heat and moisture recovery systems. The uptake of these measures can be influenced by the ownership structure of buildings. In a heterogeneous ownership model the installation of energy efficiency measures requires the consent of the large majority of flat owners in the building. Rules across EU Member States may vary, as may differences in the rights and obligations of homeowners (Matschoss et al., 2013). This can have implications for the ease of making decisions about and financing retrofitting. To accelerate the uptake of retrofitting, cities could facilitate financing models that enable energy efficiency investments to be repaid over time using energy cost savings (C40 Cities, 2019). Such retrofitting could bring co-benefits, such as reducing energy costs and creating healthier buildings for residents.

The focus in sustainable buildings is often on design, construction and retrofitting, while the use and end-of-life phases are overlooked (Clarke, 2013). Consumer awareness and behaviours are also important for the overall performance of sustainable buildings. Various studies have shown considerable discrepancies between expected and realised energy efficiency gains because of users' behaviour, meaning that theoretical potential gains are not achieved (Seebauer, 2018). To help ensure that energy efficiency gains are closer to what is actually possible, cities could seek to raise consumers' awareness of efficiency measures and of the benefits of these for households (e.g. reduced energy bills) to encourage behaviour change. This could also be achieved by city authorities organising events (e.g. public dialogue, roadshows) to involve local residents in discussions about resource and energy efficiency in homes. Engagement with local residents could also enable authorities to learn about people's requirements and preferences regarding their living space. Having this information could help authorities to design (or set standards and codes for) buildings to help them achieve their sustainability potential. City authorities can also benefit from establishing policy platforms that enable stakeholders to share their knowledge and best practices, comment on proposed building plans and raise questions.

Contextual factors and conditions can have an impact on integrated planning and action across the nexus policy areas. For example, design solutions for building systems (e.g. heating, cooling, ventilation) and materials may be influenced by existing planning policy and building regulations; the needs and preferences of all stakeholders; the design and use requirements of the client; and the wider context such as climate, location and future pandemics. Similar factors will influence the effectiveness of retrofitting in improving buildings' sustainability and resilience to future climatic conditions. Therefore, any planned interventions regarding a building's design, construction or retrofitting must consider local conditions, as well as the future climate, if they are to be effective (Lewis et al., 2013; EEA, 2015a).

Table 9.1 Overview of challenges of and actions for achieving sustainable buildings in cities

Example challenges	Example actions to address challenges
• Inefficient resource and energy use throughout the building life cycle (including energy consumption and efficiency, water and material use and waste management).	• Promoting innovative building design to help ensure efficient material use in construction, reduce ongoing running and maintenance costs and enable adaptive reuse of buildings over their life cycles. • Coordinating building design, construction and associated resource management to ensure efficient use of resources and energy. Including setting standards and targets and providing tools to encourage sustainable building design and construction. • Including water use and efficiency requirements in construction specifications. This may include eliminating leaks and recovering grey water for reuse. • Improving management of construction materials to help to reduce resource use, e.g. identifying and procuring locally sourced and/or recycled materials to minimise the need for imported materials.
• The scale of the problem with a large proportion of the existing building stock, which is inefficient and would benefit from retrofitting.	• Focusing efforts on retrofitting to incorporate energy-efficient technologies and approaches. • Facilitating financing models that enable investments in energy efficiency to be repaid over time using energy cost savings.
• The need to raise consumer awareness and influence behaviours to improve the overall sustainable performance of buildings.	• Providing information and services that raise consumer awareness and encourage behaviour change to realise energy and water efficiency gains in buildings. • Organising events (e.g. workshops) involving local residents to enable dialogue on the principles of practising resource and energy efficiency in homes and to learn about residents' requirements for their living space (to help design space that achieves its sustainability potential in practice). • Establishing well-managed policy platforms to facilitate discussions and enable stakeholders to share knowledge and best practices.
• A range of contextual factors and conditions affecting the achievement of more sustainable buildings and resilience to future climatic conditions (e.g. existing planning policy and building regulations, the needs and preferences of stakeholders, the client's design and use requirements, climate and location).	• Ensuring that an understanding of and adaptation to the local contextual factors is factored into to decision-making regarding design solutions, choice of materials for buildings, construction and retrofitting.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9.2.1 Example assessment of interlinked actions: reducing resource consumption in building construction and use through innovative design, materials and systems

How do innovative design, materials and systems to reduce resource consumption in building construction and use fit within the sustainable buildings nexus?

Innovative design, materials and systems interventions can:

- ensure efficient material use during construction and reduce ongoing running and maintenance costs;
- minimise the need for new materials and renovation over a building's lifetime;
- enable adaptive reuse of a building over its life cycle.

Reducing resource consumption focuses on natural resources, building materials and water. Increased demand for these resources in the construction and use of buildings can have negative environmental and social impacts. These impacts are particularly significant in mining regions and on production sites (e.g. cement and steel production). The circular city will need to address these negative effects by managing resource consumption throughout buildings' life cycles.

Possible policy responses and interventions

The EU circular economy and climate policy instruments and the Roadmap to a resource-efficient Europe [104] [105] encourage sustainability of buildings in the EU. Such high-level policy can support existing efforts within the building sector. This occurs through setting targets and providing tools to encourage sustainable building design and construction, for example the goals set in the EU action plan for the circular economy.

There are various interventions aimed at reducing resource consumption in building construction and use. Common interventions include innovative design, improved management of natural resources and building materials, and resource management systems in buildings (e.g. water, waste).

([104]) https://ec.europa.eu/environment/green-growth/tools-instruments/index_en.htm
([105]) https://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm

Innovative building design can ensure efficient material use in construction and reduce ongoing running and maintenance costs by using resource-efficient features, materials and appliances. Well-designed houses can further reduce building material consumption by incorporating approaches that enable adaptive reuse of a building over its life cycle (Mohamed and Alauddin, 2016).

Improved management of construction materials can also help to reduce resource use, for example identifying and procuring locally sourced and/or recycled materials to minimise the need for imported materials (Pullen, 2012). Choosing durable and low-maintenance materials can minimise the need for maintenance and renovation over a building's lifetime. Installing improved resource management systems in buildings, such as reusing grey water and recycling household waste, can improve the resource efficiency of the use phase of buildings (Lopez, 2016).

Improved waste management can have an important role by providing a source of construction materials. Using waste materials in construction can reduce environmental impacts compared with using virgin materials.

Reducing material and water consumption in the construction and use of buildings can also lead to environmental and social co-benefits. These may include (Dobson et al., 2013):

- benefits for ecosystems from reduced pollution and degradation of the natural environment (e.g. for habitats and species);
- climate benefits from reduced energy use and GHG emissions;
- health benefits from improved air quality during construction and inside finished buildings;
- longer-term economic benefits from increased returns on investment.

The following examples from two European cities highlight interventions aiming to reduce resource consumption during building construction and use. Both examples highlight the importance of coordinating design, materials and systems to help reduce resource demand during the life cycles of buildings.

Box 9.1 Applying a cradle-to-cradle design philosophy to reduce resource consumption during the use phase of a 'newly built' office park in Hoofddorp, the Netherlands

Built as the first full-service cradle-to-cradle (C2C) optimised working environment, Park20|20 is an office development with fully closed cycles of water, waste and energy. All buildings are connected to a grey water purification system and a central heating and cold storage installation specifically built for the office park. The project provided end-of-use options for buildings right from the start. It also established 'resource passports' — an approach to tracking materials and their corresponding residual value throughout the life cycle of each building. For example, users can track the value of LED light systems, solar panels and office equipment. To regain material value at a building's end of life the suppliers are urged to come up with easily applicable solutions.

The project managers also held a series of workshops for the tenants and clients of all the office buildings located in the park. The aim was not only to get to know clients and their requirements but also for clients to become acquainted with C2C principles. This was an important step in establishing a common understanding between all stakeholders and, most importantly, ensuring that users are aware of and, through their behaviour, achieve the full sustainability potential of these buildings.

Source: Leising et al. (2018).

Box 9.2 Optimising material use in a reconversion project in Loos-en-Gohelle, France

The building's owner in partnership with local small to medium-sized enterprises reconverted a historic house (Rehafutur engineer's house) into office facilities.

The project prioritised the reuse of all types of materials, considering the building's significant heritage value. For example, marble fireplaces were moved and reused as ornamental features in public rooms, spruce floorboards were relaid after installing high-performance floor insulation, and rubble was reused to level the parking spaces and access paths. A particular focus of the project was the use of building materials from renewable sources (animal and vegetal) and from recycled material. The project used a range of bio-based and recycled materials to demonstrate the effectiveness of renewable insulation materials. For example, a regional material made out of old clothes (mainly cotton) called Métisse was used for the insulation.

The building will be monitored to evaluate its thermal performance and comfort in winter and summer and to measure the achievement of energy efficiency requirements, identifying areas for potential improvement in future.

Source: Ellen MacArthur Foundation (2016).

9.3 Lessons for achieving sustainable buildings in cities

This assessment highlights the importance of involving all stakeholders (e.g. planners, architects, building owners, residents) in actions and measures to achieve sustainable buildings. The nexus identifies a range of benefits arising from considering the following factors in building design, construction and use: social (e.g. health), environmental (e.g. ecosystem health, reduced pollution), climate mitigation (e.g. reduced carbon emissions) and economic (e.g. increased investment returns).

The engagement of residents is key, as behaviours related to reducing energy and water consumption in the home are as important for achieving sustainable buildings as the use of resource-efficient technologies and design (Hayles, 2015). This could involve raising awareness among residents of the benefits of more energy- and water-efficient behaviours. More collaborative working through dialogue between architects, building contractors and potential residents can also help to realise energy and resource efficiency gains.

Although there is no legal framework on sustainable buildings in the EU, several EU policies seek to achieve improved energy efficiency and reduced resource use, including in buildings (e.g. Energy Efficiency Directive, national energy efficiency action plans, EU action plan for the circular economy, energy union). The Energy Performance of Buildings Directive is the main legislative instrument related to energy use and efficiency in the building sector. The directive recognises the need for coordinated action among all stakeholders.

The fragmentation of policies and complex legislative frameworks on energy performance, waste management and construction materials may lead to a lack of integration of sustainable building measures (e.g. materials passports, reversible building design protocols). In some cases this fragmentation can lead to contradiction (Debacker and Manshoven, 2016). Therefore, having an integrated policy approach is essential to avoid unsustainable long-term investment in building development and retrofitting.

Cities can play a key role in encouraging sustainable buildings. City authorities will often manage a sizeable building stock and can also lead by example in developing new buildings. Green public procurement is one of the tools available to cities. Through procurement, sustainability standards and criteria can be set for suppliers of materials and services (e.g. design and the construction sector), including the need for coordinated action.

Although national standards provide some guidance on addressing sustainability issues in buildings, cities can introduce their own proactive measures. For example, cities are able to institute their own building and energy codes that could establish sustainability standards for their building stocks (ClimateXChange, 2018). Active collaboration between the operators throughout the whole value chain in the construction sector (e.g. contractors, installers, architects and suppliers, as well as producers of material, equipment and energy) could be required to ensure that these standards are met.

The lockdowns in response to the COVID-19 pandemic meant that many people stayed in their homes for long periods of time. This has forced city authorities to think about their building stocks in new ways, as the pandemic has highlighted inequalities in housing quality and its repercussions for health and well-being. By recognising the urgency of improving their building stocks, cities could take advantage of the jobs created by energy-efficient retrofits to contribute to a green recovery.

9.4 Existing networks and sources of information

Various networks of cities have been established to take collective action to reduce energy and resource consumption in new and existing buildings. By engaging with member cities, these networks seek to facilitate collaboration and knowledge sharing among stakeholders to effectively achieve sustainable buildings. Examples of existing networks and information sources relevant to the sustainable buildings nexus include:

- **BPIE** ([106]). Buildings Performance Institute Europe is an independent think tank focusing on the energy performance of buildings. It supports energy performance improvements, sustainability and complete decarbonisation of the buildings sector.
- **Building Efficiency Accelerator** ([107]). A public-private collaboration coordinated by the World Resources Institute. It aims to support cities in their efforts to scale up energy efficiency in new and existing buildings.
- **European Building Automation and Controls Association** ([108]). eu.bac is a platform dedicated to energy efficiency in buildings, bringing together European manufacturers of home and building automation appliances and energy service companies.

([106]) https://www.bpie.eu
([107]) https://buildingefficiencyaccelerator.org
([108]) https://eubac.org

- **European Innovation Partnership on Smart Cities and Communities** ([109]). This is a European Commission initiative bringing together cities, industries, small and medium-sized enterprises, investors, researchers and other smart city actors to exchange ideas and initiatives to develop solutions to joint challenges, including achieving a sustainable built environment.

- **European Portal for Energy Efficiency in Buildings** ([110]). Established to support EU Member States in implementing the Energy Performance of Buildings Directive. It provides a platform for new practitioners and professional associations to exchange knowledge and best practices and to share tools and resources.

- **ICLEI** ([111]). The International Council for Local Government Initiatives (also known as Local Governments for Sustainability) is a global network of local and regional governments, providing a platform for collaboration through peer exchange, partnerships and capacity building to create systemic change towards urban sustainability. The network enables cities to engage in activities across various areas, including sustainable urban planning and the efficiency of the built environment.

- **Joint Research Centre's European Energy Efficiency Platform** ([112]). E3P supports the exchange of experience on practices, benchmarking, networking activities, and innovative practices. It features thematic areas such as 'Buildings' and 'Urban areas'.

- **Private Building Efficiency (PBE) Network** ([113]). This C40 Cities network supports cities' efforts to improve the energy efficiency of existing commercial and residential buildings.

- **Urban Data Platform Plus** ([114]). Introduces a set of indicators on resource efficiency that includes indicators on the share of old and new buildings in cities.

- **World Green Building Council** ([115]). This network of independent, non-profit organisations is seeking to transform the built environment to make it healthier and more sustainable.

Further reading

- EEA, 2020, *Cutting greenhouse gas emissions through circular economy actions in the buildings sector*, EEA Briefing No 6/2020 (https://www.eea.europa.eu/themes/climate/cutting-greenhouse-gas-emissions-through/cutting-greenhouse-gas-emissions-through) accessed 16 October 2020. Provides a new methodological approach to identifying circular economy measures that can contribute to reducing emissions in the buildings sector.

- EEA, 2015, *Urban sustainability issues — What is a resource-efficient city?*, EEA Technical Report No 23/2015 (https://www.eea.europa.eu/publications/resource-efficient-cities/file) accessed 10 June 2021. Provides data sources that can be used for assessing the metabolism of cities.

- EEA, 2018, *Environmental indicator report 2018*, EEA Report No 19/2018 (https://www.eea.europa.eu/publications/environmental-indicator-report-2018) accessed 10 June 2021**.** Provides an overview of the EU's progress towards 29 achieving environmental policy objectives. These are relevant to achieving the three key priority objectives of the Seventh Environment Action Programme, in particular a resource-efficient, low-carbon economy.

([109]) https://smart-cities-marketplace.ec.europa.eu
([110]) https://www.buildup.eu/en
([111]) https://iclei.org
([112]) https://e3p.jrc.ec.europa.eu
([113]) https://www.c40.org/networks/private-building-efficiency
([114]) https://urban.jrc.ec.europa.eu/#/en
([115]) https://www.worldgbc.org

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10 Policy and governance implications

This chapter provides an overview of the main lessons for the transition towards urban environmental sustainability by achieving the high-level urban sustainability objectives that are the focus of each nexus (e.g. climate resilience, food security). These lessons are derived from the outcomes of the analyses of the eight urban environmental sustainability nexuses, drawing on the lessons presented at the end of each nexus in Chapters 2-9.

10.1 Policy action to achieve urban environmental sustainability objectives

The eight priority nexuses illustrate the range of potential actions needed to transition towards urban environmental sustainability. A range of categories of actions can be identified across the nexuses, including new or revised:

- standards or regulations;
- policies, plans, roadmaps and strategies;
- economic incentives;
- information, knowledge sharing and behaviour changes;
- physical development, infrastructure and facilities;
- management regimes.

The case studies illustrate how many cities across Europe are already undertaking these types of action.

Table 10.1 presents some high-level policy agendas based on the building blocks or on combinations of them. These policy agendas were identified from the assessments of the eight selected nexuses. Each of these policy agendas is relevant to at least two nexuses and generally to three or more. Although not intended to be comprehensive, these policy agendas are representative of the specific nexus actions identified in the assessments. Examples of specific nexus actions are also listed against each policy agenda to illustrate the types and range of actions seen across the nexuses.

This shows that, although cities are complex systems in which there are myriad interactions between interventions and sectors, in practice a relatively small number of policy agendas can be identified through which urban environmental sustainability can be achieved. The example nexus analyses have shown that the building blocks identified as part of developing the conceptual framework are a useful way of categorising policy agendas that contribute to urban environmental sustainability.

10.2 COVID-19 pandemic and urban environmental sustainability

The COVID-19 pandemic has had many wide-ranging impacts in cities. It is likely to remain intertwined with policymaking and actions across sectors and affect the transition towards urban environmental sustainability in the immediate and longer terms.

As the pandemic is ongoing and its duration is uncertain, its overall implications for the nexus policy areas and progress towards the nexus objectives is unclear. However, many of the challenges and actions identified in the nexus analysis will be influenced by the response to and need to recover from the pandemic. For example:

- **For spatial planning —** implications for land use because of the additional demand for accessible public spaces, the potential decline in daily commuting and the preference for suburban living.
- **For transport** — infrastructure changes due to the demand for improved accessibility and active transport and to the potential ongoing reduction in public transport use because of fears over safety.
- **For the built environment** — demand for better-quality housing, as more people are spending more time at home and because of changes in building functions, with office buildings potentially being converted to alternative uses such as housing.

- **For resources and materials** — changes in urban and regional production and value chains as a result of a potential shift in emphasis to more resilient and local supply chains.

- **For energy** — an anticipated economic recession is likely to affect the funds available for investment in clean energy, as with other investments, and disruptions to the supply chain are likely to delay installations.

The nexus analysis also suggest that cities may have an opportunity to take advantage of the moment to implement policies and action that maximise co-benefits across sectors and support a green recovery.

10.3 Maximising co-benefits and avoiding trade-offs

The analysis of the eight nexuses highlights the relationships and interactions between them. Firstly, they have both thematic links (e.g. the suggested clusters of 'environment and society' nexuses and 'resources and energy' nexuses) and hierarchical links (e.g. higher-level nexuses such as 'climate resilience' and 'closing the loop', and more specific nexuses such as 'food security' or 'clean energy'). Secondly, the nexuses are interlinked by the specific actions and interventions. As highlighted in Table 10.1, policy and action intended to help achieve one nexus objective can lead directly to and/or have co-benefits and trade-offs for achieving other nexus objectives.

For example, climate adaptation and mitigation measures are key to achieving the 'climate resilience' objective, but also contribute to achieving the following objectives: 'quality of life' (e.g. through action to create or enhance green spaces); 'urban accessibility' (e.g. through action to create space for cycling and walking); and improved 'environment and health' (e.g. where creating green space or encouraging active travel leads to better air quality, reduced noise pollution and improved management of the urban heat island effect).

The nexus analysis also helps to illustrate that a lack of coordinated and integrated policy and action can result in trade-offs. For example, in the case of the 'urban accessibility' nexus, if not carefully integrated with other measures to improve urban connectivity and sustainable mobility, actions such as those aiming to increase urban density could lead to trade-offs. These could include increased traffic congestion and associated air pollution and noise; reduced availability of and access to urban green spaces; and accelerated gentrification and increases in house prices. Such outcomes could conflict with the 'quality of life, 'environment and health' and 'climate resilience' nexus objectives.

10.4 Identifying cost-effective policy and interventions

As noted above, the example nexus assessments show that some actions provide opportunities to deliver multiple benefits simultaneously across urban sustainability objectives. Maximising the benefits of coordinated and integrated policy and action has the potential to achieve urban sustainability objectives in a cost-effective way. Policy and action related to green infrastructure (GI), promoting public and active transport modes and sustainable buildings provide good examples, as illustrated in Box 10.1. Clearly, just generating multiple benefits does not necessarily mean that the action has achieved the combined benefits in a cost-effective way. Such an assumption needs to be compared with achieving the same benefits in an unintegrated way. However, it is likely that this approach will be cost-effective.

10.5 The role of cities in delivering urban environmental sustainability: top down and bottom up

The analysis of the selected urban nexuses supports the assertion that cities are well placed to be leaders in delivering the transition to a low-carbon sustainable economy, through their ability to address many of the systemic challenges that Europe faces. It should be noted, however, that this is also partially a result of the nexuses being selected for their relevance to cities and city governance. Nonetheless, for most of the policy areas across the nexuses, the role of cities is well defined (e.g. transport, housing, spatial planning). This enables cities to design, resource and implement sector-specific policy and actions without necessarily requiring reform of the policymaking process at national and/or EU levels. For example, cities are key actors in setting out and implementing land use and spatial planning policies and standards within their geographical limits, and the solutions required are often location specific.

However, EU and national governments also have an important role in ensuring complementarity between policies at different scales and helping cities to overcome the challenges of achieving the nexus objectives: for example, by setting high-level strategic targets and goals (e.g. related to reducing greenhouse gas emissions), developing clear standards and guidelines, providing financial support (Urbact III (2014-2020)) and promoting knowledge sharing (e.g. Urbact good practices database) and peer-to-peer exchange.

By addressing the urban sustainability challenges, cities can also play a pivotal role in achieving EU policy objectives, for example:

- Developing GI is a key step towards the success of the European Commission's GI strategy and EU biodiversity strategy to 2030.
- Mainstreaming urban adaptation strategies (e.g. in land use planning) can help to achieve the objectives of the EU adaptation strategy.
- Encouraging active transport modes, public transport and car-sharing/-pooling schemes can ensure success in meeting the EU Ambient Air Quality Directive targets and delivering the low-emission mobility strategy.
- Minimising waste generation and maintaining the use and value of products, materials, built assets and land can help to meet the objectives of the EU action plan for the circular economy.
- Transition to decentralised clean energy production in cities could help meet the objectives of the EU 2030 climate and energy framework.

By addressing challenges and progressing these policy objectives, cities play a key role in delivering the urban agenda for the EU.

Box 10.1 Examples of co-benefits

Developing and improving green infrastructure in cities can help to deliver multiple objectives including:

- 'Climate resilience' — reducing flood risk and urban overheating.
- 'Environment and health' — reducing air and noise pollution and encouraging active travel.
- 'Quality of life' — improving people's satisfaction with where they live.

The 'urban accessibility' nexus highlights that transit-oriented development and promoting active transport modes can help to achieve:

- 'Environment and health', 'quality of life' and 'climate resilience' objectives through, for example, improved air quality, increased physical activity levels, improvements in the quality of urban places and reduced greenhouse gas emissions.

Action to achieve the 'sustainable buildings' objective can also support:

- 'Closing the loop' — improving the management of construction waste and the use of resources and materials in construction.
- 'Clean energy' — using rooftops to produce clean energy.
- 'Climate resilience' — using sustainable heating and cooling sources to adapt buildings to a warmer climate and reduce the associated greenhouse gas emissions.
- 'Environment and health' — through well-insulated housing that has better indoor air quality and reduced exposure to outdoor noise and protects against heat and cold.
- 'Quality of life' — designing housing in which residents feel comfortable and safe.

10.6 New governance approaches to achieving urban environmental sustainability

Addressing the challenges of achieving urban sustainability will potentially require changes to existing governance approaches, which are often short term, sectoral and siloed. The assessments of the nexus examples highlight the importance of systematic identification of conflicts and barriers across policy sectors and the need for horizontal and vertical integration and coordination of measures.

Horizontal integration of measures will require an understanding of processes and objectives across sectors that might be resource intensive. To achieve vertical integration of measures the importance of multi-level governance is evident in several nexuses. For example, some policy areas (e.g. transport, built environment) relevant to achieving 'urban accessibility' and 'climate resilience' objectives are potentially managed by different stakeholders at different spatial levels. Achieving coordination between the key actors from different governance levels (e.g. EU, national, city) will help move cities towards reaching their urban sustainability objectives.

Achieving urban environmental sustainability will also require giving a greater say and more power to all residents, especially to the socially and economically disadvantaged, in urban decision-making. Participatory governance is an example in which citizens are involved in the planning and designing of strategies. As an approach to governance and decision-making, this can facilitate

10.7 Citizens and communities are at the heart of the transition

Moving towards greater urban environmental sustainability requires acknowledgement that people are a fundamental part of the various systems (food, energy, transport, etc.). To change such systems means engaging with citizens in designing and implementing solutions and encouraging sustainable behaviours. For example, the 'closing the loop' nexus highlights the value of community-led initiatives such as repair-cafes, which enable citizens to drive sustainable change in their communities.

Across all nexuses, in order to be truly effective, equitable action and collaboration must be central to any policy responses. Vulnerable groups are often the most affected by poor urban conditions (e.g. air quality, road traffic noise, access to green space) and are also the least able to benefit from improvements, as they are often not part of the decision-making process. Decision-makers in cities need to ensure that achieving urban sustainability objectives does not come at the expense of the most vulnerable urban residents and that their needs are central to urban environmental sustainability objectives.

10.8 Indicators and data measuring progress towards urban sustainability

There is a varying availability of data and information on urban sustainability from sources managed and/or owned by EU agencies including the EEA and EU institutions, including the Commission (Eurostat, Joint Research Centre and thematic directorates-general), to support nexus assessments.

It is evident that there is an abundance of quantitative contextual indicators focusing on a single topic (e.g. environmental quality, land use, transport and energy) in an urban context. In contrast, for some topics, such as urban agriculture and food systems, there are more limited sources of data, indicators and examples. The nexus approach would also benefit from the use of more complex composite indicators to provide evidence on the challenges of urban sustainability. From the eight example nexuses there is a limited number of such indicators already available that could support such assessment, but the process has started to identify indicators that it could potentially be a priority for development.

Some urban sustainability objectives could make use of qualitative evidence as well as quantitative evidence. For example, assessing the quality of life aspects in urban environments through quantitative indicators that look at the physical environment will not provide a comprehensive characterisation of this issue. Infrequent updates and lack of standardisation and comparability of cross-country data for cities are also issues that need to be addressed to support the assessment of urban sustainability.

The nexuses used in this analysis are framed around an objective (e.g. clean energy, accessibility) and selected interacting policy areas. Measuring progress towards these objectives could be achieved by either using existing overarching indicators or indices or creating new ones. The results of an initial overview of potentially relevant indicators for each nexus are presented in Annex 1.

10.9 Using the nexus approach to improve urban policy integration

In applying the nexus approach in an urban context, the assessment successfully identified opportunities for improving policy coordination and integration to achieve selected urban sustainability objectives. This approach can be useful for decision-makers, as it encourages communication and coordination to help realise co-benefits from policies and action across policy areas. It can also help to uncover

potential blind spots in decision-making processes that lead to unintended consequences and undermine progress in other policy areas or aggravate existing challenges for cities. This is achieved by highlighting potential trade-offs.

An important aspect of the nexus approach is to identify key actions in the context of meeting the selected urban sustainability objectives (e.g. climate resilience, clean energy). Here the conceptual framework is particularly useful, as it proposes the application of lenses and building blocks. Depending on the perspective of the selected lens (e.g. circular city, resilient city), this can help to identify the focus of analysis and potential critical policy agendas. By categorising the actions under policy agendas (see Table 10.1) the buildings blocks are shown to provide a useful and relatively comprehensive set of relevant actions that contribute to urban environmental sustainability. Annex 1 identifies potential indicators for monitoring outcomes related to each nexus. To measure wider progress towards urban environmental sustainability, future work on indicators could usefully explore existing indicators or develop new ones to measure progress against the identified policy agendas.

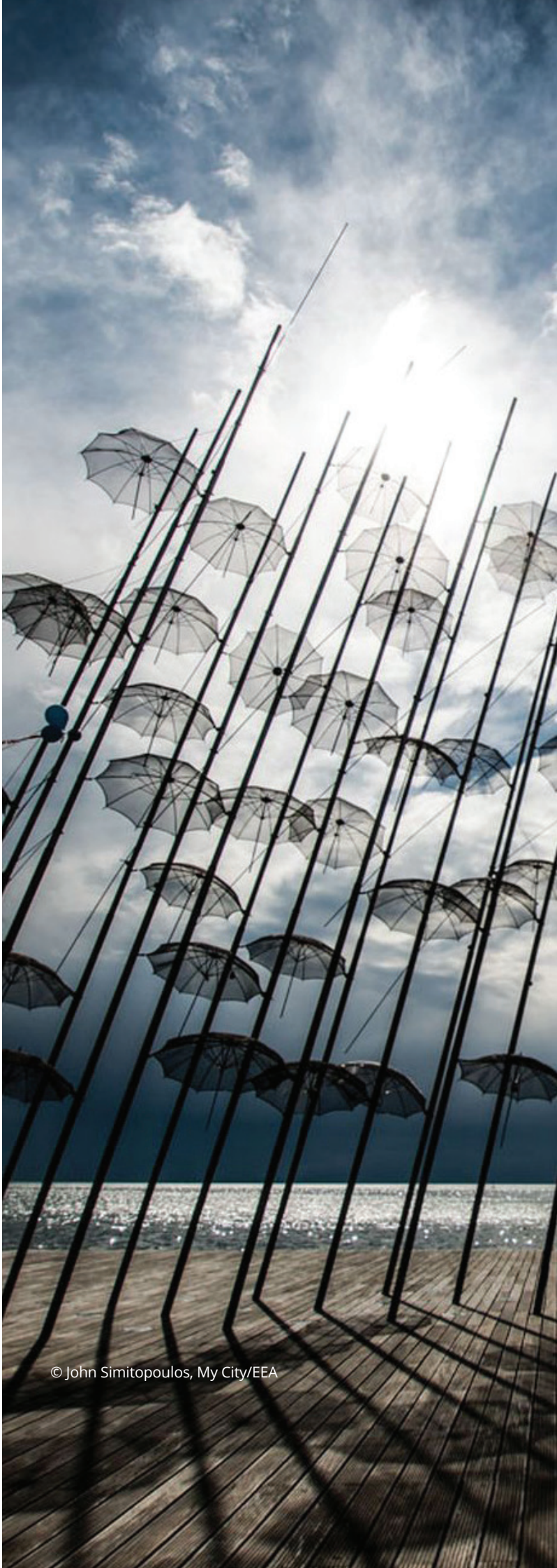
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Table 10.1 Policy agendas for achieving urban environmental sustainability objectives (cont.)

Policy agendas	Examples of specific actions from the nexuses
Improving urban environmental quality	• Introducing policies that reduce car use and motorised traffic (e.g. improved frequency and availability of public transport, reducing speed limits, restricting access and reallocating road space) and reduce air and noise pollution. • Using nature-based solutions and/or creating or improving GI to achieve multiple benefits, including reducing air, water and noise pollution.
Building adaptive capacity and reducing vulnerability to climate change	• Linking adaptation and mitigation policies and investments to maximise synergies. • Using land use planning policies to create space for water. • Using nature-based solutions to regulate water flows and mitigate flooding. • Developing policies and design standards to create cooling through greening measures. • Preparing comprehensive resilience strategies.
Improving the quality of and access to public open space and creating or improving GI and urban ecology	• Using standards such as the Green Space Factor to determine GI requirements for existing and new developments. • Designing green space and GI for multiple uses and benefits, including active transport, environmental quality, social meeting points, biodiversity conservation and enhanced quality of life. • Introducing urban containment boundary policies to create 'hard' edges between cities and the countryside.
Supporting urban agriculture and food systems	• Promoting urban agriculture though small-scale innovation projects. • Providing incentives and building capacity among start-ups and community-based food-related innovation projects.
Increasing the production of renewable energy, reducing energy consumption/demand and improving energy efficiency	• Integrating spatial planning and built environment policies to ensure that the orientation and spacing of new buildings allows for solar photovoltaic installations on roofs and walls. • Planning and integrating clean energy generation within new infrastructure developments. • Developing local building codes and sustainable design standards that promote reducing energy consumption and improved energy efficiency in buildings and reduce running costs. • Providing information and services to encourage behaviour change (e.g. public awareness campaigns) to reduce energy demand; measures to make the energy transition affordable.
Reducing material use and waste and improving resource efficiency	• Restructuring organisations, introducing policies, investing and training workforces to reduce material consumption, encourage material repair and reuse, and find uses for and value in waste as a resource. • Developing local building codes and sustainable design and retrofitting standards that promote resource efficiency and reduced material use and waste in building construction and use, including reduced maintenance costs. • Setting up consumer repair and reuse hubs by working with communities, civil society and the private sector. • Investing in the waste management infrastructure to minimise waste and maximise reuse and repair. • Introducing systems to support urban agriculture as part of the wider circular economy and resilience efforts.
Using digital technology	• Developing initiatives to use developments in telecommunications and e-commerce to reduce need for conventional transport. • Using technology that provides real-time information about available food (e.g. donation-matching software).

Table 10.1 Policy agendas for achieving urban environmental sustainability objectives (cont.)

Policy agendas	Examples of specific actions from the nexuses
Improving urban connectivity and sustainable mobility	• Using economic incentives (e.g. road pricing, congestion charging) or regulations (e.g. parking restrictions, speed limits) to encourage a shift to active transport modes. • Providing information and services to encourage behaviour change (e.g. public awareness campaigns) to shift away from cars and towards walking, cycling and public transport. • Introducing policies to cluster new developments around existing transport nodes and routes to promote transit-oriented development. • Introducing policies to promote car-free cities.
Strengthening transitions to a green economy	• Running awareness-raising campaigns, setting up networks and capacity building among citizens and businesses on the economic opportunities of the circular economy (e.g. new jobs, reduced costs, supply security).
Enhancing the built environment and physical infrastructure	• Introducing policies and initiatives to promote regeneration through pedestrianisation schemes and greening 'grey' areas or brownfield sites. • Integrating clean energy generation within new infrastructure developments.
Improving the quality of housing stock	• Retrofitting buildings to improve environmental performance (e.g. energy efficiency) and reduce greenhouse gas emissions. • Setting targets and providing tools to encourage sustainable building design and construction.
Promoting integrated, long-term spatial planning and policymaking	• Using land use planning policies to develop and protect GI for flood management. • Bringing municipalities together to coordinate transport across a wider metropolitan area. • Developing circular city strategies, polices and/or roadmaps.
Enhancing social and environmental justice	• Proofing investments in greening existing urban spaces to ensure that they benefit low-income residents and avoid 'green' gentrification. • Designing climate adaptation and mitigation interventions to address the needs of most vulnerable groups.
Promoting participation and empowerment of stakeholders and citizens	• Using land use planning to empower stakeholders to contribute to both food security and community cohesion. • Involving citizens, businesses and other stakeholders in the development and design of strategies or plans (e.g. adaptation and mitigation, circularity).
Encouraging partnerships and community-led initiatives and facilitating social innovation	• Facilitating community-civil society-private sector partnerships to set up consumer repair and reuse hubs (e.g. urban resource centres). • Removing legal barriers to make community and/or private investment in decentralised clean energy systems easier.

Abbreviations and symbols

BEA	Barcelona Energy Agency
BREEAM	Building Research Establishment Environmental Assessment Method
C2C	cradle-to-cradle
CO_2	Carbon dioxide
EC	European Commission
EEA	European Environmental Agency
EIB	European Investment Bank
ERDF	European Regional Development Fund
ETC	European Topic Centre
ETC/CCA	European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse gas
GI	Green infrastructure
GIZ	Gesellschaft für Internationale Zusammenarbeit
ICLEI	International Council for Local Environmental Initiatives (also known as Local Governments for Sustainability)
IEA	International Energy Agency
ISO	International Organization for Standardization
ITU	International Telecommunication Union
Jessica	Joint European Support for Sustainable Investment in City Areas
JRC	Joint Research Centre
LEED	Leadership in Energy and Environmental Design
NbS	Nature-based solutions
NGO	Non-governmental organisation
NO_2	Nitrogen dioxide
O_3	Ozone
OECD	Organisation for Economic Co-operation and Development
PM_{10}	Particulate matter (diameter 10 µm or less)
$PM_{2.5}$	Fine particulate matter (diameter 2.5 µm or less)
PTAL	Public transport accessibility level
PV	Photovoltaic
QoL	Quality of life
SDG	Sustainable Development Goal
SOER	The European environment — state and outlook report
STO	Solar Thermal Ordinance
TOD	Transit-oriented development
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WBDG	Whole Building Design Guide
WEEE	Waste electrical and electronic equipment
WHO	World Health Organization

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Annex 1 Potential urban nexus indicators

Table A1.1 sets out the results of an initial overview of potentially relevant indicators for each nexus. Where they are available, potential indicators for each key nexus issue are proposed (i.e. an overall indicator or indicator set related to the nexus objective) and for measuring nexus outcomes.

The following resources were used in identifying the potential indicators: stakeholders suggestions made in workshops and during the review of this report; EEA indicators ([116]); the Joint Research Centre's *European handbook for SDG voluntary local reviews* ([117]); and the ETC-ULS report on *Indicators from screening study on indicators for local SDG implementation.*

A range of other potentially relevant indicator sources exist. These have not been included in this overview, given the very large number of indicators they contain. If a city or other authority wished to expand or adapt a nexus analysis to their case, these sources could prove valuable additional information on indicators and measuring progress. Other relevant sources include:

- International Organization for Standardization (ISO) indicators for 'Sustainable cities and communities — Indicators for city services and quality of life' (ISO 37120:2018) ([118]): a set of more than 100 indicators relating to a range of aspects of city services and urban quality of life (QoL) that could be relevant to many nexuses (e.g. energy, environment and climate change, housing, waste, water and transport).
- ISO indicators for 'Sustainable cities and communities — Indicators for resilient cities' (ISO 37123:2019) ([119]): a set of more than 60 indicators relating to a range of aspects of urban resilience that could be relevant to the climate resilience nexus but also to a range of others. Indicator topics in this set include energy, environment and climate change, finance, governance, population and social conditions, urban agriculture and food security.
- ITU (the International Telecommunication Union) 'Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals' ([120]) ([121]). A large number of indicators are proposed under 19 distinct topics, many of which could be of relevance to nexus outcomes, including physical infrastructure, a range of environmental indicators, health, housing and social inclusion.
- National-level statistical bodies and environment agencies are likely to provide potentially valuable indicators, indicator sets and data, which may also be disaggregated to sub-national including city/urban area level.

Note that in proposing a potentially relevant indicator, clearly for it to be used it would need to be available for just urban areas and/or the particular city of interest. Currently the data may not be available to this level of disaggregation.

([116]) Using EEA indicators online (https://www.eea.europa.eu/data-and-maps/indicators/#c0=30&c12-operator=or&b_start=0) and not a comprehensive review of EEA reports and documents at this stage.
([117]) https://publications.jrc.ec.europa.eu/repository/bitstream/JRC118682/european_handbook_for_sdg_voluntary_local_reviews_online.pdf
([118]) https://www.iso.org/obp/ui/#iso:std:iso:37120:ed-2:v1:en
([119]) https://www.iso.org/obp/ui/#iso:std:iso:37123:ed-1:v1:en
([120]) https://www.itu.int/rec/T-REC-Y.4903-201610-I/en
([121]) https://www.itu.int/en/ITU-T/ssc/united/Pages/default.aspx

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators
Climate resilience	**Nexus issue indicators:** • No specific resilience indicators/indices identified • The importance of building climate resilience can be measured by indicators of climate change (e.g. temperature, extreme events) and of climate exposure/vulnerability in cities **Potentially relevant EEA indicators:** • None directly relevant to resilience in cities EEA indicators cover various aspects of climate change (e.g. floods, droughts, precipitation, temperature/heat and health). These are not disaggregated to city levels. **Indicators from European handbook for SDG voluntary local reviews:** • People affected by disasters • Urban flood risk • Heat vulnerability **Indicators from Screening study on indicators for local SDG implementation:** This report proposes a lot of indicators, all of which are potentially relevant but would make a long list. A few examples are listed here: • Resilience plans (yes/no) • Climate change adaptation strategy and/or action plan (yes/no) • Demonstrate a measurable reduction in vulnerability and/or increase in resiliency to existing community-wide hazard threats over time • Do you mainstream measures into other sectors such as water management, climate mitigation, green spaces or others to use win-win-options? (yes/no) • Has your city taken the following measures to improve its flood resilience? (followed by a list of quite specific adaptation measures, such as rainwater infiltration) **Notes:** To be considered if it would be useful to research whether there are any suitable resilience metrics already developed/proposed suitable for European cities. Sources to review could include publications ([a]) and Horizon 2020 projects ([b]).

Notes: ([a]) e.g. JRC, 2014, Concepts and metrics for climate change risk and development — Towards an index for climate resilient development (https://publications.jrc.ec.europa.eu/repository/bitstream/JRC89538/lb-na-26587-en-n.pdf); OECD, 2018, Indicators for resilient cities (https://doi.org/10.1787/6f1f6065-en); Feldmeyer et al., 2019, 'Indicators for monitoring urban climate change resilience and adaptation (https://www.mdpi.com/2071-1050/11/10/2931).
([b]) e.g. RESIN (http://www.resin-cities.eu/home), RAMSES (https://ramses-cities.eu/home), Smart Mature Resilience (https://smr-project.eu/home).

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators
Quality of life	**Nexus issue indicators:** A range of QoL indices exist. The following indices are currently referred to in the nexus: • Economist Intelligence Unit Global Liveability Index ([c]) • Mercer quality of living ([d]) city ranking Eurostat has also developed a set of QoL measures (11 dimensions). Data are currently available only at national level, but it could be investigated whether they could be disaggregated to cities and urban areas: https://ec.europa.eu/eurostat/cache/infographs/qol/index_en.html **Potentially relevant EEA indicators:** • Exceedances of air quality limit values due to traffic • Exposure of EU population to environmental noise **Thermal comfort indicators (EEA ([e])):** • The number of days with a maximum temperature exceeding 30 °C and a minimum temperature above 20 °C per year • The number of cooling degree days per year • The number of heating degree days per year Individual topics/dimensions in the Eurostat QoL indicator set correspond with QoL elements. **Indicators from European handbook for SDG voluntary local reviews:** • Percentage of population without green urban areas in their neighbourhood **Indicators from Screening study on indicators for local SDG implementation:** Under Sustainable Development Goal (SDG) 11 there are a very large number of specific indicators that could be relevant, but they may be too specific; examples include: • Air quality index/emissions of pollutants to air • Population living in households suffering from noise (%) • Percentage of people living within 300 m of a public open area • Percentage of inhabitants with accessibility to green areas • Public outdoor recreation space (m^2) • Percentage of city designated as a pedestrian/car-free zone • Natural areas in city (%)

Notes: ([c]) https://www.eiu.com/topic/liveability
([d]) https://mobilityexchange.mercer.com/Insights/quality-of-living-rankings

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators
Accessibility	**Nexus issue indicators:** • PTAL (public transport accessibility level) — measured by distance to public transport • ATOS (access to opportunities and services) **Potentially relevant EEA indicators:** • Transport emissions (EU figure) ([f]) **Indicators from European handbook for SDG voluntary local reviews:** • Journeys to work by public transport • City transport performance • Access to public transport **Indicators from Screening study on indicators for local SDG implementation:** Large number of specific indicators under SDG 11/target 11.2, including: • Compactness (of urban area) • Percentage of population living withing 500 m of public transit running at least every 20 minutes in peak periods • Public transport network and length of cycle paths/lanes (both km/100 000 inhabitants) **Other indicators (EU):** • Costs of congestion (EU figure) ([g]) • Costs of road accidents ([h])

Notes: ([f]) EEA (2018c).
([g]) EC (2017).
([h]) EEA (2018a).

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators

Environment and health	**Nexus issue indicators:**
	• No overall indicators identified
	See also QoL and accessibility nexuses — active transport/green space
	
	Potentially relevant EEA indicators:
	• Premature deaths from air pollution:
	  • Premature deaths due to exposure to $PM_{2.5}$
	  • Premature deaths due to exposure to NO_2
	  • Premature deaths due to exposure to O_3
	• Premature deaths from noise pollution (EU)
	• Exposure to noise pollution (EU urban areas) ([i])
	• Exposure to air pollution above standards (EU urban areas) ([j])
	• Contribution of mobility to air pollution (%) ([k])
	
	Indicators from European handbook for SDG voluntary local reviews:
	• Population exposed to NO_2 concentration
	• Urban greenness
	
	Indicators from Screening study on indicators for local SDG implementation:
	• Does city have an air quality action plan? (yes/no)
	• Air Quality Index/exceedances of limit values
	• Number of days with good/healthy air quality
	• Does city have a noise map and action plan? (yes/no)
	• Population exposed to harmful environmental noise (%)/levels above Environmental Noise Directive reporting thresholds

Notes: ([i]) EEA (2019d).
([j]) EEA (2019a).
([k]) EEA (2019c).

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators
Food security	**Nexus issue indicators:** • Level of food security in population (food insecurity experience scale). From Screening study on indicators for local SDG implementation. Note: data not available at city scale **Potentially relevant EEA indicators:** • None directly relevant **Indicators from European handbook for SDG voluntary local reviews:** • Soup kitchens for people who cannot afford food **Indicators from Screening study on indicators for local SDG implementation:** • Level of food security in population (food insecurity experience scale) • Presence of food policies, targets and programmes focused on vulnerable groups • Various indicators on access to/need for food aid/support • Total consumer expenditure on 'local food' • Distance from households to health food retail outlets by income group (to identify 'food deserts') • Number of urban agriculture/community gardens within city/region/in low-income areas (per 100 000 inhabitants) **Other suggested possible measures:** • Proportion of food consumed in the city that is grown there • Percentage of population with access to food grown in urban area, with break-down by area/socio-economic group (to measure equality of access) • Location of foodbanks and proportion of residents reliant on them • Proportion of residents in 'food poverty' and/or regularly eating fruit and vegetables/with breakdown by area/socio-economic group • Number and distribution of community gardening/farming projects/percentage population able to access them

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators
Closing the loop	**Nexus issue indicators** • There is a comprehensive set of indicators for the circular economy in cities proposed as part of the EU urban agenda ([l]) • Other possible overarching indices also exist but are largely theoretical, such as CCAF — circular city analysis framework ([m]) **Potentially relevant EEA indicators:** • Waste generation (in Europe) • Waste recycling • Diversion of waste from landfill • Percentage land recycled in urban developments ([n]) **Indicators from European handbook for SDG voluntary local reviews:** • Local recycling rates • Urban waste per capita **Indicators from Screening study on indicators for local SDG implementation:** • Implementation of circular economy measures/action plans (yes/no) • Number of initiatives promoting/enabling sharing, reuse and repair and circular economy business models • Projects/action to increase skills/jobs related to green/circular economy (yes/no) **Eurostat indicators** • Eurostat has developed a set of indicators for the circular economy (o) including those related to rates of circular material use, waste management, secondary raw materials, and competitiveness and innovations. These are EU-level indicators and would need to be adapted to the city level

Notes: ([l]) EC, 2019, Urban agenda for the EU: Indicators for circular economy transition in cities — Issues and mapping paper (https://ec.europa.eu/futurium/en/system/files/ged/urban_agenda_partnership_on_circular_economy_-_indicators_for_ce_transition_-_issupaper_0.pdf).
([m]) Calvaleiro de Ferreira and Fuso-Nerini, 2019, 'A framework for implementing and tracking circular economy in cities: the case of Porto' (https://www.mdpi.com/2071-1050/11/6/1813).
([n]) EEA (2019a).

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators
Clean energy	**Nexus issue indicators:** • Percentage of (EU) energy production from fossil fuels/renewables (P) (would require city-level data) From Screening study on indicators for local SDG implementation: • Energy generated locally from renewable resources (%) • Energy consumed in the city that comes from renewable sources **Potentially relevant EEA indicators:** • Share of renewables in final energy production (EU) • Final energy consumption by fuel type and sector (to be updated in 2021 to include both final and primary energy consumption) • Share of renewable energy in gross final energy consumption in Europe • Overview of electricity production and use in Europe The EEA is proposing two new indicators in 2021: • CO_2 emissions and emissions intensity of household energy use • Air pollutant emissions and emissions intensity of household energy use **Indicators from European handbook for SDG voluntary local reviews:** • Technical photovoltaic potential **Indicators from Screening study on indicators for local SDG implementation:** Large number of indicators related to energy in cities, including: • City strategy/policies/targets for renewable/low-carbon/clean energy supply (yes/no) • Energy generated locally from renewable resources (%) • Energy consumed in the city that comes from renewable sources • Solar power generation in public buildings • Installed wind power **Other suggested possible measures:** • Proportion of energy generated inside city compared with that imported from outside city/by generation type (renewable, coal, gas, nuclear, etc.) • Proportion of energy generated and/or demand (of city) met by local/small-scale renewable generation vs large-scale renewable + location of generation

Note: (P) Eurostat (2020).

Table A1.1 Urban nexus indicators — selected key nexus issue and nexus outcome indicators (cont.)

Nexus	Potential nexus issue and outcome indicators
Sustainable buildings	**Nexus issue indicators:** • None identified **Potentially relevant EEA indicators:** • None directly relevant **Indicators from European handbook for SDG voluntary local reviews:** • None identified that are specifically relevant **Indicators from Screening study on indicators for local SDG implementation:** • Has city implemented measures in support of sustainable buildings? (yes/no) • Promotion/support of use of rainwater in residential buildings (yes/no) • Energy consumption of residential buildings • Promotion of energy saving renovations (residential buildings) (yes/no) • Climate-robust buildings • Energy-efficient buildings standards • Percentage of area of public buildings with sustainability certification for ongoing operations **Other indicators:** • Percentage of waste in the EU that is construction/demolition waste • Percentage water and energy use/consumption by households ([q]) ([r]) • Percentage of the existing building stock in the EU that is energy inefficient ([s]) **Other suggested possible measures:** • Proportion of new buildings/retrofitted buildings attaining highest sustainability ratings (e.g. BREEAM) • Proportion of construction resources/material reused or from secondary sources (vs new/virgin) • Average energy/water use per household (per day) as proxy for more efficient buildings/systems

Notes: ([q]) EEA (2019a).
([r]) Eurostat (2019).
([s]) BPIE, 2017, Factsheet: 97% of buildings in the EU need to be upgraded (http://bpie.eu/wp-content/uploads/2017/10/State-of-the-building-stock-briefing_26Ott_v1.pdf).

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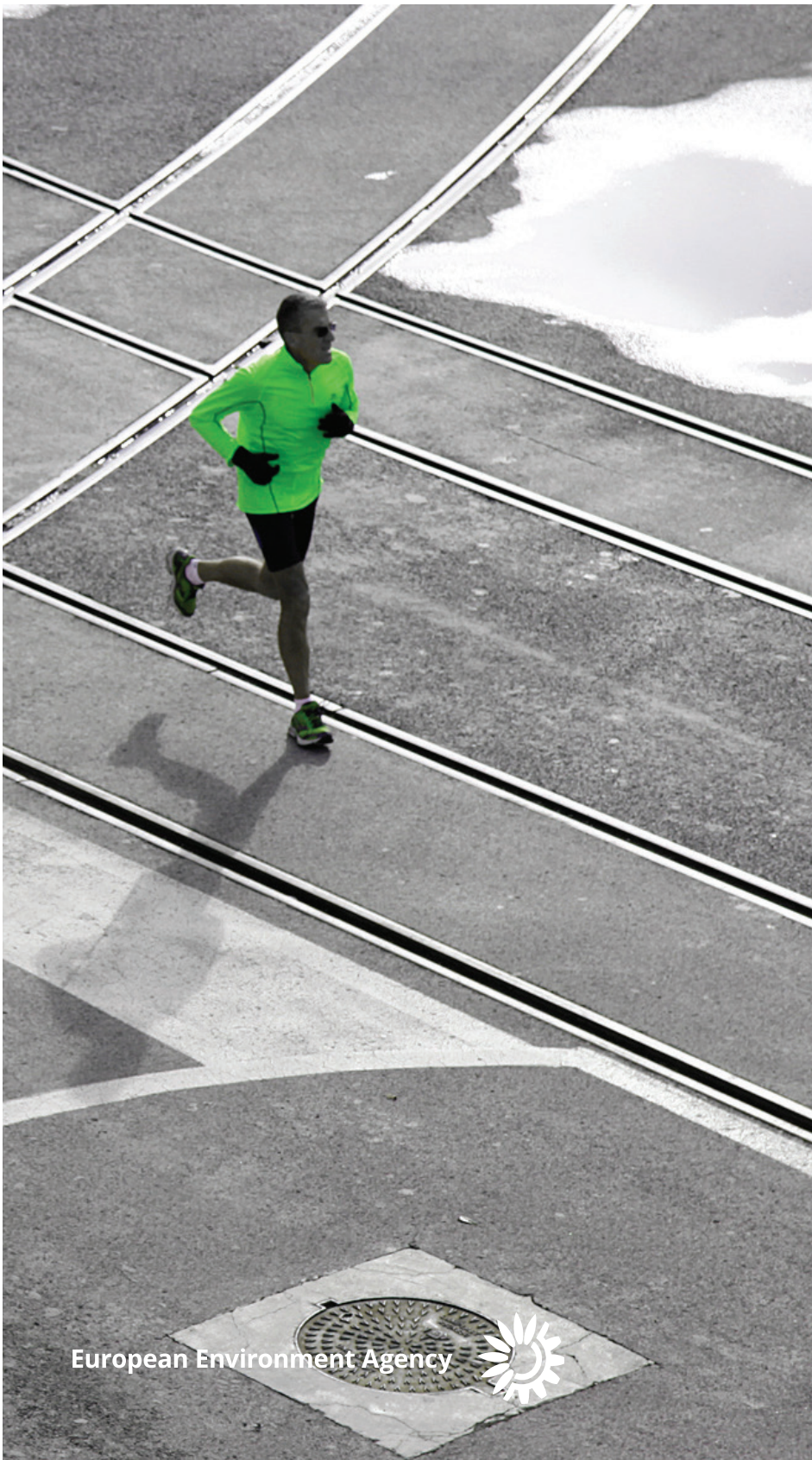

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