

PLANNING AND AGRICULTURE: SUSTAINABILITY AND CLIMATE CHANGE ACROSS DISCIPLINES

Alberto BONORA^{1,2}

¹Università IUAV di Venezia

²Università La Sapienza di Roma

Abstract

This chapter explores the evolving relationship between agriculture and spatial planning, arguing for an integrated and agroecological perspective in territorial governance. While agriculture has long been treated as a sectoral domain or residual land use, it is increasingly recognised as a multifunctional infrastructure that supports ecological balance, food systems, cultural identity, and climate resilience. The chapter critically examines how planning tools and policies can valorise the ecosystem services provided by agricultural landscapes, while addressing the challenges posed by land abandonment, urbanisation, and climate change. Through a series of Italian case studies—ranging from regional landscape plans and peri-urban agricultural parks to LEADER programmes and community gardens—the chapter demonstrates how participatory governance and cross-scalar planning can support sustainable rural development. Emphasis is placed on the need for a systemic approach that bridges technical knowledge and local practices, reconnects urban and rural territories, and aligns spatial strategies with the Sustainable Development Goals. Ultimately, the chapter advocates for a cultural and operational shift in planning: one that positions agriculture not as a constraint, but as a strategic resource for resilient and regenerative territorial futures

Keywords: *Agroecology, Spatial planning, Ecosystem services, Rural governance, Land use.*

1. INTRODUCTION

In recent decades, agriculture has taken a central role in debates about sustainability and the resilience of both rural and non-rural areas, particularly in light of the environmental and social pressures imposed by climate change, urbanization, and the degradation of natural resources. The intensification of extreme weather events, the progressive loss of fertile soils, and the growing competition for land use have brought to the fore the need to rethink the role of agriculture beyond its productive function. At the same time, the growing disconnection between urban and rural areas has generated new forms of spatial fragmentation, eroding the ecological and cultural continuity that historically linked agricultural practices to territorial identity. The relationship between land use, agricultural production, and spatial planning has thus become a crucial issue that can influence not only quality of life and food security, but also the preservation of biodiversity, the maintenance of ecosystem services, and the reactivation of local economies. In this context, agriculture emerges as both a pressure factor and a potential driver for transformation, depending on the strategies adopted by institutions, communities, and planning frameworks.

Spatial planning and territorial design disciplines are therefore called to engage in a renewed dialogue with the world of agriculture—one that is no longer sectoral or residual, but central to the construction of integrated and adaptive development models. Such dialogue must recognize the multifunctionality of agricultural landscapes, their cultural and symbolic value, and their strategic role in climate adaptation and mitigation policies.

This chapter aims to explore the interactions between agriculture and spatial planning in an integrated and systemic way, offering a detailed overview of tools, policies, and case studies that highlight the potential of planning to enhance the ecological, economic, and social functions of agriculture. By addressing this relationship through both theoretical frameworks and grounded practices, the chapter seeks to outline a new planning paradigm capable of responding to the challenges of the Anthropocene.

2. THE ROLE OF AGRICULTURE IN TERRITORIAL SUSTAINABILITY

Territorial planning cannot consider agriculture solely in its role of food production but must fully acknowledge its deep interdependence with the land and its ability to deliver essential services for both human and ecological systems. Agricultural landscapes are not just productive surfaces—they are living systems that safeguard places, shape identities, preserve biodiversity, and regulate vital biogeochemical cycles. Recognising this broader role is crucial if planning is to contribute meaningfully to climate change mitigation, territorial resilience, and sustainable development.

Well-managed agricultural land contributes to carbon sequestration, biodiversity conservation, regulation of the water cycle, and prevention of hydrogeological instability. Conversely, land abandonment or its indiscriminate conversion into impermeable surfaces—due to urban sprawl, infrastructure, or industrial expansion—results in the irreversible loss of ecosystem functions, fragmentation of habitats, and increased vulnerability to extreme weather events. These dynamics call for a radical revision of

land-use priorities, recognising agriculture as a strategic infrastructure for the ecological functioning of the territory.

In this context, it is useful to adopt the framework of ecosystem services to understand the multiple contributions of agriculture beyond its economic output. These services, increasingly adopted in international environmental and planning policy (e.g. MAES, IPBES, Green Infrastructure strategies), can be grouped into four main categories:

Regulatory services: These refer to the natural processes that agriculture helps maintain, essential for the stability and health of ecosystems.

- Regulation of the water cycle: vegetation and agricultural practices influence water infiltration and retention, contributing to flood prevention and groundwater recharge.
- Climate regulation: crops, particularly agroforestry practices, absorb CO₂, contributing to climate change mitigation.
- Erosion control: vegetated soil cover reduces erosion and nutrient loss, maintaining fertility.
- Biological control: presence of natural predators in the fields (e.g. beneficial insects) that limit the spread of agricultural pests.
- Natural air and water purification: sustainable agricultural systems filter pollutants and improve environmental quality.

Supply services: These are the tangible products derived from agriculture, many of which underpin local economies and food systems.

- Food production: supply of cereals, vegetables, fruit, meat, milk, etc.
- Biomass and energy production: crops for biofuels and timber.
- Renewable raw materials: wool, plant fibres, medicinal plants.
- Water for agricultural use: collection and storage of water for irrigation.

Cultural services: Agriculture is deeply embedded in the cultural fabric of territories, shaping meanings, identities, and forms of belonging.

- Landscape value: traditional agricultural landscapes constitute cultural heritage and identity (e.g. hillside vineyards, terracing).
- Recreation and rural tourism: agritourism, hiking trails, food and wine.
- Education and local knowledge: transmission of agricultural knowledge, preservation of traditions and historical techniques.
- Spirituality and sense of place: many communities link agriculture to ritual and religious practices.

Support services: These services are the ecological foundations that allow all other functions to exist and be sustained over time.

- Soil formation: organic activity and decomposition that generate humus and fertility.
- Pollination: essential for many crops, provided by bees and other beneficial insects.
- Nutrient cycling: rotations and cover crops improve the availability and distribution of nutrients in the soil.
- Agricultural biodiversity: variety of crops, animal breeds and secondary habitats in agricultural fields.

Integrating these ecosystem services into planning processes means redefining agricultural land as a common resource, not merely as a private economic asset. It requires the adoption of tools that can map, monitor, and value these services spatially—such as ecological network planning, soil health assessments, and multi-criteria evaluation systems—so that land-use decisions are guided not just by short-term profitability, but by long-term territorial functionality and equity.

An emblematic example is the Po Valley, where urban pressure has significantly reduced the usable agricultural area, compromising the soil's capacity to absorb rainwater and increasing the risk of flooding. However, virtuous experiences are not lacking: in Trentino-Alto Adige, for example, consortium management of water resources has played a central role in sustainable planning. Local irrigation consortia, often organised on a cooperative basis, collectively manage water resources, guaranteeing efficient and sustainable water distribution, including through modern technologies such as drip systems and catchment basins.

Furthermore, the region has invested significantly in the protection of the traditional agricultural landscape, with incentives for the preservation of dry stone walls, terracing and historical orchards. One example in particular is Val di Non, famous for its apple production. Here, territorial policies have favoured close integration between producers, administrations and landscape protection bodies, maintaining the high aesthetic and environmental quality of the agricultural landscape.

Similarly, in Vinschgau, the integrated use of organic practices, the promotion of local varieties and the enhancement of cultivated alpine landscapes have been key tools for planning that combines economic development and environmental sustainability.

Moreover, multifunctional agriculture - capable of producing not only food, but also the aforementioned social, educational, cultural and environmental services - is gaining increasing relevance in the definition of new territorial strategies. Indeed, it represents a concrete opportunity to revitalise rural economies, fight depopulation and promote innovative forms of local governance.



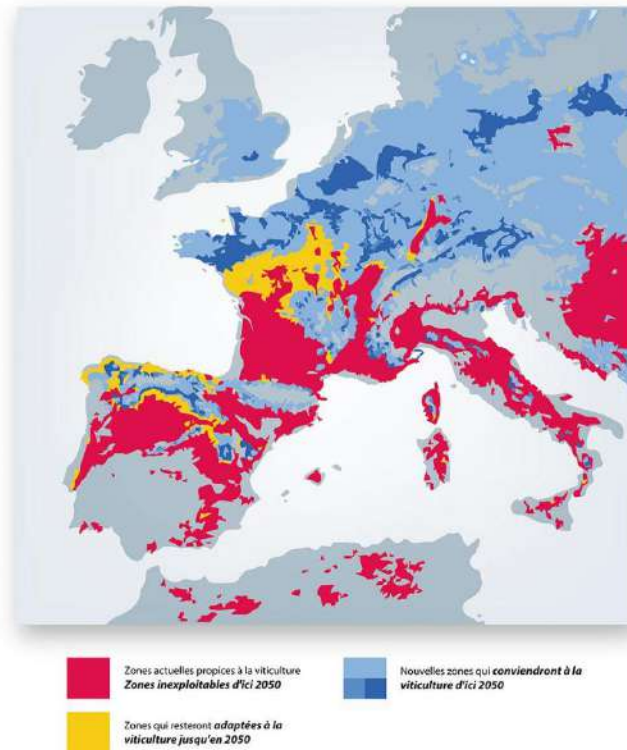
Figure 1 – Val di Non orch

3. CLIMATE CHANGE: HAZARDS AND IMPACTS ON AGRICULTURAL SYSTEMS

Climate change manifests itself through a series of natural hazards that significantly affect agriculture and land use: increased average temperatures, reduced precipitation, and more frequent extreme events such as droughts, heat waves, floods and hailstorms. These phenomena not only put agricultural productivity at risk, but also generate profound impacts on rural communities in terms of food security, economic stability and social cohesion (IPCC, 2022).

According to the FAO (2022), more than 50 per cent of the rural population in Mediterranean countries is already exposed to at least one type of climate risk, with tangible effects on water availability, soil fertility and the spread of plant diseases. In Italy, the shift in cultivation towards higher altitudes and northern latitudes is a phenomenon documented by numerous studies, testifying to a change that is already underway, as shown by the following figure regarding the future grapevine ranges in Europe.

Among the most significant case studies is that of Emilia-Romagna, where rising summer temperatures have compromised the quality of crops such as processing tomatoes, pushing many producers towards more resistant and less water-demanding varieties. The regional sector has managed to distinguish itself for an integrated approach, which has involved agricultural consortia, research bodies and local administrations, leading to the adoption of innovative drip irrigation systems, climate sensors and forecasting models for water management.



*Fig.2: In red are the areas that are currently productive but where vines are expected to disappear. In yellow are the areas currently producing vines that are expected to remain productive in 2050. In blue/blue are the areas where new production will be possible in the future. In grey are areas not taken into account or where there is no viticulture. Source: Payan J-C., 2012 d'après García de Cortázar I., 2006, in *Viticulture et changement climatique: adaptation de la conduite du vignoble méditerranéen*.*

A sustainable supply chain certification system has also been established, which enhances production with a low environmental impact and guarantees high quality standards for consumers. These strategies have not only improved the climatic resilience of crops, but also strengthened the competitiveness of the product in international markets. Similarly, in Sicily, the increase in soil salinity - caused by marine intrusion in coastal territories, accentuated by drought events and the reduction of groundwater recharge - has pushed farms to resort to adaptive techniques. In particular, conservation agriculture has become widespread, with practices such as minimum tillage, organic mulching, the use of cover crops and crop rotation.

These methods, widespread mainly in the provinces of Ragusa and Trapani, have made it possible to improve soil structure, increase its capacity to retain moisture and reduce organic degradation. Moreover, thanks to the support of Rural Development Programmes (RDP) and the collaboration between agricultural cooperatives and local universities, ancient native varieties with high salt tolerance are being recovered, contributing to the preservation of regional agricultural biodiversity.



Fig.3: Example of direct sowing of soybeans on wheat stubble, a conservative soil management practice.

Adaptation to climate change therefore requires an integrated approach, capable of combining technological innovation, agronomic tradition and territorial planning. European and national policies, as they already do through the Common Agricultural Policy (CAP), must continue to support this transition with resources, training and tools consistent with the new climate scenarios.

In this perspective, it becomes increasingly urgent to rethink agricultural policies not only in terms of productivity or competitiveness, but as levers for climate resilience, territorial cohesion, and ecological transition. New planning tools should favour adaptive land uses, incentivize regenerative practices, and support diversification strategies that reduce vulnerability to climate shocks. At the same time, rural and peri-urban areas—often perceived as marginal—must be revalorized as laboratories of innovation and co-evolution, where traditional ecological knowledge can meet digital technologies and landscape planning.

Strengthening the connection between agricultural strategies and spatial policies also means developing cross-sectoral governance frameworks, capable of integrating climate data, land-use planning, and risk prevention in a coherent way. This includes not only supporting farmers in the transition, but also involving local communities, planners, and institutions in the co-design of resilient agro-ecosystems. Ultimately, the challenge is to move from emergency responses to a structural adaptation model, rooted in territorial specificities and informed by both scientific and experiential knowledge.

4. AGRICULTURE AND PLANNING: AN INTEGRATED VIEW

The integration of agriculture and spatial planning represents a crucial challenge today to ensure sustainable and equitable development of territories. Historically, urban planning policies have considered agriculture as a residual element, often relegated to a buffer function or soil reserve for urbanisation. However, a new awareness is emerging: agriculture is not just a productive space, but an essential component of the landscape, culture and local identity.

In this context, spatial planning is called upon to recognise the centrality of agriculture in decision-making processes, adopting tools and approaches that enhance its ecological, economic and social potential. Landscape planning, for example, can play a strategic role in protecting historical agricultural landscapes and promoting the aesthetics of cultivated land. A particularly significant example is the Landscape Plan of the Region of Tuscany, approved in 2015, the first in Italy to have fully integrated the contents of the European Landscape Convention with the tools of territorial governance. This plan was distinguished by a strongly interdisciplinary and participatory approach, involving local authorities, farmers, technicians and citizens. It explicitly recognises agriculture as a constituent element of the Tuscan landscape, emphasising the value of historical agrarian mosaics, traditional crops and local cultivation techniques. In particular, the plan identifies 20 landscape areas, each of which is analysed in detail to identify critical issues and potential, and establishes specific directives for the conservation, redevelopment or innovation of the agricultural landscape.

Riqualificare i rapporti fra territorio urbanizzato e territorio rurale nella pianura di Lucca, tutelando le residue aree naturali e agricole e favorendo la loro integrazione con le aree urbanizzate



Fig.4: examples of fact sheets for landscape areas with information on rural areas

A case in point is the Val d'Orcia, where the hilly landscape cultivated with cereals, vineyards and olive groves has been recognised as a UNESCO World Heritage Site. Here, the plan has provided for measures to protect the visual and functional quality of cultivation, while promoting sustainable agricultural practices and agritourism activities compatible with the landscape context. Moreover, the Tuscan landscape plan has introduced innovative tools such as the guidelines for landscape quality agriculture, which integrate environmental, aesthetic and production objectives. These tools represent a replicable model for other Italian regions, demonstrating that planning can support an agriculture capable of preserving the landscape, enhancing local production and contributing to the resilience of rural territories.

A further significant example is the Regional Territorial Landscape Plan (PPTR) of the Apulia Region, adopted in 2013. This plan stands out for its systemic approach to landscape protection and enhancement, in which agriculture plays a central role as the territory's identity and environmental matrix. The Apulian PPTR has identified traditional agricultural practices and historical agricultural landscapes (such as monumental olive groves, terraced vineyards, trulli and masserie) as cultural heritage to be protected and integrated into sustainable development strategies. One of the most innovative aspects of the plan is the classification of landscape contexts on the basis of their ecological, aesthetic and productive function, accompanied by precise directives and prescriptions for local urban planning. In particular, the plan introduced instruments to limit the consumption of agricultural land, favouring the recovery of the existing rural building heritage and encouraging the multifunctionality of farms. Emblematic cases include the protection of the Ostuni and Valle d'Itria countryside, where the integrity of the agricultural landscape is threatened by strong tourist and residential pressure. The PPTR has constrained new land transformations and promoted the enhancement of extensive and organic farming practices, helping to maintain the balance between conservation and development. In addition, the plan has strengthened the role of municipalities in landscape management through the drafting of General Urban Plans (PUGs), geared towards safeguarding agricultural and natural resources. This integrated approach represents a landscape planning model that recognises agriculture as a strategic component for the well-being of local communities, environmental protection and the promotion of sustainable tourism.

On the other hand, strategic planning on a metropolitan and inter-municipal scale also makes it possible to orient urban development so as not to compromise valuable agricultural areas, favouring the regeneration of disused areas and limiting soil consumption. An exemplary case is represented by the Parco Agricolo Sud Milano (South Milan Agricultural Park), established in 1990, which covers over 47,000 hectares and includes a vast agricultural area between the city and the Lombardy countryside. The park was created with the aim of countering disorderly urban expansion and protecting the agricultural, historical and environmental identity of the area. In this context, planning has played a decisive role in constraining land uses, limiting new construction and consolidating a development model compatible with agricultural and environmental functions.

PATTO CITTA' – CAMPAGNA: aiutarsi reciprocamente a ricostruire la città e il mondo rurale
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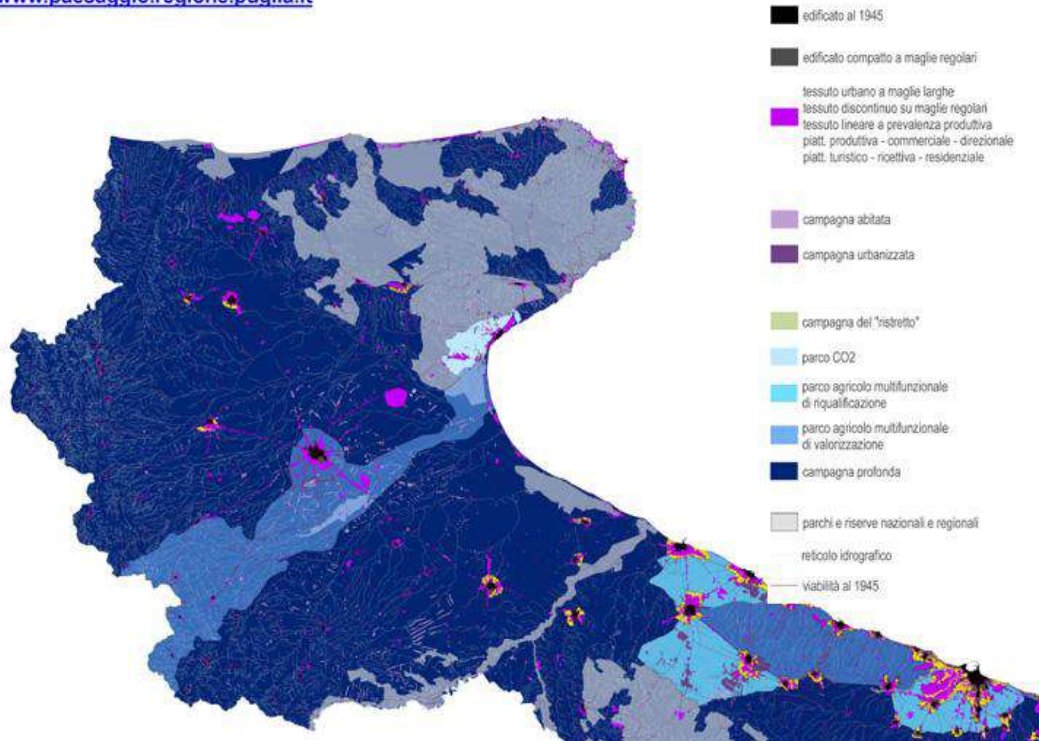


Fig.5: extract from the Apulian PPTR concerning the "City-Countryside" pact

The Park actively promotes sustainable farm management, short supply chains, environmental education activities and the valorisation of the rural heritage. It has also been included in numerous European projects (such as Life and Horizon) aimed at regenerating peri-urban landscapes, promoting social agriculture and creating ecological corridors.

Its role as a "green belt" for the city of Milan has demonstrated the effectiveness of forward-looking planning in containing urbanisation, ensuring local food security and supporting agro-ecological practices. The Park is a model of integrated governance, where farmers, local administrators and citizens work together for the protection and shared enhancement of the territory.

Urban planning can also contribute to mending the fractures between city and country, providing spaces for urban and peri-urban agriculture, community gardens, farmers' markets, short supply chains. The experience of Roma Capitale, with the creation of a widespread system of participatory urban gardens, shows how planning can foster access to healthy food, psycho-physical wellbeing and social cohesion.

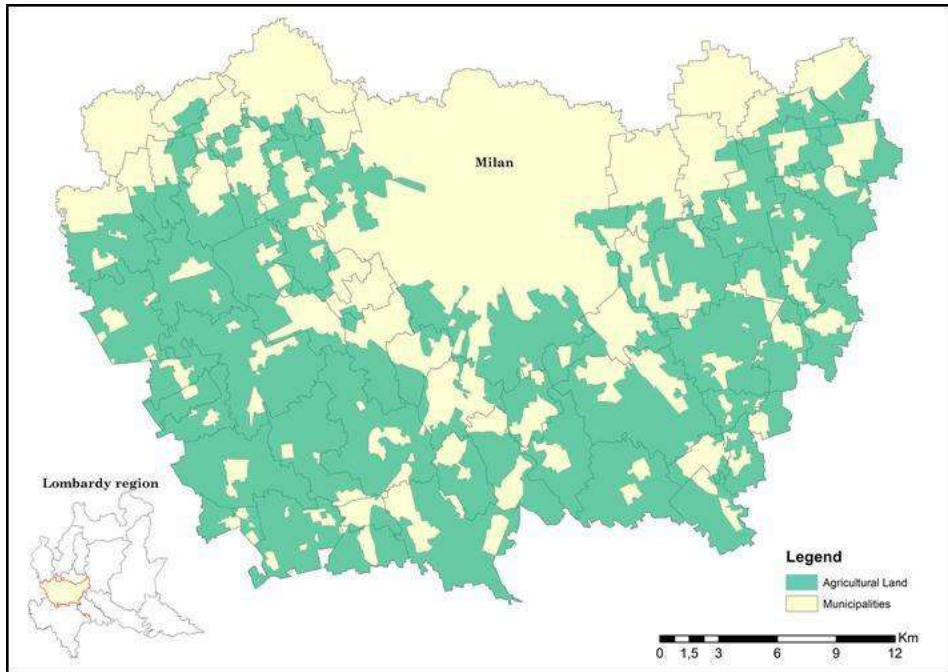


Fig.6: Green belt of the Milan Southern Agricultural Park

In short, an integrated view of agriculture and planning requires a cultural and operational change: we need a systemic vision capable of connecting different scales, of promoting dialogue between technical and practical knowledge, and of recognising the complexity and value of rural and agricultural territories. This renewed vision of agriculture within spatial planning also implies a redefinition of how decisions are made and by whom. Agricultural territories are not static backdrops, but living systems shaped by the daily practices, knowledge, and choices of local actors. Recognizing this complexity requires that planning processes become more open, dialogic, and adaptive—capable of incorporating the voices of farmers, communities, associations, and new rural actors into territorial governance.

From this perspective, the integration of agriculture into spatial planning cannot rely solely on normative frameworks or top-down regulations. It must be supported by participatory tools, shared visions, and governance mechanisms that empower local stakeholders and foster collective stewardship of rural landscapes. As the next chapter will explore, these dynamics are crucial to building long-term territorial resilience and promoting agroecological transitions rooted in local contexts.

5. PARTICIPATION AND GOVERNANCE IN RURAL LAND GOVERNANCE

Sustainable planning of rural territories requires a collaborative and participatory approach, actively involving all local actors: farmers, public authorities, associations,

citizens and researchers. Multi-level governance is an essential tool for managing the complexities of the territory and enhancing local resources in a logic of policy co-production. Effective governance must be capable of integrating different knowledge systems, negotiating competing land uses, and adapting to evolving ecological and socio-economic dynamics.

Participatory models such as Community-Led Local Development (CLLD), promoted by the European Union through the LEADER programme, represent concrete experiences of integrated governance. In these contexts, Local Action Groups (LAGs) are called upon to draw up territorial strategies that respond to the specific needs of rural communities, enhancing agricultural, environmental and cultural resources. These bottom-up initiatives are grounded in the principle that local actors are best positioned to interpret and activate the potential of their territories, especially when supported by enabling institutional frameworks.



Fig.7: Logo of the LEADER Network 2014-2020

A significant example of how the Leader Network is fundamental for the vitality of the rural territory is represented by the LAG Valli Marecchia e Conca in Emilia-Romagna, active in the hinterland of Rimini and characterised by a strong rural and hilly component. As part of the 2014–2020 Local Development Strategy, this Local Action Group has developed a set of actions aimed at enhancing local agricultural and landscape resources in a sustainable way. Among the main actions, there has been support for farms that adopt agroecological practices and conservation farming techniques aimed at reducing soil erosion and maintaining fertility. The LAG also promoted integrated projects between agriculture and sustainable tourism, such as food and wine itineraries, agritourism and local processing workshops, capable of generating added value for local communities. Particular attention has been paid to the preservation of the traditional agricultural landscape and the reactivation of marginal land through the creation of social and community gardens, with the involvement of local schools and associations. The LAG also launched training initiatives and exchanges of best practices between young farmers and technicians in the area. The experience of the Marecchia and Conca Valleys LAG shows how participatory and deep-rooted local governance can act as a catalyst for truly sustainable rural development, capable of integrating the economic, social and environmental dimensions of agricultural planning.

Digital tools and co-design platforms are also transforming the way citizens and public administrations interact. In Piedmont, the AgriOpenData project has involved farming communities in the participatory mapping of virtuous practices, improving the transparency and traceability of local production. These digital environments enable a more horizontal distribution of knowledge and can play a key role in facilitating adaptive governance, particularly in contexts marked by fragmentation or institutional weakness. However, participatory governance is not without its challenges. Information asymmetry between actors, unequal access to decision-making spaces, the under-representation of marginalised groups (e.g. migrant workers, women, young farmers), and the difficulty of ensuring long-term continuity of participatory processes all risk limiting the effectiveness and inclusiveness of local governance. In many cases, participatory tools remain confined to consultation rather than enabling true co-decision.

To overcome these barriers, it is essential to invest in capacity building, communication strategies, and trust-building mechanisms. Strengthening the technical and relational skills of local actors, creating alliances between public and private institutions, and recognising the legitimacy of informal knowledge are fundamental steps toward more democratic and resilient rural planning. Moreover, institutional support must go beyond funding, offering long-term accompaniment and flexibility in policy design and implementation. At the same time, new models of collaborative territorial governance are emerging, inspired by concepts such as the commons, agroecology, food sovereignty, and territorial co-management. These models propose a deeper integration between planning and collective action, encouraging new forms of rural citizenship where communities not only inhabit, but co-govern their territories.

In this evolving framework, spatial planning must become a platform for negotiation and co-production, rather than merely a regulatory instrument. Participatory rural governance is not a substitute for planning, but a necessary condition for its legitimacy, responsiveness, and capacity to produce shared value. By reconnecting public action with territorial intelligence, planning processes can become more sensitive to context, more inclusive of plural interests, and more capable of supporting transitions toward sustainability.

6. CONCLUSIONS: FOR AGRO-ECOLOGICAL SPATIAL PLANNING

Agriculture represents a fundamental lever for building resilient, equitable, and sustainable territories. It is not only a productive activity, but also a landscape-maker, an ecological infrastructure, and a social engine. The contemporary planning challenge lies in fully integrating the needs, rhythms, and complexities of the agricultural world into land governance processes, moving beyond a sectoral or residual vision and embracing an agroecological perspective. Such a shift requires acknowledging agriculture's multifunctional role: it contributes to climate mitigation, biodiversity conservation, territorial identity, food sovereignty, and the well-being of local communities. Agroecological planning must therefore operate on multiple levels: it must protect and regenerate rural landscapes, foster short and sustainable supply chains, support circular land use logics, and reconnect urban and rural systems through spatial, ecological and social proximity. This transition entails not only technical innovation and normative

adjustments, but also a profound cultural reorientation. It demands planning practices that are open, adaptive, and participatory, capable of weaving together data, local knowledge, and forward-looking visions to tackle the intertwined challenges of climate change, food insecurity, and socio-territorial inequality.

The experiences analysed in this chapter — from regional landscape plans in Tuscany and Apulia, to the Parco Agricolo Sud Milano, to LEADER strategies and grassroots governance platforms — demonstrate that alternative models of territorial development are not only necessary but already emerging. These practices challenge traditional hierarchies between rural and urban, centre and periphery, expertise and practice. They show how agricultural spaces can become laboratories of innovation, where environmental regeneration, social inclusion, and economic diversification converge. However, to turn these scattered experiences into a structural transformation, it is necessary to consolidate a new planning culture. One that no longer treats agriculture as a constraint or a reserve of land for future urban expansion, but rather as a strategic infrastructure for the transition to post-carbon, regenerative and just territories. This culture must be nurtured through cross-disciplinary education, supportive policy frameworks, long-term investments in rural innovation, and the creation of stable governance arenas where territorial actors can truly co-design their future.

Moreover, the agroecological transition cannot be left to the goodwill of individuals or isolated territories: it requires a collective commitment. Institutions must ensure coherence between agricultural, environmental, and spatial policies. Local communities must be empowered to act as custodians and co-producers of landscape and food systems. Academia must continue to develop critical tools for analysis and action, while civil society must remain vigilant and creative in defending the common goods embedded in the land. Ultimately, planning is not only about organising space — it is about shaping the relationships between humans and nature, production and reproduction, care and use. The transition to agroecological spatial planning offers an opportunity to rethink these relationships in ways that are more equitable, democratic, and resilient. Only through a shared and systemic approach will it be possible to imagine and construct territorial futures that are capable of facing the uncertainties of the 21st century, while honouring the diversity and richness of agricultural landscapes.

7. LINKS WITH THE SUSTAINABLE DEVELOPMENT GOALS (SDGS) OF THE UN 2030 AGENDA

The integration of agriculture and spatial planning, as explored throughout this chapter, is not only a strategic priority for territorial governance but also a crucial contribution to the global sustainability agenda. The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, identifies 17 Sustainable Development Goals (SDGs) as a shared blueprint for peace, prosperity, and environmental balance. Within this framework, agriculture and land use emerge as cross-cutting fields of intervention that interconnect ecological, social, and economic dimensions.

A sustainable and spatially integrated approach to agriculture is essential for advancing multiple SDGs simultaneously. Far from being an isolated sector, agriculture shapes key

global dynamics — from climate action to biodiversity conservation, from food security to inclusive growth — and is therefore central to the construction of resilient and equitable futures. Planning tools and governance mechanisms that support agroecological transitions can act as powerful accelerators for this global agenda, provided they are rooted in place-based strategies and inclusive processes. In particular, the following SDGs are directly and structurally linked to the themes addressed in this chapter:

- SDG 2 - Zero Hunger: Promote sustainable, resilient, and productive agriculture by improving food and nutrition security, supporting small-scale producers, and safeguarding food systems from climatic and economic shocks.
- SDG 6 - Clean Water and Sanitation: Ensure sustainable water management in agriculture through efficient irrigation systems, protection of aquifers, and reduction of pollution from agrochemicals.
- SDG 12 - Responsible Consumption and Production: Foster circularity and efficiency in the agri-food system, from reducing food waste to enhancing local, low-impact supply chains.
- SDG 13 - Climate Action: Contribute to mitigation (e.g. through carbon sequestration in soils and agroforestry) and adaptation (e.g. resilient cropping systems, water conservation, risk-aware planning).
- SDG 15 - Life on Land: Protect ecosystems, halt land degradation, conserve biodiversity, and restore multifunctional agricultural landscapes.
- SDG 11 - Sustainable Cities and Communities: Reconnect rural and urban systems through food policy, urban gardens, green belts, and land stewardship models that enhance territorial cohesion.
- SDG 8 - Decent Work and Economic Growth: Promote dignified employment in the agricultural sector, encourage generational renewal, and support local economies through value-added rural production.

These connections reveal that spatial planning and agriculture should not be approached as sectoral or technocratic issues, but rather as key levers in the integrated pursuit of sustainability at all scales - from local rural communities to global policy frameworks. Strengthening the synergies between planning practice and the SDGs means reimagining agriculture as a common good, and the land as a living infrastructure for planetary well-being.

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PLANNING SUSTAINABLE FOOD SYSTEMS

Paolo CAPOVILLA¹,

¹Università IUAV di Venezia

Abstract

The transition towards sustainable food systems is one of the most pressing challenges for urban planners and policymakers. This learning material provides a comprehensive overview of the social, environmental, and economic dimensions of food system transformation, with a focus on the role of urban governance, circular economy principles, and local innovation. The course explores how food systems intersect with key Sustainable Development Goals (SDGs), EU policy frameworks (such as the Farm to Fork Strategy and the Green Deal), and multi-level governance mechanisms. Emphasis is placed on the emerging role of cities through urban food policies, illustrated by case studies from Milan, Detroit, Copenhagen, and Tirana. The materials also introduce planning tools such as food atlases and alternative food supply chains and examine strategies to reduce food waste and promote upcycling and ecodesign. Drawing from the experience of Iuav University of Venice, the module highlights the value of interdisciplinary education and spatial planning in shaping resilient, inclusive, and circular food environments capable of responding to global crises and local needs.

Keywords: *Sustainable food systems, Urban food policy, Circular economy, Planning policies, SDGs.*

1. INTRODUCTION

1.1. Why do we need to change our food systems?

Today’s global food systems face increasingly urgent and complex challenges. By 2050, the world’s population is projected to exceed 9.7 billion people, requiring a food system that can provide safe, nutritious, and sufficient food for all — without exceeding the planet’s ecological limits. However, current practices contribute significantly to environmental degradation. Food systems account for approximately 21–37% of total global greenhouse gas emissions, consume up to 70% of freshwater resources, and use about 40% of the Earth’s ice-free land.

These impacts are intensified by three global food paradoxes:

- For every person suffering from malnutrition, there are two who are overweight or obese.
- One-third of global agricultural production is used for livestock feed or biofuels instead of human consumption.
- One-third of all food produced is wasted, largely during distribution and household consumption stages.

In addition, more than half of food waste (54%) comes from households, with 19% from the food industry and 11% from the restaurant sector. These inefficiencies not only harm the environment but also reflect deep social and economic inequalities that must be addressed through systemic transformation.

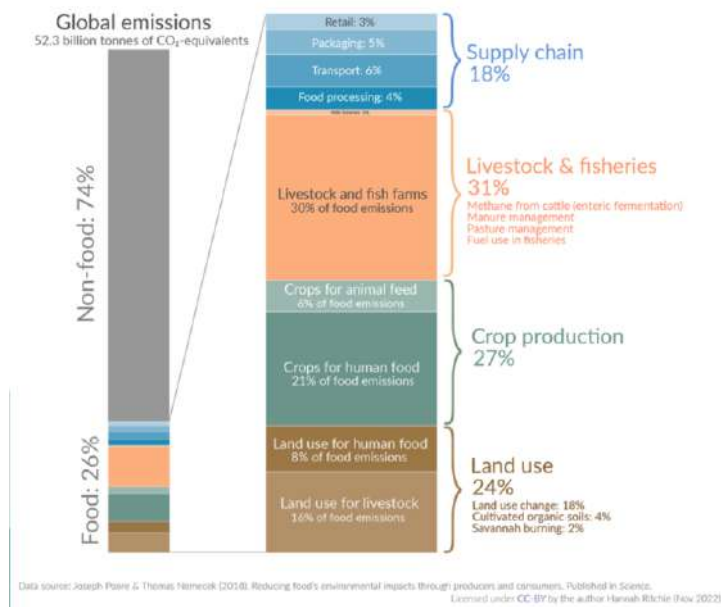


Figure 1 – Food supply chain global emissions

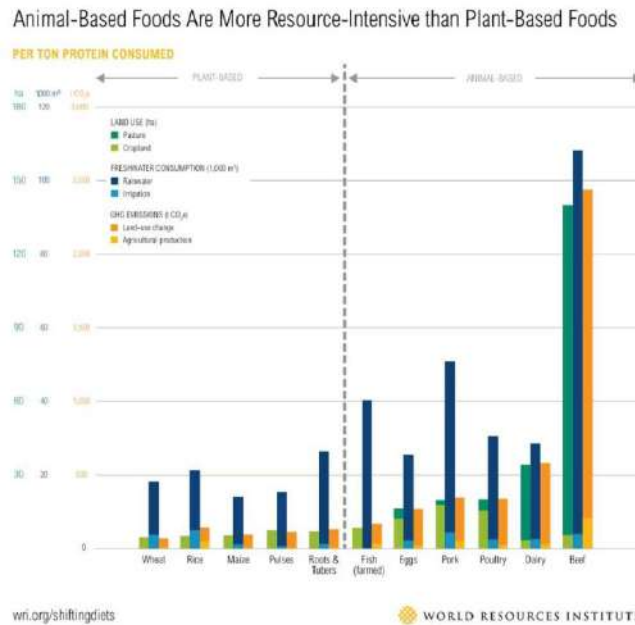


Figure 2 – Animal based food impacts

1.2. How are food topics integrated into an Italian university of planning and urban design (IUAV University of Venice)?

The IUAV University of Venice plays a pioneering role in integrating food-related challenges into planning and urban design education. Recognizing the strategic role of cities and urban systems in shaping sustainable futures, IUAV includes food systems within its curricula and research projects. Food is considered not only as a biological necessity but as a designable infrastructure involving social, environmental, cultural, and economic dimensions. Through interdisciplinary approaches, IUAV explores how cities can become key actors in the transition toward sustainable food systems. Planning tools, spatial strategies, public policies, and urban governance are examined to create localized solutions that can respond to global issues. This includes promoting food justice, reducing waste, enhancing circularity, and fostering innovation within territorial food economies.

1.3. How to design sustainable food systems?

Designing sustainable food systems involves a holistic, multi-level approach that spans:

- Ecological sustainability: minimizing environmental impacts across the entire food supply chain, from production to waste.
- Economic resilience: supporting local economies, ensuring fair wages and access to markets.

- Social justice: guaranteeing access to healthy food for all, reducing inequalities, and respecting cultural food traditions.
- Urban integration: embedding food systems into planning, zoning, and infrastructural frameworks of cities and territories.

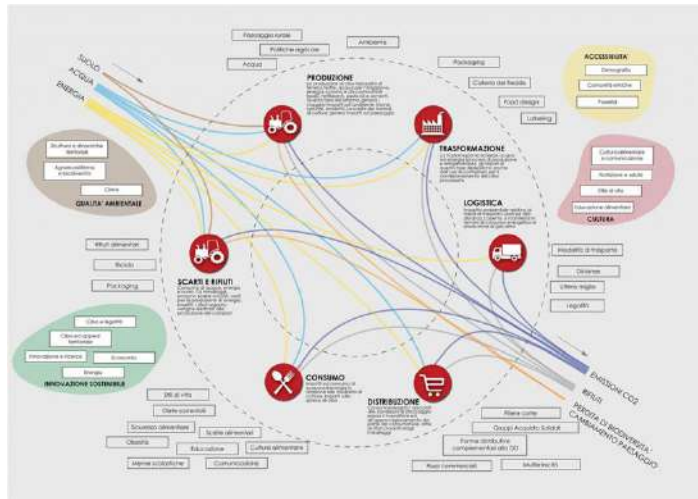


Figure 3 – Food atlas by Milano food policy

By adopting participatory processes, inclusive governance, and design-oriented strategies, planners and policymakers can co-create resilient food environments adapted to the specificities of place and people.

2. SUSTAINABLE DEVELOPMENT GOALS (SDGS) RELATED TO FOOD SYSTEMS

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, includes 17 Sustainable Development Goals (SDGs) that provide a shared blueprint for peace and prosperity (Figure 4). Food systems are deeply interconnected with many of these goals, but the following five are particularly relevant.

- **SDG 2: Zero Hunger**

Objective: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.

Food systems are directly at the core of SDG 2. This goal calls for universal access to sufficient, safe, and nutritious food all year round. Achieving this means transforming agricultural practices to increase productivity and incomes of small-scale farmers while ensuring the sustainability of food production systems. Addressing hunger also requires reducing food loss and waste, improving distribution mechanisms, and ensuring resilience to climate change, pests, and diseases.

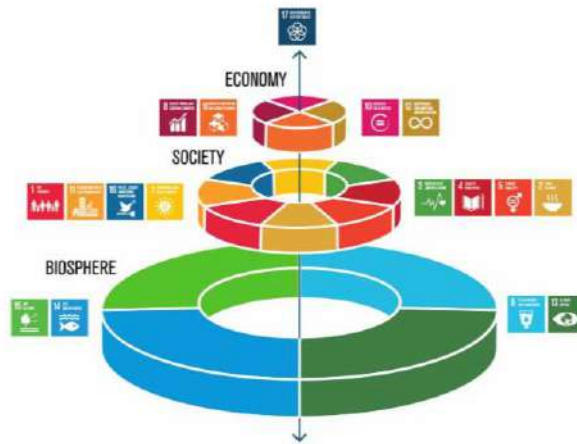


Figure 4 SDG's wedding cake by Azote for Stockholm Resilience Centre, Stockholm University CC BY-ND 3.0.

In addition, more than half of food waste (54%) comes from households, with 19% from the food industry and 11% from the restaurant sector. These inefficiencies not only harm the environment but also reflect deep social and economic inequalities that must be addressed through systemic transformation.

- **SDG 11: Sustainable Cities and Communities**

Objective: Make cities inclusive, safe, resilient, and sustainable.

As urbanization continues to grow, cities play an increasingly central role in shaping how food is produced, distributed, and consumed. SDG 11 highlights the need for urban areas to develop food policies that ensure accessibility to healthy food, reduce food deserts, and promote local food economies. Integrating food systems into urban planning can help make cities more livable, equitable, and resilient to crises.

- **SDG 12: Responsible Consumption and Production**

Objective: Ensure sustainable consumption and production patterns.

Food systems are among the most resource-intensive sectors. SDG 12 encourages reducing food loss and waste across supply chains, improving efficiency, and promoting responsible consumer behavior. This includes supporting circular economy approaches in food systems, encouraging sustainable diets, and raising awareness about the environmental impact of food choices.

- **SDG 13: Climate Action**

Objective: Take urgent action to combat climate change and its impacts.

Climate change both affects and is affected by food systems. Agricultural activities contribute significantly to greenhouse gas emissions through deforestation, methane emissions from livestock, and energy use in processing and transportation. Conversely, climate change threatens food security through unpredictable weather patterns, droughts,

and crop failures. SDG 13 calls for the mitigation of these impacts through sustainable agricultural practices, agroecology, and climate-smart food systems.

- **SDG 15: Life on Land**

Objective: Protect, restore, and promote sustainable use of terrestrial ecosystems.

Food production depends on healthy ecosystems. Intensive farming practices have led to soil degradation, deforestation, loss of biodiversity, and water pollution. SDG 15 urges the restoration of degraded land, the sustainable management of forests, and the preservation of biodiversity. Food systems must evolve to support ecosystem services, protect pollinators, and promote regenerative agriculture.

3. FOOD GOVERNANCE AND THE EU POLICY FRAMEWORK

Food governance refers to the set of rules, policies, and institutional arrangements that shape how food is produced, distributed, consumed, and disposed of. In Europe, food governance is structured across multiple levels — from international agreements to local initiatives — and involves a wide range of actors, including institutions, private companies, civil society, and citizens.

3.1. Key EU policies for sustainable food systems

The European Union has taken important steps to reform its food system to become healthier, more sustainable, and more resilient. Among the most relevant policies and frameworks:

Farm to Fork Strategy (2020)

This flagship initiative of the European Green Deal aims to transition to a fair, healthy, and environmentally friendly food system. It addresses every step of the food chain, from production and processing to distribution and waste management. Its goals include:

- Reducing the environmental and climate footprint of the food system
- Strengthening food security
- Ensuring food affordability and health for all
- Promoting sustainable agricultural practices
- Encouraging innovation and fair trade

Common Agricultural Policy (CAP)

The CAP is one of the oldest and most influential EU policies. It provides subsidies and support to farmers, promotes rural development, and ensures food security. The recent reform of the CAP (2023–2027) emphasizes:

- Climate action and environmental sustainability
- Social equity and generational renewal in agriculture
- Increased support for small farms and organic agriculture
- Enhanced monitoring and accountability mechanisms

European Green Deal

The Green Deal outlines the EU’s strategy to become climate-neutral by 2050. It includes food as a key sector for change, advocating for carbon-neutral production methods, restoration of biodiversity, and reduction of food loss and waste.

EFSA and Food Safety Regulations

The European Food Safety Authority (EFSA) plays a central role in ensuring that food products are safe, traceable, and labeled correctly. These regulations help protect public health and build consumer trust.

Food Waste Reduction Strategies

In line with SDG 12.3, the EU has committed to halving per capita food waste by 2030. Legislative and non-legislative initiatives aim to optimize food recovery, improve donation systems, and raise public awareness.

Labelling and Traceability Regulations

EU regulations ensure that consumers are informed about the origin, composition, and sustainability of food products. This transparency supports ethical consumption and promotes accountability throughout the supply chain.

3.2. Multi-Level food governance

Food governance in Europe operates through a **multi-level structure**, reflecting the complexity of the food system and the diversity of territories. The main levels include:

International Level

At the global scale, the EU aligns with international frameworks such as the UN Food Systems Summit, the Codex Alimentarius, and climate agreements. A key example is the upcoming **Legislative Framework for Sustainable Food Systems (2023/2024)**, which will provide a binding basis for integrated food policies across the EU.

National Level

Member States develop their own food strategies in line with EU directives. Examples include:

- **UK National Food Strategy** (post-Brexit)
- **France’s National Food Programme (PNA)** – a comprehensive framework to ensure food sovereignty and security

Regional Level

Regions implement food policies tailored to their specific agricultural, economic, and cultural contexts. Notable examples:

- **Catalonia (Spain, 2021)** – Integrated food planning strategies
- **Flanders (Belgium)** – Food transition roadmaps
- **Piedmont (Italy)** – Regional department for agriculture and food

Local Level

Cities and municipalities are increasingly becoming laboratories for food innovation. Through local food policies, cities promote urban agriculture, reduce waste, and improve public procurement systems. Case studies like **Milan, Copenhagen, Detroit, and Tirana** offer concrete examples of bottom-up governance with high impact.

4. URBAN AND LOCAL FOOD POLICIES

Over the past two decades, cities around the world have become key players in the transformation of food systems. Urban and local food policies provide a strategic framework for municipalities to address food-related challenges, promote sustainability, and strengthen social cohesion.

A significant turning point occurred in 2015 with the launch of the **Milan Urban Food Policy Pact (MUFPP)**, an international commitment that has since become a reference point for urban food governance.

4.1. What are urban food policies?

Urban food policies are defined as practical and theoretical tools that connect local governments, citizens, and stakeholders in shaping sustainable strategies for food systems (Dansero, Marino, et al., 2019). These policies:

- Recognize the **criticalities and opportunities** of the territory
- Integrate **political action and civic participation**
- Address the **entire food chain**, from production to waste
- Consider **social, cultural, economic, and environmental implications**

They intersect with various policy domains, such as:

- Agriculture and land use
- Environment and climate action
- Public health and nutrition
- Commerce and logistics
- Education and cultural heritage
- Urban planning and spatial development

Urban food policies may take both formal and informal forms: from municipal resolutions and strategic plans to community-driven initiatives, mapping exercises, and participatory labs.

4.2. The Milan Urban Food Policy Pact (MUFPP)

The MUFPP was signed in 2015 by over 250 cities worldwide. It provides a shared framework of action across six key categories:

- **Governance:** Establishing inclusive and accountable food governance structures.
- **Sustainable Diets and Nutrition:** Promoting healthy eating, reducing diet-related diseases, and ensuring food access.
- **Social and Economic Equity:** Supporting vulnerable populations, reducing food insecurity, and promoting social inclusion.
- **Food Production:** Encouraging urban and peri-urban agriculture, supporting local producers, and preserving agricultural land.
- **Food Supply and Distribution:** Enhancing short supply chains, improving logistics, and supporting local food economies.
- **Food Waste:** Reducing food loss and encouraging circular practices.

4.3. Case Studies

Milan (Italy) – A national leader in urban food policy

Since 2014, Milan has become a pioneer in food policy innovation in Italy. As the promoter of the MUFPP, the city has implemented various initiatives to fight food waste, support food security, and reconnect urban and rural areas.

Key initiatives:

- Daily recovery of food surpluses from supermarkets and school canteens
- 8 neighborhood hubs for food redistribution
- Collaboration with 21 non-profit organizations
- Over 795 tonnes of food recovered in 2024
- Conversion of public land for agricultural purposes
- Participation in European research and innovation projects



Figure 1 - Food Hub in Milan

Copenhagen (Denmark) – Public procurement as a driver of change

Copenhagen is an example of how institutional food procurement can transform food systems and shape public behavior.

Results:

- 88% of public meals use organic, local ingredients
- Meals provided across 800 public institutions (from schools to hospitals)
- CO₂ emissions reduced by 25% per kg of food procured
- Implementation of 700 climate-friendly meals based on the EAT–Lancet guidelines



Figure 6 - Food education in Copenhagen

Tirana (Albania) – Emerging food policy and cultural integration

Tirana is currently building its first urban food policy through the **Food Trails project**, with a focus on reconnecting people to local food traditions.

Pilot actions:

- Awareness campaigns on sustainable diets
- Creation of a multifunctional food hub connecting farmers, restaurants, and consumers
- Development of a quality certification for sustainable restaurants
- Mapping of the local food system and waste flows through a Living Lab model

4.4. Examples of policy instruments

Urban food policies are implemented through a variety of formats, including:

- Municipal protocols or resolutions
- Strategic food plans and city-level councils
- Food system mapping and food atlases
- Workshops, thematic reports, and public events



Figure 7 - Food Trails project in Tirana

These instruments help build a shared understanding of local food systems and create long-term, participatory strategies for improvement.

5. CIRCULAR ECONOMY FOR FOOD

The circular economy represents a fundamental shift in how we manage resources. Unlike the traditional linear model — extract, produce, consume, dispose — the circular economy is regenerative by design. It aims to keep materials and nutrients in use for as long as possible, minimizing waste and maximizing value.

In the context of food systems, this model is not only possible — it is essential.

5.1. What is a circular economy for food?

A circular food economy replicates the logic of natural ecosystems, where there is no concept of waste. Every output from one process becomes an input for another. In this framework, organic resources are recovered and reused, food is valued throughout its entire life cycle, and environmental externalities are drastically reduced.

A circular food system involves:

- **Preventing food waste** at the source (production, transport, retail, households)
- **Reusing surplus food** for human or animal consumption
- **Recycling food waste** into compost, energy, or new materials
- **Designing food products and packaging** for sustainability and reusability

This systemic approach supports both environmental goals (climate mitigation, biodiversity, soil health) and social outcomes (food security, job creation, education).

5.2. Key concepts

Upcycling

Upcycling refers to the creative re-use of materials traditionally seen as waste, transforming them into new products with added value. In food systems, this means:

- Turning food by-products (like fruit peels or spent grains) into new food items, ingredients, or supplements
- Using organic waste to produce **bioenergy** (biogas, bioethanol)
- Creating **textiles, packaging, or design products** from agricultural waste
- Developing cosmetics and pharmaceuticals from food processing residues

Ecodesign

Ecodesign is a design philosophy that aims to reduce environmental impact across the entire life cycle of a product. In the food sector, ecodesign may involve:

- Designing **food packaging** that is biodegradable, reusable, or recyclable
- Creating **nutritionally balanced products** with lower environmental footprints
- Planning **closed-loop supply chains** where resources are recovered and reintegrated
- Minimizing transportation and storage needs through **local sourcing and smart logistics**

The adoption of ecodesign principles ensures that sustainability is embedded from the start, not as an afterthought.

5.3. Benefits of a circular food system

- **Environmental impact reduction:** Minimizes greenhouse gas emissions, water use, and soil degradation.
- **Food waste reduction:** Helps close the loop by reusing edible surplus and composting organic waste.
- **Economic resilience:** Opens new markets, stimulates innovation, and supports local economies.
- **Social innovation:** Involves citizens, creates new jobs (especially in green sectors), and promotes equity.
- **Health and nutrition:** Encourages the use of fresh, local, and less processed ingredients.

5.4. Challenges and opportunities

Implementing a circular food system requires overcoming several challenges, including:

- Lack of infrastructure for waste collection and processing
- Regulatory barriers to the use of secondary raw materials
- Need for behavioral change among consumers and producers
- Investment in innovation and digital technologies

Nevertheless, growing public awareness, EU policies (such as the Circular Economy Action Plan), and increasing collaboration between governments, businesses, and research institutions provide a strong foundation for progress.

6. FOOD ATLAS AND ALTERNATIVE FOOD SUPPLY CHAINS

6.1. What is a food atlas?

A Food Atlas is a strategic tool used in urban and regional planning to document, analyze, and visualize the food system of a specific territory. It collects data and transforms it into accessible knowledge for decision-makers, researchers, and citizens. The goal is to support more informed, inclusive, and sustainable food policies.

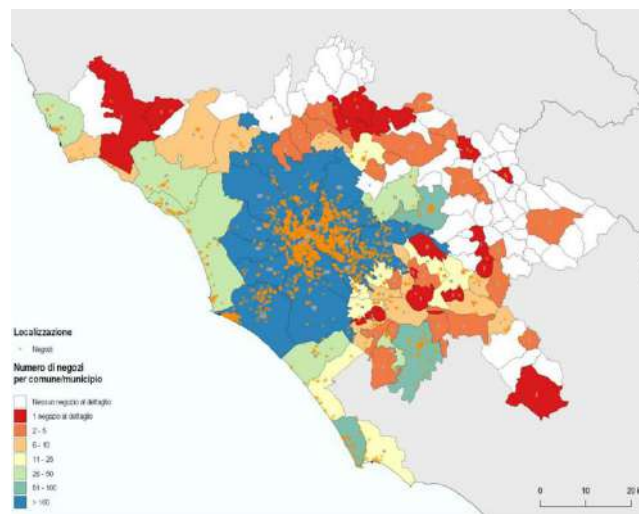


Figura 8 - Food Atlas in Rome

Key functions of a Food Atlas:

- **Mapping food production:** where and how food is grown locally
- **Analyzing distribution networks:** markets, retailers, logistics infrastructure
- **Identifying food deserts** and areas lacking access to healthy food
- **Visualizing waste flows** across the system
- **Documenting food cultures and practices**

These atlases may take the form of maps, infographics, texts, videos, or interactive platforms, depending on the audience and objectives. They are often developed in collaboration with municipalities, universities, NGOs, and local food actors.

6.2. Traditional vs Alternative Food Supply Chains

Modern food systems are largely dominated by **long and complex supply chains**, which prioritize efficiency, standardization, and global trade. While these systems enable large-scale distribution, they are often associated with significant environmental, economic, and social costs.

Traditional supply chain characteristics:

- Multiple intermediaries (producers → processors → wholesalers → retailers → consumers)
- Long transport distances
- Heavy reliance on packaging, refrigeration, and storage
- Reduced transparency and traceability
- Lower share of profit for producers

To address these issues, alternative food networks (AFNs) and short food supply chains (SFSCs) have emerged as promising solutions.

6.3. Alternative food supply chains

Alternative food systems are based on proximity, trust, transparency, and social responsibility. They seek to reconnect producers and consumers, shorten distances, and strengthen local economies.

Main models include:

- **Farmers' Markets:** direct sale of local, seasonal products
- **Community Supported Agriculture (CSA):** consumers subscribe to receive regular produce directly from farms
- **Solidarity Purchasing Groups (GAS):** collective buying systems promoting ethical and sustainable consumption
- **Urban and peri-urban agriculture:** local production integrated into the urban fabric
- **Food cooperatives:** community-run stores based on democratic principles

6.4. Benefits of short food supply chains

- **Lower environmental impact:** Reduced emissions from transport, storage, and packaging.
- **Higher economic returns for farmers:** Direct relationships allow producers to retain more of the final price.

- **Stronger community ties:** Food becomes a medium for cultural exchange, education, and civic participation.
- **Transparency and food quality:** Consumers have greater trust in origin, practices, and freshness.
- **Promotion of local culture and heritage:** Regional products, traditional recipes, and agroecological practices are preserved.

6.5. Toward food system transition

By integrating tools like Food Atlases and promoting alternative supply chains, cities and regions can:

- Improve food sovereignty
- Reduce dependence on fragile global markets
- Enhance social resilience
- Support circular, equitable, and regenerative economies

A sustainable food system is not a fixed model but a living process, shaped by the active participation of all stakeholders — from farmers to planners, from policymakers to citizens.

7. CONCLUSION

Planning sustainable food systems requires a multidimensional and interdisciplinary approach that integrates environmental, social, economic, and cultural dimensions. The complexity of current food challenges demands coordinated efforts at multiple levels— from global commitments, such as the United Nations Sustainable Development Goals (SDGs), to regional frameworks like the European Union’s Farm to Fork Strategy, down to local initiatives including urban food policies and the development of alternative food networks. By fostering collaboration among policymakers, producers, consumers, and civil society, it becomes possible to co-design food environments that are not only more just and inclusive but also resilient to social and environmental shocks.

In this transformative process, educational institutions such as IUAV hold an important position. Beyond their role in educating future planners and professionals, universities serve as hubs for generating innovative research and new knowledge, fostering interdisciplinary dialogue, and connecting diverse stakeholders across different territories. By bridging academic expertise with real-world practices, these institutions can catalyze systemic change and support the creation of sustainable food systems that respect local contexts while contributing to global sustainability goals. Ultimately, the active involvement of universities, combined with multi-level governance and community engagement, is essential for achieving a future where food systems are equitable, sustainable, and capable of nourishing both people and the planet.

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SPATIAL PLANNING FOR RESILIENCE TO CLIMATE CHANGE

Filippo MAGNI¹

¹Università IUAV di Venezia

Abstract

This module explores the multidimensional nature of urban and territorial resilience, highlighting the need for integrated, inclusive, and adaptive planning approaches. Drawing on international frameworks and practical case studies, it presents five core dimensions of resilience: context analysis and risk assessment, community engagement and participatory governance, resilient infrastructure, early warning systems, and adaptive capacity. Each dimension is examined through a critical and interdisciplinary lens, emphasizing the intersection between spatial planning, social justice, climate adaptation, and digital transformation. Particular attention is given to the role of local communities, knowledge co-production, and cross-sectoral collaboration in shaping long-term resilience strategies. By integrating both technical tools and social processes, the module provides a foundational framework for students, practitioners, and policymakers to understand and apply resilience as a transformative and dynamic process, rather than a fixed outcome. Ultimately, it invites reflection on how crises—whether climatic, social or technological—can become opportunities for territorial regeneration and democratic innovation.

Keywords: *urban resilience, adaptive planning, participatory governance, climate risk, spatial planning.*

1. INTRODUCTION

By 2050, it is estimated that 7 out of 10 people will likely live in urban areas. Cities are engines of economic growth and contribute more than 80% of global GDP. Designing sustainable and resilient cities requires a thorough understanding of the interconnections between social, economic and environmental factors. Goal 11 of the 2030 Agenda is to make cities and human settlements inclusive, safe, resilient and sustainable.

Cities are engines of economic growth and contribute more than 80% of global GDP. However, they also account for more than 70% of global greenhouse gas emissions. If well planned and managed, urban development can be sustainable and can generate inclusive prosperity.

In today's rapidly changing world, urban resilience has become a crucial concept in smart city management, meaning the ability to recover from and adapt to various shocks and stresses, such as natural disasters, economic downturns and social challenges. It therefore involves the capacity of a city to absorb, recover and transform in the face of these challenges, maintaining essential functions and supporting the well-being of its residents.

In an era defined by environmental uncertainty, social transformation, and rapid technological change, the role of spatial planning has become increasingly central to the resilience of cities and territories. More than a technical or regulatory function, spatial planning today is a strategic discipline that helps shape the physical, economic, social, and ecological structure of urban and regional systems. By determining how land is used, infrastructure is developed, and communities are connected, spatial planning holds a unique potential to reduce vulnerabilities, manage risks, and enhance the adaptive capacity of society as a whole. It can facilitate integrated responses to complex challenges, support long-term visioning, and ensure that development processes are inclusive, equitable, and sustainable.

This learning materials outlines five fundamental aspects essential to Spatial Planning For Resilience To Climate Change in the face of increasing global challenges. With the growing frequency of natural disasters, socio-economic shocks, and technological disruptions, building resilient systems is more critical than ever.

The purpose of this report is to provide a comprehensive overview of how resilience can be systematically integrated into planning and policy frameworks. Each of the five chapters focuses on a key dimension of resilience: context analysis and risk assessment, community engagement and participatory governance, resilient infrastructure and sustainable urban planning, early warning systems and emergency management, and adaptive capacity and post-crisis learning.

Together, these interconnected aspects offer a roadmap for creating adaptive, inclusive, and sustainable societies that are prepared for current and future disruptions.

2. URBAN RESILIENCE: WHAT DOES IT MEAN AND HOW TO ACHIEVE IT?

According to some international definitions, urban resilience can be identified with three definitions:

UNITED NATIONS HABITAT “the measurable capacity of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, adapting positively and transforming towards sustainability. From earthquakes to floods, from rapid immigration to cyber attacks, all cities face a range of shocks and stresses, both natural and man-made. Today, cities and their inhabitants face additional and amplified challenges due to rapid urbanization, a changing climate and political instability, among others” (Source: Urban Resilience Hub)

UNITED NATIONS OFFICE FOR DISASTER RISK REDUCTION (UNISDR): “The capacity of a system, community or society exposed to hazard to resist, absorb, adapt, transform and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and the management of risk.” (Source: UNDRR)

100 RESILIENT CITIES: “Resilience is about surviving and thriving, regardless of the challenge. Urban resilience is the ability of individuals, communities, institutions, businesses and systems within a city to survive, adapt and grow regardless of the type of chronic stress and acute shock they experience. **CHRONIC STRESSES** weaken the fabric of a city on a daily or cyclical basis. Examples include: high unemployment, inefficient public transportation systems, endemic violence and chronic food and water shortages. **ACUTE SHOCKS** are sudden, acute events that threaten a city. Examples include: earthquakes, floods, epidemics and terrorist attacks.” (Source: Rockefeller Foundation)

Many cities around the world have undertaken urban resilience projects to create sustainable and future-proof urban environments and systems. But it is not enough to simply understand a city’s systems. To build resilience, these systems must be designed and operated in ways that can more easily withstand, respond, and adapt to shocks and stresses.

There are 7 characteristics that urban systems need to build resilience:

- **REFLECTIVE:** Individuals and institutions that are reflective use past experience to inform future decisions and will adjust standards and behaviors accordingly. For example, planning processes that are more reflective are better able to respond to changing circumstances.
- **RESOURCEFUL:** Enterprising people and institutions are able to recognize alternative ways to use resources in times of crisis to meet their needs or achieve their goals. For example, although households in cities in the Central Valley of Chile use water supplied by municipal networks on a daily basis, service is often interrupted after major earthquakes. In response, many households maintain wells to continue the water supply.

- **ROBUST:** A robust design is well conceived, built, and operated, and includes creating provisions to ensure that failure is predictable, safe, and not disproportionate to the cause. For example, a robust protection infrastructure will not fail catastrophically when design safety thresholds are exceeded.
- **REDUNDANT:** Redundancy refers to spare capacity created specifically to cope with disruptions due to extreme pressures, peaks in demand, or external events. It includes diversity where there are multiple ways to reach a given need. For example, energy systems that incorporate redundancy provide multiple delivery routes that can accommodate peaks in demand or disruptions in supply networks.
- **FLEXIBLE:** Flexibility refers to the willingness and ability to adopt alternative strategies in response to changing circumstances or sudden crises. Systems can be made more flexible by introducing new technologies or knowledge, including acknowledging traditional practices. For example, in times of crisis, cities can redeploy public buses for emergency evacuations.
- **INCLUSIVE:** Inclusive processes emphasize the need for broad consultation and “many seats at the table” to create a sense of shared ownership or a common vision for building city resilience. For example, early warning that reaches all at risk will enable people to protect themselves and minimize loss of life and property.
- **INTEGRATED:** Integrated processes bring together systems and institutions and can also catalyze additional benefits as resources are shared and actors are enabled to work together to achieve larger goals. For example, integrated urban plans enable a city to address multidisciplinary issues such as climate change, disaster risk reduction, or emergency response through coordination.

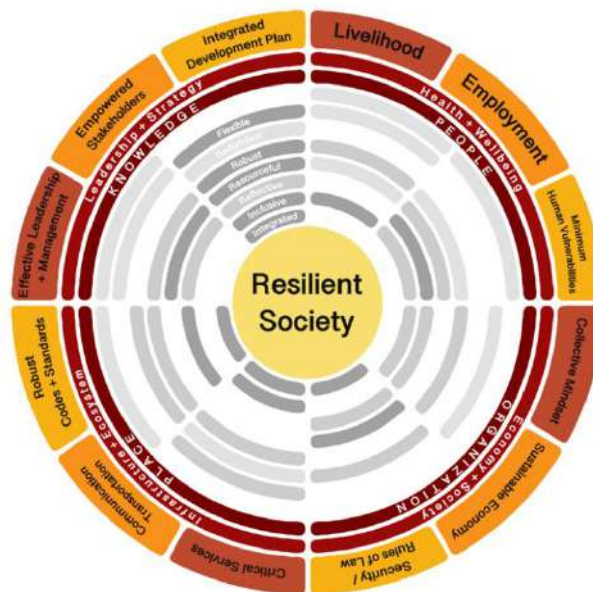


Figure 1 - Resilient Society Codex - Source: Think To DO Institute

It is now necessary to ensure adequate urban planning that includes the development of adequate infrastructure and public services to cope with the increase in population. This includes the construction of schools, hospitals, efficient public transport, green areas and accessible public spaces. It is important to promote accessibility for all, including disadvantaged and marginalized groups, by ensuring access to basic services such as drinking water, electricity and sanitation. This can be done through affordable housing policies, construction of social housing and social inclusion policies. Security is another important challenge for urban areas. It is essential to ensure the safety of people, both through crime prevention and management of natural disasters. This requires investments in public safety, strengthening the police and emergency services, and adopting risk mitigation measures, such as planning flood-resistant areas or building earthquake-resistant buildings.

Building urban resilience requires a holistic and proactive approach that encompasses various aspects of city planning and management. Below, the next chapters will explore some key strategies and factors to consider in order to achieve this goal:

- context analysis and risk assessment,
- community engagement and participatory governance,
- resilient infrastructure and sustainable urban planning,
- early warning systems and emergency management,
- adaptive capacity and post-crisis learning.

3. CONTEXT ANALYSIS AND RISK ASSESSMENT

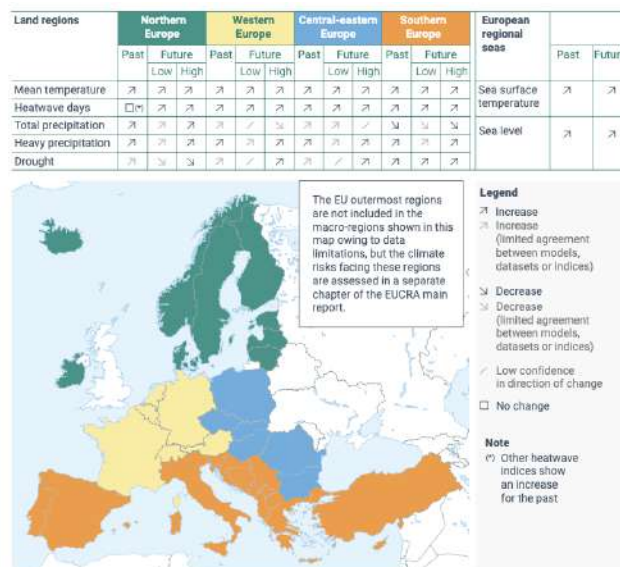


Figure 2 - Observed and projected trends in key climatic risk drivers in different European region. Source: EUCRA - European Climate Risk Assessment

Effective resilience planning begins with a comprehensive understanding of the context in which a system operates. This requires detailed risk assessments that consider both natural and human-induced hazards, including earthquakes, floods, climate change impacts, sea level rise, heatwaves, cyber threats, economic shocks, and pandemics. However, risk is not defined solely by the presence of hazards, but by their interaction with exposure, sensitivity, and adaptive capacity—components that must all be analyzed within a territorial framework.

A robust context analysis involves evaluating the social, economic, environmental, spatial, and infrastructural characteristics of a place. This multidimensional lens makes it possible to identify spatial inequalities, critical infrastructures, institutional gaps, and the presence (or absence) of social capital. One widely used method is the SWOT analysis (Strengths, Weaknesses, Opportunities, Threats), which provides a structured approach to identifying internal vulnerabilities and external pressures, but it can be complemented by PESTLE analysis (Political, Economic, Social, Technological, Legal, and Environmental factors) for a more systemic overview. Technological tools such as Geographic Information Systems (GIS), remote sensing, and predictive modelling are essential for spatializing risk, visualizing cascading effects, and identifying vulnerable areas, particularly when dealing with climate-related hazards. These tools can be used to develop multi-risk maps or exposure scenarios that support spatial decision-making. For instance, climate models that project the frequency and intensity of extreme events can be coupled with socio-demographic datasets to reveal at-risk populations.



Figure 3 - SWOT Analysis structure

However, data alone is not sufficient. Incorporating historical memory, community knowledge, and perceptions of risk is vital to contextualize planning decisions and avoid top-down approaches that ignore local realities. For example, the flood defense strategy of Venice has been informed not only by long-term monitoring of sea level rise and land subsidence, but also by local adaptation practices and institutional learning across decades. Risk perception also plays a role in shaping behaviours and institutional responses:

populations that underestimate threats may be less likely to adopt preventive measures, while others may be disproportionately affected by a lack of access to information or early warnings.

Risk assessment must also include a capacity analysis, which examines the existing assets—both tangible (e.g., infrastructure, financial resources) and intangible (e.g., governance structures, social networks, institutional trust)—that can be activated or reoriented in times of crisis. This requires mapping formal and informal institutions, identifying key stakeholders, and understanding the governance ecosystem in which resilience strategies will be implemented. Tools such as the UNDRR’s Risk Information Exchange (RiX), the IPCC’s vulnerability assessment frameworks, and the Disaster Resilience Scorecard offer useful reference points for building consistent and transparent methodologies.

Finally, effective context and risk analysis must be forward-looking and place-based, combining current observations with scenario planning to anticipate future trajectories under conditions of uncertainty. This stage is foundational: it ensures that all subsequent resilience strategies—whether infrastructural, social, or institutional—are tailored, evidence-based, and capable of addressing both the systemic causes of vulnerability and the specific configurations of risk that characterize each territory.

Stakeholders to involve:

- Local government agencies (e.g., planning and environmental departments)
- National risk management authorities
- Academic institutions and research organizations
- NGOs and civil society organizations
- Private sector experts in GIS, risk analysis, and insurance
- Local communities and indigenous groups

4. COMMUNITY ENGAGEMENT AND PARTICIPATORY GOVERNANCE

Resilience is not merely a technical objective—it is a collective and political process grounded in the capacity of communities to shape their own futures. Building resilience requires more than robust infrastructure or smart technologies; it demands inclusive governance, where local knowledge, values, and needs are meaningfully incorporated into planning and decision-making. Participatory governance thus becomes a cornerstone of resilience, enabling communities to act not only as beneficiaries, but as co-creators of strategies and agents of change. Community engagement can take many forms, ranging from traditional public consultations and town hall meetings to more innovative approaches such as collaborative mapping workshops, deliberative assemblies, and digital platforms for participatory planning. These tools are not merely procedural—they help build trust, facilitate transparency, and foster a sense of ownership over policies and projects. Engaging communities early and continuously in the planning process improves the quality of decisions and ensures that interventions are culturally appropriate and locally grounded.

Effective governance for resilience must be multilevel and multisectoral, promoting coordination between municipal, regional, national, and even transnational actors, as well as between public institutions, private sector entities, NGOs, grassroots organisations, and academia. This networked approach allows for resource sharing, policy coherence, and the bridging of knowledge systems, from institutional expertise to experiential community insights.



Figure 4 - Co-designing and participatory approach

Several cities offer illustrative examples of this approach. In Medellín, Colombia, inclusive urban planning transformed public safety, mobility, and access to services by embedding participatory mechanisms at the heart of urban regeneration. In Barcelona, participatory budgeting and neighborhood councils give residents a direct voice in determining how resources for climate adaptation and social resilience are allocated. These practices demonstrate how governance can become more democratic and effective when citizens are seen as partners, not passive recipients.

Furthermore, social networks and informal community structures play a critical—yet often under-recognised—role in resilience. During crises, these networks facilitate rapid information dissemination, enable coordinated local responses, and provide emotional and psychological support. Strengthening social capital and relational infrastructure is therefore as essential as investing in physical systems. True participation must also be inclusive and intersectional, ensuring the active involvement of groups often excluded from decision-making, such as women, youth, the elderly, migrants, and persons with disabilities. This diversity not only promotes equity, but enhances the robustness and creativity of resilience strategies by incorporating a wider range of experiences, needs, and solutions.

Stakeholders to involve:

- Urban planners and architects
- Infrastructure and utility companies (energy, water, transportation)
- Municipal and national infrastructure agencies
- Environmental and engineering consultants
- Construction and real estate developers
- Financial institutions and investors
- Community representatives

5. EARLY WARNING SYSTEMS AND EMERGENCY MANAGEMENT

A critical component of resilience planning is the ability to anticipate risks and respond to them swiftly and effectively. In this context, Early Warning Systems (EWS) are essential tools for reducing vulnerability, saving lives, and limiting damage. Far from being only technological infrastructures, EWS are complex socio-technical systems that rely on coordination, communication, and capacity-building. According to international frameworks such as the Sendai Framework for Disaster Risk Reduction, a fully functioning EWS must incorporate four interdependent components: risk knowledge, monitoring and forecasting, communication and dissemination, and response capability. Risk knowledge involves mapping hazards, identifying exposure, and understanding vulnerability. Monitoring and forecasting systems collect data through meteorological stations, seismic networks, hydrological gauges, satellites, and increasingly through remote sensing technologies, drones, and Internet of Things (IoT) sensors. These tools generate real-time insights, but technology alone is not enough: the efficacy of an early warning depends on how information is communicated—clearly, rapidly, inclusively, and in culturally appropriate ways.

Communication strategies must therefore be tailored to local contexts and accessible across linguistic, technological, and social barriers. Marginalized communities, elderly populations, and individuals with disabilities often face difficulties in receiving or acting upon warnings. Ensuring universal accessibility is thus a critical aspect of risk communication. Effective early warning is also contingent upon emergency management structures that are robust, regularly updated, and embedded into planning and institutional routines. This includes the design of evacuation routes, designation of emergency shelters, resource allocation protocols, and the integration of these measures into urban and regional plans. Regular drills, scenario-based simulations, and tabletop exercises are essential to test response systems, train actors, and expose critical gaps. Coordination across multiple levels and sectors is vital. Inter-agency cooperation—between emergency services, local governments, health systems, NGOs, and civil society—enables efficient deployment of resources, rapid information exchange, and shared situational awareness. In Italy, for example, the Civil Protection Department operates a sophisticated multi-hazard EWS that

coordinates with regional and municipal levels, ensuring that alerts are context-specific and action-oriented. Importantly, community-based early warning systems (CBEWS) offer a complementary and often more resilient approach, especially in remote, underserved, or hazard-prone territories. These systems involve training local residents to interpret environmental signals (e.g. water levels, ground shifts, unusual weather patterns), disseminate warnings through local networks (e.g. radio, SMS, door-to-door messaging), and activate response protocols. CBEWS strengthen local agency and embed risk preparedness into everyday life, fostering a culture of resilience.

Another pillar of effective warning systems is risk education and public awareness. When individuals understand the nature of hazards, know how to interpret alerts, and are familiar with appropriate responses, warnings are more likely to be acted upon. Awareness campaigns—delivered in schools, workplaces, media, and public spaces—should be continuous, not limited to emergency periods.

In sum, early warning systems are not just about technology or institutional protocols: they are about creating trust, shared responsibility, and readiness. The goal is not only to avoid harm, but to build the foundations for a prepared, informed, and connected society capable of responding to crises with competence and solidarity.

Stakeholders to involve:

- Meteorological and geological agencies
- Emergency services (fire, police, ambulance)
- Civil protection and disaster response agencies
- Local and national government bodies
- Media organizations
- Community leaders and volunteers
- Technology providers and telecommunication companies

6. ADAPTIVE CAPACITY AND POST-CRISIS LEARNING

Resilience is not a fixed condition, but a dynamic and evolving process. It is built over time as societies, institutions, and communities learn from experience, adjust to changing conditions, and reorganize in ways that reduce future vulnerability. At the heart of this evolution lies adaptive capacity—the ability of systems to absorb shocks, respond to disruptions, and transform in the face of new risks or opportunities. Adaptive capacity goes beyond short-term recovery. It involves systemic reflexivity, allowing communities to reflect on what worked, what failed, and why. Following a crisis, this means conducting thorough post-event assessments, identifying both weaknesses and strengths, and translating those lessons into improved policies, infrastructures, and institutional arrangements. The objective is not merely to restore the status quo, but to emerge stronger and better prepared for future challenges—a principle at the core of the Build Back Better approach promoted by the Sendai Framework for Disaster Risk Reduction.

To institutionalize this learning process, it is essential to cultivate and preserve institutional memory. This includes formal mechanisms such as training programmes, technical documentation, evaluation reports, and knowledge-sharing platforms, but also more informal practices such as storytelling, peer exchange, and intergenerational transmission of know-how. Organizational learning must be embedded in governance cultures to prevent the repetition of past mistakes and to reinforce adaptive thinking. Adaptive capacity also relies on the capacity for innovation and experimentation. Encouraging bottom-up solutions, pilot projects, and policy experimentation creates room for creative responses that may be more appropriate to local contexts. Access to emerging technologies, such as AI-powered forecasting tools or nature-based solutions, should be matched by support for community-led innovation, ensuring that technological advances do not deepen inequalities but contribute to inclusive resilience.

Education is another pillar of adaptation. From resilience-oriented curricula in schools and universities to community workshops, simulation exercises, and vocational training, educational initiatives equip individuals with the knowledge, attitudes, and practical skills needed to prevent, absorb, and recover from shocks. Education also supports social cohesion, which is a crucial but often underestimated dimension of resilience. Monitoring progress in adaptive capacity requires robust indicators and evaluation frameworks. Tools such as the Disaster Resilience Scorecard for Cities, ISO 22316 for organizational resilience, or the Urban Resilience Index provide guidance for benchmarking and identifying areas of improvement. However, metrics must be interpreted critically and used as part of broader participatory evaluation processes that include qualitative feedback and local perspectives.

Ultimately, resilience is not the absence of crisis, but the capacity to evolve through crisis. It requires humility, openness to change, and a commitment to continuous learning. Adaptive systems are not only those that survive disruption, but those that use it as a catalyst for transformation—moving from fragility to sustainability, from vulnerability to innovation. In this sense, adaptive capacity is the engine of long-term resilience and a precondition for thriving in an uncertain and rapidly changing world.

Stakeholders to involve:

- Government agencies at all levels
- Disaster recovery and humanitarian organizations
- Academic institutions and think tanks
- Community-based recovery groups
- Media and communication specialists
- Donors and international development agencies
- Private sector and innovation hubs

7. FINAL NOTES

Ensuring that urban areas are inclusive, safe, sustainable, and resilient is one of the greatest challenges—and opportunities—facing societies as we approach 2050. With nearly 70% of the global population expected to live in cities, urban areas are becoming the primary stage on which the consequences of climate change, social inequality, economic volatility, and technological disruption will unfold. Responding to this reality requires a comprehensive and forward-looking policy agenda that integrates spatial planning, risk management, social justice, and environmental stewardship. Addressing urban growth in a sustainable way means going beyond technical planning to embrace a transformative vision of urban development. This includes designing cities that are compact, connected, resource-efficient, and ecologically integrated, but also socially inclusive and culturally sensitive. Accessibility for all—regardless of age, gender, ability, or income—must be a foundational principle, ensured through affordable housing, universal access to basic services, inclusive mobility systems, and equitable public space.

Environmental sustainability is another non-negotiable pillar. Cities must radically reduce their ecological footprint by advancing energy efficiency, promoting a just transition to renewable energy, implementing circular waste and water systems, and supporting urban

KEYPOINTS FOR RESILIENCE

- **Designing sustainable and resilient cities requires a thorough understanding of the interconnections between social, economic, and environmental factors.** Urban planners, planners, and building engineers must be able to identify and address the unique challenges that each city faces. This may include designing infrastructure that is resistant to hurricanes or earthquakes, developing green spaces and parks to improve air quality and quality of life, and promoting sustainable transportation practices to reduce pollution.
- **To gain this knowledge, investment in education and training is essential.** Students should be encouraged to study urban planning, architecture, and related disciplines to learn how to design urban environments that are resilient, inclusive, and sustainable. Additionally, professionals already working in the field should be encouraged to participate in continuing education programs to keep their skills and knowledge up to date.
- **In addition, partnerships between local communities, academic institutions, nonprofit organizations, and the private sector are key to building resilient cities.** Through collaboration, these diverse stakeholders can share knowledge, resources and expertise to address challenges and promote sustainable practices. Local communities must be involved in the decision-making process to ensure that proposed solutions meet the needs and priorities of local people.

nature through green and blue infrastructure. These strategies not only reduce emissions and resource use, but also enhance urban habitability and health. However, sustainability alone is not enough: it must be combined with urban resilience—the capacity to anticipate, absorb, adapt to, and recover from shocks and stresses.

Building resilience in cities requires proactive planning and continuous preparedness. This includes integrating risk assessments into territorial governance, developing adaptive infrastructure, strengthening early warning systems, and embedding flexibility into urban form and functions. Importantly, resilience must also be relational—built through social cohesion, trust, and the empowerment of local communities. It must be democratically governed, collectively imagined, and contextually grounded.



Figure 5 - Example of a Resilient project: Beiqijia Technology Business District, Beijing, China 2016, Martha Schwartz

In conclusion, integrating the five key dimensions outlined in this module—context analysis and risk assessment, community engagement, resilient infrastructure, early warning systems, and adaptive capacity—is essential for developing systemic resilience. These components are not isolated technical fixes, but interconnected and mutually reinforcing pillars that must be woven into the daily practices of planning, design, and governance. Together, they form the basis for a robust, responsive, and regenerative urban future.

Looking ahead, this integrated and cross-sectoral approach is more critical than ever. The escalating impacts of the climate crisis—rising sea levels, intensifying extreme events, prolonged droughts, and accelerating biodiversity loss—pose existential threats to urban and rural communities alike. Simultaneously, rapid urbanization is concentrating populations in hazard-prone areas, exacerbating existing inequalities, and stretching the capacity of infrastructure, services, and governance systems. The digital transition, while offering unprecedented tools for risk monitoring and coordination, also introduces new challenges, including cyber risks, algorithmic biases, and digital exclusion. Only by embracing a systemic and inclusive perspective—one that recognises the interdependence between ecological integrity, social equity, economic vitality, and technological evolution—can we build cities and territories that are truly prepared for the complexities of the 21st century. This means investing in innovation, governance reform, education, and civic capacity, while embedding resilience as a normative principle in all aspects of planning and public policy.

In this context, the Sustainable Development Goals (SDGs) offer a powerful framework to align resilience strategies with broader global objectives. Goals such as SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), SDG 2 (Zero Hunger), and SDG 6 (Clean Water and Sanitation) provide clear targets for creating inclusive, safe, and adaptive urban systems. By operationalizing resilience through the lens of the SDGs, we ensure that no one is left behind, and that local actions contribute to global transformation. Resilience, in this sense, is not an endpoint but a continuous and transformative process. It is both a condition for survival and an opportunity for reimagining the future. By committing to this vision—pragmatic, inclusive, and ambitious—we can transform crises into catalysts for sustainable development, democratic renewal, and long-term wellbeing.

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CIRCULAR ECONOMY & URBAN METABOLISM: A FRAMEWORK FOR TRANSFORMATIVE AND SUSTAINABLE CITIES

Elena FERRAIOLI¹

¹Iuav University of Venice

Abstract

Cities function as complex systems, continuously exchanging resources, energy, and materials with their surroundings. Understanding urban metabolism—the way cities consume and transform resources—provides a crucial foundation for implementing circular economy strategies that reduce waste, promote regeneration, and enhance sustainability. This lecture will explore the key principles of urban metabolism and circularity, framed within the Sustainable Development Goals (SDGs) and their relevance to climate change adaptation and mitigation. By examining how cities can transition from linear to circular resource flows, we will discuss five key priorities for integrating circular economy principles into urban planning and governance. These include closing material loops, promoting resource efficiency, leveraging nature-based solutions, fostering multi-sectoral collaboration, and designing policies that support circular innovation. The lecture will highlight the interdisciplinary nature of circular economy approaches, demonstrating their relevance beyond urban planning to fields such as engineering, environmental science, business, and public policy. Through real-world examples, case studies, and discussion of emerging trends—such as zero-waste cities, industrial symbiosis, and regenerative urbanism—students will gain a comprehensive understanding of how circular economy principles can drive sustainable urban transformations. The session aims to equip students with critical insights into the challenges and opportunities of circularity, encouraging a cross-disciplinary dialogue on solutions for more sustainable and climate-resilient cities.

Keywords: *Urban Metabolism, Circular Economy, Sustainable Development Goals (SDGs), Climate Resilience, Urban Planning*

1. INTRODUCTION

In an era marked by deep and interrelated transformations, cities and regions are emerging as critical arenas for addressing the environmental, social, and economic challenges of our time. Rapid urbanisation, increasing pressure on natural resources, the emergence of new forms of vulnerability, and the intensifying climate crisis all call for a fundamental rethinking of how human settlements produce, consume, and regenerate materials, energy, and knowledge. Within this evolving landscape, the concept of the circular economy has gained traction as a potentially transformative strategy to guide the transition towards more sustainable, inclusive, and resilient development models. Yet, for the circular economy to become a genuine driver of change, it must be interpreted not merely as a set of industrial or technical practices, but as a broader cultural and political framework capable of redefining the relationships between the built environment, material flows, ecological systems, and society. In this perspective, the notion of urban metabolism becomes a key analytical lens: understanding the city as an open system of exchanges, transformations, and dependencies helps to reveal the underlying dynamics that govern resource use, waste production, inequalities, and regenerative potential. Based on this metabolic approach, the lesson that forms the basis of this report offers a conceptual and operational journey through five strategic priorities for embedding circular economy principles into urban planning and territorial governance. These priorities, ranging from closing material loops and enhancing resource efficiency to implementing nature-based solutions and fostering cross-sectoral innovation through policy instruments and multi-actor cooperation, provide a comprehensive framework for navigating the complexity of circular transitions. The circular economy is thus examined as a systemic and transformative approach, one that bridges disciplines—from engineering and environmental sciences to spatial planning and economics—and translates into concrete interventions that reshape the way we inhabit, produce, and govern collective life. Cities represent a privileged locus for such transitions. They concentrate most of the population, consumption, and waste, but also offer a unique scale for public policy experimentation, proximity-based collaboration, and flexible innovation. Similarly, regions provide an intermediate level that enables synergies across urban, peri-urban, and rural areas, supporting the emergence of industrial symbiosis, local supply chains, ecological restoration, and territorial circular economies. A spatial perspective on the circular economy is therefore crucial to avoiding fragmented or technocratic interpretations, enabling a more grounded response to the pressing questions posed by ecological transition: where do material flows occur, who controls them, who benefits from circular strategies, and under what conditions can these transitions be socially and ecologically just? Aligned with the Agenda 2030 and the broader goals of climate adaptation and mitigation, this report aims to synthesise the content of the lesson by emphasising its interdisciplinary grounding, systemic vision, and practical relevance. It seeks to provide a conceptual framing of urban metabolism and circularity as tools for territorial sustainability, to discuss the spatial and political implications of circularity at urban and regional scales, and to outline key insights to guide the design and planning of regenerative and collaborative models. The report is structured along five thematic sections corresponding to the priorities discussed in the lesson: contextual analysis and risk assessment, community engagement, resilient infrastructures, early warning systems, and

adaptive capacity. Each section is informed by theoretical references, practical examples, and operational reflections, with the goal of fostering a critical dialogue on the transformations required to shape cities and regions that are capable of learning, adapting, and regenerating in harmony with their socio-ecological systems.

2. CIRCULAR ECONOMY: FRAMEWORKS, CHALLENGES AND PERSPECTIVES

The transition to a circular economy (CE) represents one of the most ambitious and multifaceted challenges for contemporary cities and regions. It entails a paradigmatic shift from the dominant linear model—based on extraction, production, consumption, and disposal—to systems that aim to retain the value of resources for as long as possible, minimize waste, and regenerate natural capital. Although CE has often been associated with the realm of technological innovation or industrial production, its evolution in the urban context reveals a deeper transformative potential. Cities are not only major consumers of resources and generators of waste, but also strategic laboratories for reconfiguring socio-economic and spatial relations. They embody the possibility of developing territorially embedded circular practices that exceed sectoral or efficiency-based interpretations of circularity. This broader perspective on CE calls for a redefinition of its objectives, expanding the focus from the material dimension to the structural transformations of governance, planning, and everyday practices. While initial CE frameworks were rooted in eco-efficiency, recycling and industrial symbiosis, recent approaches underscore the importance of regeneration, repair, shared ownership, and systemic innovation. In this regard, the CE discourse has begun to incorporate social, spatial, and institutional variables, acknowledging that circularity is not simply a technological fix, but a political and cultural project that must be adapted to the unique features of each place.

Yet, the diversity of definitions and interpretations has generated a certain conceptual ambiguity. The most widely referenced definition, developed by the Ellen MacArthur Foundation, describes CE as a restorative and regenerative system by design, based on three principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. Other frameworks, such as RESOLVE, identify a wider set of action levers—regenerate, share, optimise, loop, virtualise, and exchange—but often without considering the embeddedness of these principles within specific spatial, institutional, or cultural contexts. In this regard, the need for a more explicitly territorial interpretation of CE becomes evident.

The five principles most frequently associated with CE—circular flows, slowing down resource cycles, reducing inputs, substituting unsustainable materials, and promoting localism—can provide a useful heuristic for policy design. However, their practical translation into urban and regional systems remains uneven. One of the main limitations lies in the frequent neglect of spatial dimensions in CE strategies. While local and regional authorities are often seen as the most suitable actors to activate circular practices—due to their proximity to communities and their cross-sectoral competences—their action is often constrained by institutional fragmentation, insufficient financial resources, and a lack of robust planning instruments.

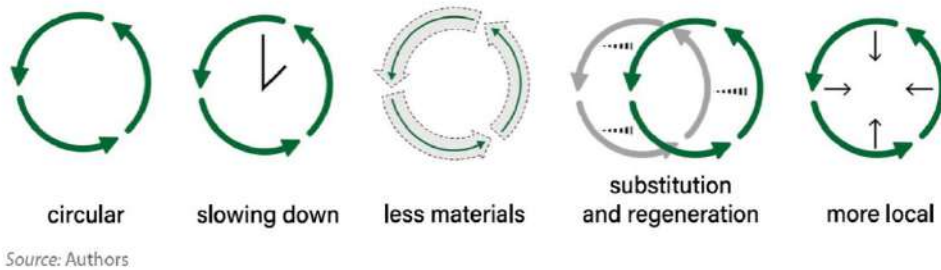


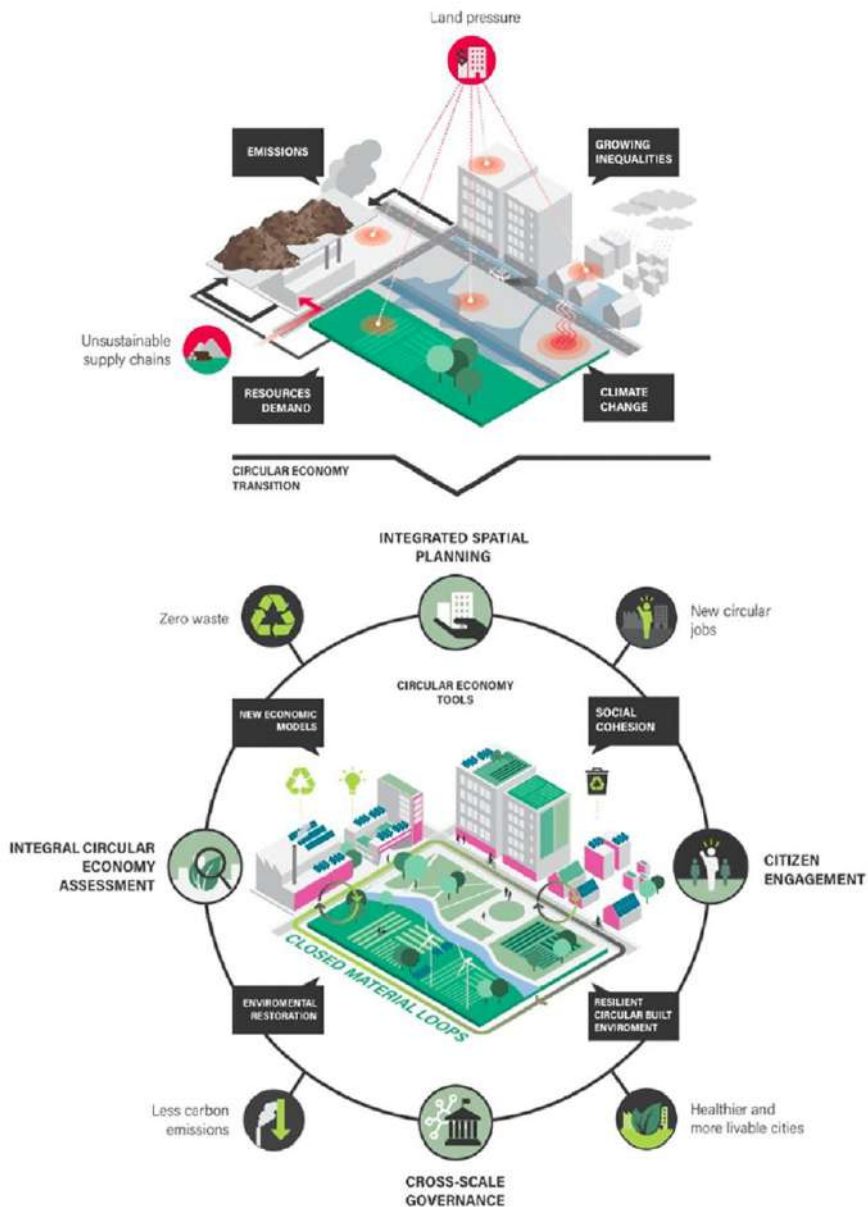
Figure 1: The five principles of circular economy (CE)

Moreover, circular policies tend to remain sector-specific, concentrating on waste management or green procurement, without addressing the structural conditions that shape urban metabolism or enable regeneration.

Recent analyses, including those focusing on cities such as Amsterdam, Hamburg, Paris or Naples, underline the potential of integrated CE policies but also the complexity of their implementation. The risk of "circular washing"—that is, the rhetorical invocation of CE principles without substantial change—is tangible, especially when strategies prioritise market-based mechanisms over structural reform. Initiatives focused on green jobs or alternative consumption may fail to tackle underlying inequalities or spatial disparities. Peripheral areas, often deprived of infrastructures for repair, reuse, or community economies, risk being marginalised in circular transitions or relegated to residual functions, such as waste treatment or energy production.

This asymmetry calls for a more grounded and situated understanding of circularity, one that includes not only the flow of materials, but also the circulation of knowledge, political agency, and governance capacity. CE should not be seen as a homogeneous and universally applicable model, but rather as a repertoire of place-based strategies, emerging from the interaction between socio-technical systems, ecological contexts, and institutional arrangements. In this sense, planning for CE means rethinking the very foundations of urban development: land use patterns, infrastructure provision, housing and food systems, and above all, the forms of governance capable of supporting experimentation and collective learning.

From this perspective, urban planning plays a crucial role in enabling CE, not only as a spatial coordination tool but as an arena of negotiation between different visions, actors, and temporalities. It is through planning that circular principles—such as regeneration, closed-loop resource cycles, and multifunctional land use—can be integrated into long-term territorial strategies. At the same time, CE calls for new assessment tools capable of evaluating not only the material outputs of circular initiatives, but also their socio-ecological impacts, distributive effects, and capacity to generate transformative change.



Source: Authors; graphic design by Fábio Alzate Martínez (TU Delft)

Figure 2: Matrix of the Land pressure and circular strategies

The figure above visualises this shift by connecting the pressures faced by cities—emissions, climate change, resource demand, and growing inequalities—to a set of circular strategies including zero waste policies, environmental restoration, cross-scale governance, and citizen engagement. The model illustrates how integrated spatial planning, combined with circular economy tools and multi-level governance, can support the creation of resilient, low-carbon, and inclusive urban systems. Central to this vision is the idea of *closed*

material loops not as purely technical systems, but as part of a broader socio-ecological infrastructure that sustains everyday life.

To truly activate the transformative potential of CE, cities and regions must therefore engage in processes of co-design, inter-scalar coordination, and cross-sectoral dialogue. This involves not only integrating CE into existing spatial plans, but also developing new types of indicators, narratives, and decision-making tools. A spatial perspective on CE allows us to shift from fragmented actions to integrated urban-rural metabolisms, from isolated projects to shared visions for socio-ecological regeneration. The challenge, then, is not only to "close loops", but to open new political and planning spaces where circularity becomes a collective project for a more just, resilient, and regenerative urban future.

3. URBAN METABOLISM: A CONCEPTUAL AND OPERATIONAL LENS FOR CIRCULAR TRANSITIONS

The concept of urban metabolism (UM) has progressively emerged as a critical analytical and planning framework to understand how cities function as complex systems of resource transformation. Rooted in early analogies with biological organisms, where cities were likened to living bodies that consume, digest, and excrete resources, the concept has since evolved into a more nuanced and systemic interpretation. Contemporary understandings of UM transcend its purely bio-physical origins, incorporating socio-technical, ecological, and political dimensions. This evolution allows for a more comprehensive interpretation of cities not merely as passive recipients of flows but as dynamic and contested spaces where material, energy, and informational processes are continuously produced, managed, and reshaped. Urban metabolism enables scholars, planners, and policymakers to investigate the material basis of urban life, highlighting how water, energy, food, construction materials, and waste circulate through the urban fabric. By tracing these flows, UM unveils the structural conditions and spatial logics that drive resource inefficiencies, environmental burdens, and socio-spatial disparities. In doing so, it challenges the invisibility of the infrastructures and socio-political arrangements that underpin urban functioning. More than a descriptive device, UM is a diagnostic lens that can reveal hidden patterns of dependency, accumulation, and exclusion, offering a powerful entry point for transformative planning.

A key strength of the urban metabolism approach lies in its capacity to translate the complexity of urban systems into intelligible patterns and relationships. Through data visualization, mapping, and systemic analysis, UM supports a deeper understanding of the interdependencies between sectors—such as housing, mobility, energy production, and food systems—and facilitates the identification of critical points for intervention. These insights are essential for designing policies that aim to reduce urban vulnerability, promote circular practices, and enhance ecological resilience. Moreover, by making material flows visible, UM nurtures a culture of awareness that is crucial for both institutional change and citizen engagement. In recent years, the operational potential of UM has gained increasing recognition. Beyond its analytical function, UM is now widely employed as a planning and design tool capable of guiding decision-making at multiple scales. This shift reflects a growing demand for integrative strategies that move beyond siloed sectoral interventions and embrace the systemic nature of urban challenges. UM supports the co-design of circular

solutions by linking material stocks and flows with spatial configurations and governance processes. For example, it can inform spatial zoning decisions by identifying areas of resource intensity or metabolic fragility, or support infrastructural planning by pinpointing opportunities for industrial symbiosis, water reuse, or localized energy production.

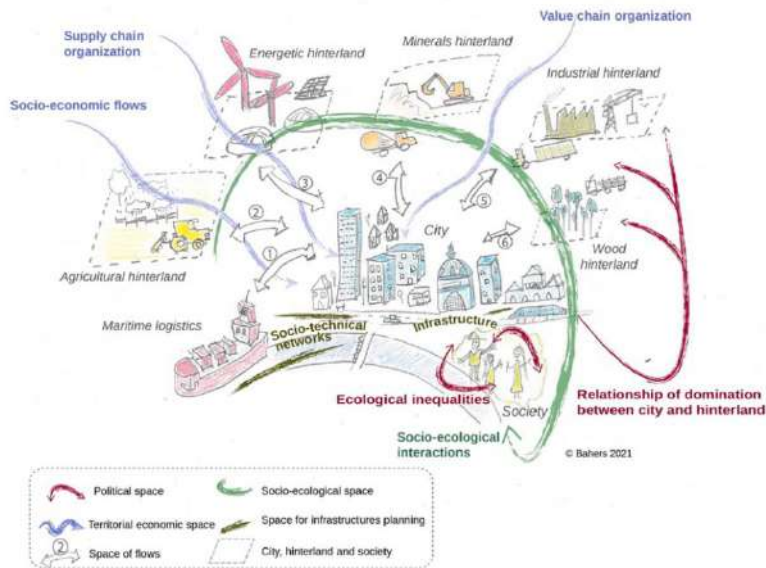


Figure 3: Graphic representation of urban metabolism space

Crucially, the notion of urban metabolism has expanded toward the broader framework of *territorial metabolism*, which recognizes the embeddedness of urban systems within larger territorial dynamics. Cities rely extensively on peri-urban, rural, and even transboundary territories to sustain their metabolic functions. These regions provide essential resources—such as food, water, biomass, and energy—while simultaneously absorbing urban waste, pollution, and environmental pressures.

Territorial metabolism thus reveals the extractive nature of contemporary urbanization and calls for a fundamental reconsideration of the scale and scope of planning interventions. It also highlights the political implications of circular transitions: not all territories benefit equally from these transformations, and addressing such disparities is a precondition for socially just and environmentally sound outcomes. Furthermore, urban metabolism serves as a temporal lens that foregrounds the path dependencies, legacies, and inertias that characterize urban development. Resource flows are not only spatially uneven but also historically sedimented. Infrastructure systems, building stock, and land uses often reflect decades of investment and institutional lock-in, which can constrain efforts to implement circular strategies. UM brings these temporal dimensions into focus, encouraging planners to adopt long-term, adaptive, and iterative approaches. This orientation is particularly relevant in the context of climate change, where the urgency of mitigation and adaptation must be balanced with structural reforms that may unfold over generations.

Another essential contribution of the UM framework is its capacity to foster interdisciplinarity. By drawing on insights from urban ecology, environmental engineering, planning theory, political economy, and geography, UM dissolves the traditional boundaries between natural and social sciences. It invites a relational understanding of urban systems, one that acknowledges the interplay between material processes and power relations, between ecological constraints and institutional arrangements. In this way, UM contributes to reimagining the role of planning as a practice grounded in ecological rationality and socio-political responsibility. Importantly, urban metabolism also aligns with emerging paradigms of participatory governance and co-production. Mapping urban flows can become a powerful tool for dialogue among stakeholders, enabling local communities, public authorities, researchers, and private actors to engage in joint problem-solving. By making visible the interconnections between consumption patterns, infrastructural decisions, and environmental outcomes, UM stimulates a more democratic and transparent approach to urban planning. This participatory dimension reinforces the idea that circular transitions are not merely technical challenges, but collective projects rooted in shared values, aspirations, and responsibilities.

In conclusion, urban metabolism offers a comprehensive, systemic, and operational lens for understanding and reshaping urban systems toward circular and regenerative futures. It provides the conceptual grounding and methodological instruments necessary to align planning practices with the principles of circular economy, while remaining attentive to questions of equity, temporality, and governance. Integrating UM into spatial planning means recognizing cities not only as nodes of consumption but as agents of transformation—capable of reconfiguring their material basis, institutional frameworks, and cultural imaginaries in pursuit of a more resilient and sustainable urban condition.

4. THE WATER-ENERGY-FOOD NEXUS: A SYSTEMIC APPROACH TO URBAN RESILIENCE

The Water-Energy-Food (WEF) Nexus has emerged as a key conceptual and operational framework for understanding and managing the complex interdependencies among essential resources. Within the context of urban systems, this approach becomes particularly relevant, as cities represent both major consumers of natural resources and strategic arenas for experimenting with integrated, circular solutions. Rather than addressing water, energy, and food in isolation, the WEF Nexus promotes a systemic logic, recognizing that interventions in one domain often generate cascading effects—either positive or negative—across the others. As highlighted in Del Borghi et al. (2020), the increasing global demand for food, water, and energy—driven by population growth, urban expansion, and changing consumption patterns—is putting significant pressure on soils, ecosystems, and finite resource stocks. This growing demand is further complicated by the spatial and temporal disjunctions typical of urban metabolism: cities tend to import resources from distant hinterlands, externalizing the environmental costs while concentrating consumption and waste production. Consequently, the WEF Nexus represents not only an analytical tool but also a normative compass for advancing urban sustainability through resource efficiency, symbiosis, and regeneration.

From an urban planning perspective, the WEF Nexus calls for a shift from sectoral policies toward integrated territorial strategies.

Water is not only a basic service, but also a key component in energy production and agricultural systems. Energy, in turn, is required for water treatment, distribution, and food production.

Food systems depend on water for irrigation and on energy for cultivation, storage, and transport. This triadic relationship reveals numerous trade-offs, but also opportunities for co-benefits. For example, the recovery of biogas from food waste can simultaneously address energy needs and reduce organic waste volumes. Similarly, the reuse of treated wastewater for urban agriculture can alleviate water stress while enhancing local food security.

Urban implications of the WEF Nexus are manifold. First, cities must confront the competition for space and resources among these sectors. The expansion of photovoltaic installations, for instance, may reduce the availability of land for agriculture, just as bioenergy production can intensify water usage or displace food crops.

Second, infrastructure planning must account for the interoperability of systems: energy grids, water networks, and food logistics must be conceived not as parallel layers but as interacting subsystems within a shared urban ecology. This perspective reinforces the need for adaptive and integrated governance, capable of managing uncertainties, coordinating across scales, and involving a wide array of stakeholders.

Furthermore, applying the WEF Nexus in urban settings helps identify innovative cross-sectoral solutions. Integrated urban farms, vertical agriculture powered by renewable energy, or buildings designed with water harvesting and reuse systems are concrete expressions of this nexus-thinking. These solutions are not only more sustainable, but also more resilient, as they reduce dependence on long supply chains and enhance local autonomy in the face of climate disruptions.

At a governance level, the Nexus perspective can foster co-design processes and participatory planning, aligning infrastructure investment with community needs and knowledge. Urban decision-makers are increasingly called to move beyond siloed departments and embrace collaborative frameworks, where water, energy, and food policies are harmonized and informed by shared data systems, scenario modelling, and inclusive deliberation. This paradigm shift requires new competencies, new institutional arrangements, and—crucially—a cultural reorientation toward complexity, relationality, and interdependence.

Finally, the WEF Nexus plays a crucial role in enhancing urban security, especially considering climate change, socio-economic inequalities, and geopolitical tensions. Ensuring access to clean water, affordable energy, and nutritious food is not only a sustainability issue, but a matter of equity and human rights. The Nexus approach, when embedded in territorial planning and circular economy strategies, can thus serve as a powerful driver for just, regenerative, and climate-resilient urban futures.

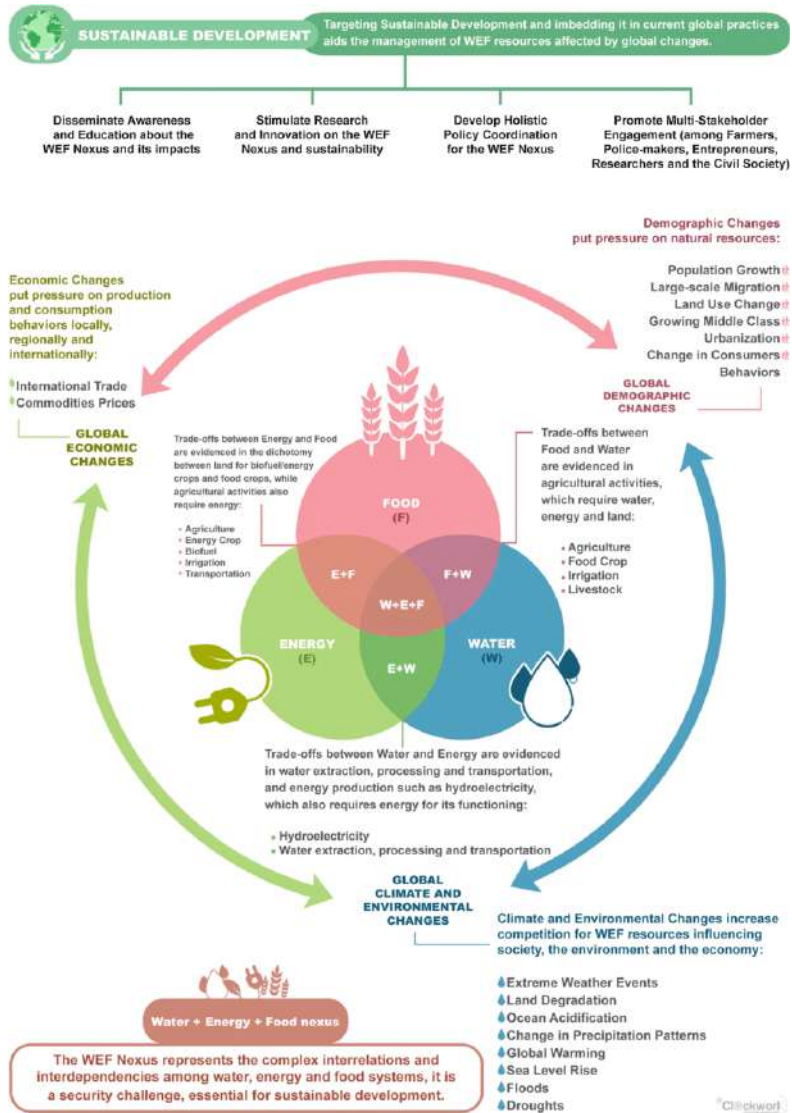


Figure 5: Matrix of WEF Nexus

5. INTEGRATING CIRCULARITY INTO THE GLOBAL AGENDA

The concept of circularity is not only a technical paradigm for resource efficiency but also a broader political and cultural vision that redefines how we conceive and govern urban and territorial systems. Circularity calls for a structural rethinking of production and consumption models, of spatial configurations and governance practices, and of the relationships between cities, ecosystems, and communities. As such, it is deeply connected to the 2030 Agenda for Sustainable Development and to the Sustainable Development Goals (SDGs), which offer a comprehensive framework for addressing the interconnected challenges of our time—climate change, biodiversity loss, social inequality, and

unsustainable resource use. Planning for circularity therefore finds in the SDGs a coherent and enabling platform for action. Many of the transformations required to activate circular processes at the urban and territorial level—such as improving water and energy efficiency, reducing waste, regenerating ecosystems, fostering local economies, and ensuring social inclusion—are directly aligned with specific SDG targets. But beyond individual goals, what is particularly relevant is the systemic logic of the SDGs: their recognition of interdependence between ecological, social, and economic dimensions, and their call for integrated, inclusive, and forward-looking strategies.

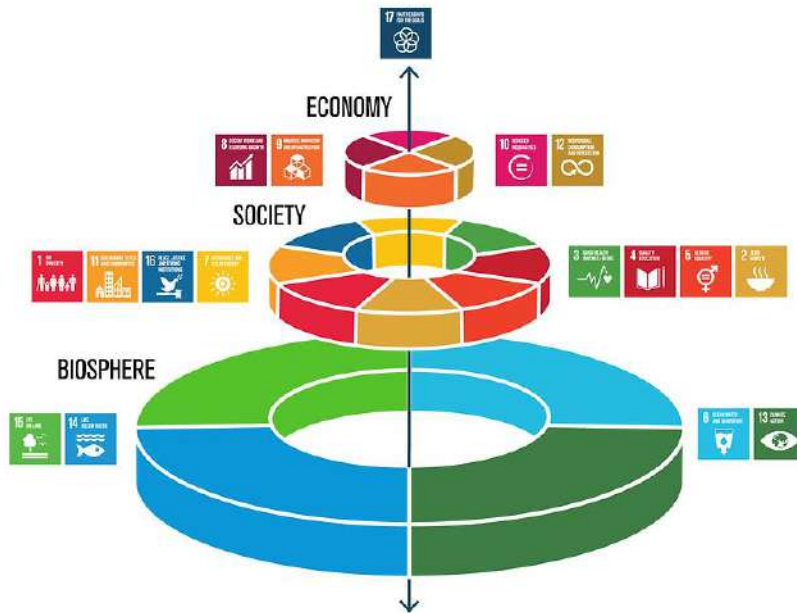


Figure 6: SDGs structure

In this sense, embedding the SDGs into spatial planning processes is not merely a matter of compliance or alignment with international agendas. It is a way to translate the principles of circularity into operational and measurable objectives, to mobilize multi-level actors around shared goals, and to reinforce the legitimacy and coherence of planning actions in a time of transformation. The SDGs act as a connective framework that enables a common language across disciplines, sectors, and territories, enhancing the capacity of planning to deal with complexity and long-term visions. Above all, the SDGs provide a structured horizon for guiding the transition towards more sustainable, inclusive, and resilient societies. This transition is not linear nor purely technological; it requires institutional change, new forms of collaboration, and the capacity to rethink priorities in light of planetary boundaries and social thresholds. In this perspective, planning becomes a strategic tool to localize the SDGs, to shape place-based pathways of transformation, and to support the shift from extractive models to regenerative ones. The following sections explore in more detail how specific SDGs—particularly Goals 6, 7, 11, 12, 13 and 15—can be

mobilized through planning practices to foster circular governance and accelerate the transition.

5.1. Leveraging Key Goals for Circular and Sustainable Planning

Among the 17 Sustainable Development Goals, several are particularly aligned with the principles of circularity and play a pivotal role in shaping planning strategies capable of fostering environmental regeneration, social equity, and resource efficiency. In particular, SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land) offer direct entry points for embedding circular thinking into spatial and territorial planning.

SDG 6 – Clean Water and Sanitation promotes the sustainable management of water resources, which is a core dimension of circular urban metabolism. Planning with this goal in mind means prioritizing nature-based solutions for stormwater management, wastewater reuse, and aquifer recharge, as well as ensuring equitable access to safe water and sanitation in both formal and informal settlements. Integrated water planning strategies—such as water-sensitive urban design—can effectively support the transition toward a more circular and resilient hydrological cycle.

SDG 7 – Affordable and Clean Energy calls for a transition to renewable energy systems and improvements in energy efficiency. Urban and regional planning can directly influence this goal by promoting compact city models, district heating networks, low-energy building codes, and local production of solar, wind, or geothermal energy. Moreover, planning can support decentralized energy infrastructures that enhance local autonomy, reduce transmission losses, and create synergies with other circular initiatives such as waste-to-energy systems.

SDG 11 – Sustainable Cities and Communities provides a direct mandate for planners to address sustainability, inclusion, and resilience at the urban scale. From the regeneration of brownfields to the development of mixed-use and walkable neighbourhoods, this goal underpins the spatial reconfiguration of urban forms in line with circularity. It also includes targets related to participatory planning, safe and inclusive public spaces, disaster risk reduction, and access to affordable housing—key components of a fair and future-oriented urban transition.

SDG 12 – Responsible Consumption and Production is perhaps the most explicitly circular of all the goals. It encourages the reduction of waste generation, the promotion of sustainable value chains, the adoption of eco-design principles, and the decoupling of economic growth from environmental degradation. Spatial planning can support SDG 12 by facilitating the localization of circular economy activities—such as repair hubs, local food systems, and circular innovation districts—and by integrating life-cycle thinking into land-use decisions and infrastructure investments.

SDG 13 – Climate Action requires urgent measures to mitigate and adapt to climate change. Planning plays a fundamental role in both dimensions: by reducing emissions through sustainable mobility, energy-efficient urban development, and green infrastructures, and by enhancing adaptation through risk-sensitive land use, flood

protection strategies, and the restoration of ecological buffers. Circularity amplifies these efforts by closing resource loops and fostering regenerative processes that strengthen climate resilience over time.

SDG 15 – Life on Land addresses the need to protect, restore, and promote sustainable use of terrestrial ecosystems. Circular planning engages with this goal by preserving agricultural land, curbing urban sprawl, enhancing green-blue infrastructures, and promoting ecosystem services through multifunctional landscapes. Rural-urban linkages, biodiversity corridors, and land stewardship initiatives are all spatial expressions of SDG 15 that can be activated through integrative planning approaches.

Taken together, these six goals form a powerful constellation through which the principles of circularity can be translated into place-based planning strategies. Rather than being pursued in isolation, they call for synergistic approaches that bridge ecological, social, and economic priorities, enabling a planning culture that is both regenerative and future-proof.

5.2. The Potential of the SDGs for Circular Governance

Integrating the Sustainable Development Goals into urban and territorial planning is not merely a matter of alignment with global agendas; it is a strategic opportunity to reframe planning as a transformative practice capable of guiding the transition toward sustainable, inclusive, and regenerative futures. The SDGs offer a shared vocabulary and a multidimensional framework that help connect local actions to global challenges—bridging scales, sectors, and disciplines. When embraced as a guiding system for planning, they foster coherence between spatial strategies and broader societal goals, promoting long-term vision over short-term fragmentation. In particular, the SDGs encourage the adoption of systems thinking, which is essential for circular governance. Rather than addressing urban issues in silos—transport, housing, water, waste, energy—the SDG framework invites planners and decision-makers to recognize the interdependencies between infrastructures, ecosystems, economies, and communities. This approach is foundational for a circular perspective, which relies on closing resource loops, maximizing synergies, and regenerating natural and social capital.

Furthermore, the SDGs create a platform for governance innovation. Their integrated nature calls for participatory and multi-level processes, in which local authorities, civil society, private actors, and academia collaborate in the co-design of solutions. In this sense, SDG-oriented planning strengthens democratic legitimacy and transparency, while enabling policy coherence across urban, regional, and national scales. This is particularly relevant in the context of climate transition, where trade-offs between mitigation, adaptation, and socio-economic development must be openly negotiated and continuously revised. Ultimately, the potential of the SDGs lies in their capacity to institutionalize circularity—not only as a technical principle for resource efficiency but as a normative horizon for just and resilient societies. By embedding the goals into the planning cycle—analysis, visioning, design, implementation, monitoring—they become both a compass and a toolkit for systemic change. Planning with the SDGs means transforming cities and territories into laboratories of transition, capable of turning complexity into opportunity and uncertainty into collective agency.

6. CLIMATE CHANGE AND URBAN ADAPTATION: SYSTEMIC TOOLS AND STRATEGIES

Cities stand at the forefront of the climate crisis. As dense and complex territorial systems, they are simultaneously among the largest contributors to greenhouse gas emissions and among the most exposed to climate-related risks. Rising temperatures, intensified heatwaves, increased frequency of extreme weather events, urban flooding, and sea-level rise disproportionately affect urban areas, particularly those already facing socio-economic vulnerabilities. The imperative to act is therefore not only environmental, but profoundly spatial, political, and social. Urban adaptation must go beyond short-term mitigation and embrace a systemic approach capable of reconfiguring infrastructures, institutions, and everyday practices. In this context, climate adaptation is no longer conceived as a mere technical add-on, but as a transformative agenda that requires the alignment of spatial planning, resource management, and community engagement. The shift from mitigation to adaptation calls for integrating climate risks into all phases of urban development: from land use planning and infrastructure design to governance frameworks and financial instruments. This requires moving from reactive strategies to anticipatory approaches that promote resilience, flexibility, and co-benefits across sectors and scales.

Among the emerging instruments for integrated climate governance, the Climate City Contract (CCC) represents a significant innovation. Originating within the framework of the EU Mission on Climate-Neutral and Smart Cities, the CCC is conceived as a binding commitment between cities, national governments, and the European Commission. Its purpose is to co-develop tailored pathways towards climate neutrality, combining mitigation and adaptation in an integrated and participatory manner. The CCC is not a generic declaration, but a multi-actor platform that links visionary goals with operational planning, investment strategies, and long-term governance mechanisms. The value of the CCC lies in its capacity to activate systemic and place-based actions, capable of reorienting urban metabolism toward decarbonization and ecological regeneration. Rather than focusing exclusively on technological fixes, it emphasizes the importance of social innovation, stakeholder involvement, and territorial intelligence. This means fostering co-design processes with citizens and local actors, aligning public and private investments, and mobilizing knowledge across disciplines and sectors. The CCC enables cities to combine climate planning with economic, spatial, and social transformation, leveraging adaptation not only as a response to risk, but as an opportunity to reimagine urban futures. Examples of CCC-inspired actions include nature-based solutions for flood control, heat mitigation through urban greening, district-scale energy retrofitting, integrated mobility plans, and circular strategies for water reuse and food systems. These actions are not isolated interventions, but components of a broader ecological transition. By embracing multi-level governance, cities become laboratories for experimentation, linking local ambitions with national and European frameworks, and creating shared accountability for long-term outcomes.

In conclusion, facing climate change requires cities to act as protagonists in a collective transition, embracing vulnerability as a catalyst for transformation. The Climate City Contract offers a concrete pathway to do so, anchoring climate goals in spatial strategies,

collective visions, and operational tools. It is a governance infrastructure for the Anthropocene city—open, flexible, and deeply rooted in place.

7. CONCLUSIONS: TOWARD CIRCULAR AND REGENERATIVE CITIES

The transitions explored throughout this report—from circular economy frameworks to urban metabolism, from the WEF Nexus to climate adaptation—converge toward a shared objective: transforming cities into more resilient, regenerative, and inclusive systems. This transformation requires abandoning linear and fragmented models of urban development, and embracing new paradigms based on integration, sufficiency, and co-evolution with ecological systems. A key insight emerging from these explorations is that sustainability cannot be achieved through sectoral policies or technological fixes alone. Rather, it demands a reconfiguration of urban governance, planning practices, and socio-economic relations. Circularity is not only about resource loops—it is about rethinking the metabolism of cities, the logics of production and consumption, and the distribution of risks and benefits across space and society. Moving “from the design of objects to the design of systems” means shifting focus from isolated solutions to interdependent networks of action. This involves aligning infrastructures with ecosystems, embedding resilience into land use decisions, and fostering a culture of co-responsibility and long-term stewardship. Regenerative urbanism calls for new institutional architectures, capable of accommodating experimentation, learning, and participation. Planning becomes less about control and more about enabling enabling adaptation, facilitating transitions, and cultivating collective agency. The long-term nature of these challenges requires new forms of participatory governance, where cities are not only spaces of decision-making, but also of co-creation. Communities, researchers, institutions, and the private sector must be engaged in the co-production of knowledge, visions, and actions. Tools such as urban living labs, climate contracts, and digital platforms for participatory mapping can support this shift, fostering transparency, inclusion, and reflexivity.

Ultimately, the transition toward circular and regenerative cities is not only a technical or institutional endeavour. It is a cultural and ethical transformation, grounded in values of care, reciprocity, and interdependence. It invites us to rethink the role of cities not as machines for economic growth, but as living systems embedded in broader ecological and planetary dynamics. This requires imagination, courage, and a renewed commitment to equity, justice, and the common good.

As the climate crisis deepens and inequalities persist, urban regions can either perpetuate unsustainable trajectories or become crucibles of transition. The choice is not abstract—it is spatial, political, and urgent. This report has outlined the tools and frameworks to navigate this path. The future of cities depends on our capacity to design not only spaces, but relationships, processes, and possibilities for regeneration.

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DIGITAL CITIES: SPATIAL DATA ANALYTICS FOR URBAN PLANNING AND GOVERNANCE

Davide LONGATO¹

¹Department of Architecture and Arts, University IUAV of Venice

Abstract

The evolution of data analytics, particularly geospatial data and Geographic Information Systems (GIS) is extremely relevant in the context of supporting urban planning and governance through the exploitation of big data. From historical practices of big data collection and early socio-demographic maps, the storage, manipulation, and visualization of large-scale geospatial data have become more sophisticated and digitally integrated thanks to modern GIS technologies. This evolution allows for the transformation of raw data into useful information and actionable knowledge that can effectively support decision-making by providing insights – especially through maps – into urban dynamics, environmental conditions, and socio-economic patterns, among others. This is instrumental in developing evidence-based policies and addressing many urban challenges aligned with global sustainable development goals. However, while GIS maps are powerful tools for communication, they can carry biases and subjective interpretations, which must be critically assessed. The use of spatial data analytics is not merely technical but deeply tied to social implications, requiring careful consideration of data sources, methods, and the intended outcomes. As such, GIS and spatial data analytics are pivotal in shaping equitable and sustainable urban futures, provided they are used transparently and thoughtfully to uncover meaningful insights for real-life decisions in the digital city era.

Keywords: *Big data, Decision support tools, Sustainable development, Urban challenges, Digital city.*

1. EVOLUTION OF (BIG) DATA ANALYTICS FOR SUPPORTING THE PLANNING AND GOVERNANCE OF CITIES¹

Today’s digital systems and technologies are producing huge amounts of data (the so-called big data) that can help inform how we manage and plan cities. There is now a big potential to directly measure issues that have always been central to urban planning and governance, such as socio-environmental issues, urban forms, and many city’s spatial dynamics (e.g., transport-related). These measures and data can help a lot in understanding the issues and complex interactions affecting cities and territories, and – in principle – supporting decision-making processes to address them in the best possible way. But, has it always been so? Of course not. Big data, in fact, is not a completely new concept. It always existed, but in different forms. For instance, population surveys in the form of written lists can be considered among the first forms of big data collection. One of the first documented examples is the so-called Domesday book, a complete survey of England written in AD 1086 listing land holdings in Warwickshire (Figure 1).

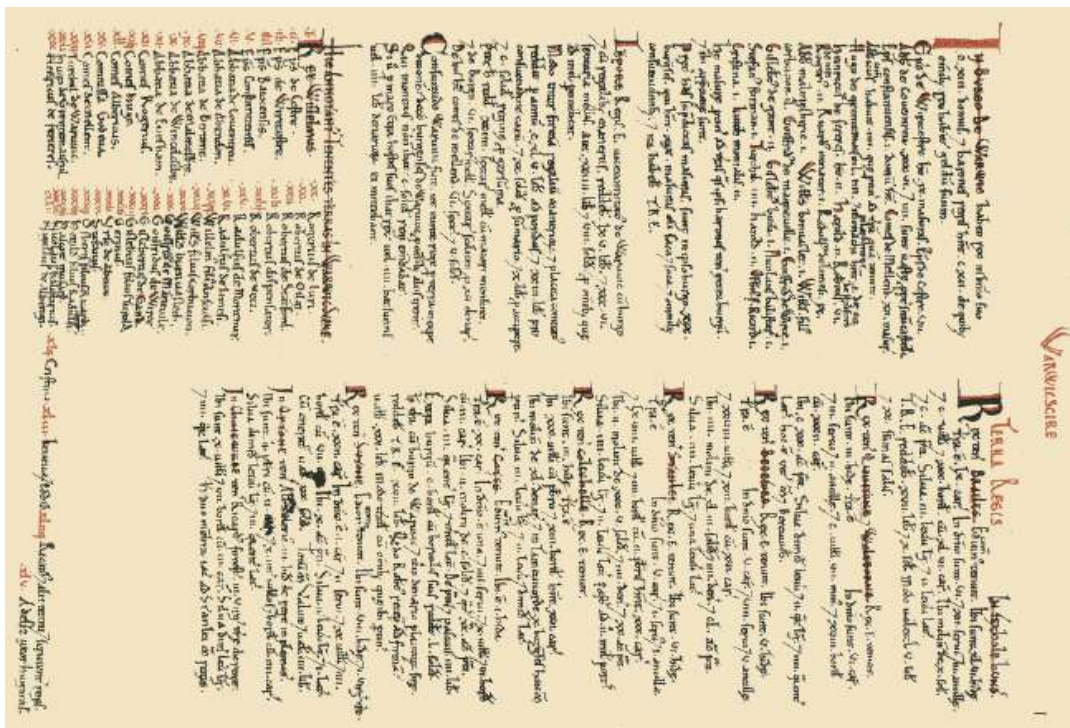


Figure 1 – A page from the Domesday book (AD 1086), listing land holdings in Warwickshire (England). Source: <https://opendomesday.org/book/warwickshire/01/>

¹ Part of this chapter was inspired by: Sarah Williams (2020). Data Action: Using Data for Public Good. The MIT Press, Cambridge, Massachusetts. Figures 1, 2 and 4 are also published in this book.

However, at a certain point, information about cities and their inhabitants was not just collected in the form of lists, but also mapped to add a spatial dimension to the represented information. The first mapping efforts focused on creating maps using socio-demographic data, which have been developed since the First Industrial Revolution (late 1700 – early 1800). In this context, the first social data and maps were especially aimed at marking the location of poverty, race, cleanliness, and disease. For example, Figure 2 shows the sanitary map of Leeds, in United Kingdom (where the industrial revolution first began), produced in 1842. This map describes the physical and social concerns that might be contributing to outbreaks of cholera.



Figure 2 – Sanitary map of Leeds (UK), 1842. Source: <https://www.parliament.uk/about/living-heritage/transformingsociety/livinglearning/coll-9-health1/health-02/1842-sanitary-report-leeds/>

Maps of this type were often used to create policies of exclusion and segregation, marking the undesirable city areas. Especially in the US, socio-demographic maps created using population data (the so-called census data) were aimed at marking the location of the minority racial/ethnic groups (see a more recent example in Figure 3), and often used for lasting oppression through urban planning and governance.

However, in more recent times, (census) data about population turned out to be very useful for governing and managing cities and have been incorporated into digital systems. For instance, they can be used to provide services, build infrastructure, collect taxes, and enforce policy, among others, but also to combine with other types of data to analyze complex socio-environmental (spatial) interactions. In many countries, census data today is more openly available to the public than ever before (however, many countries still don't conduct population surveys).

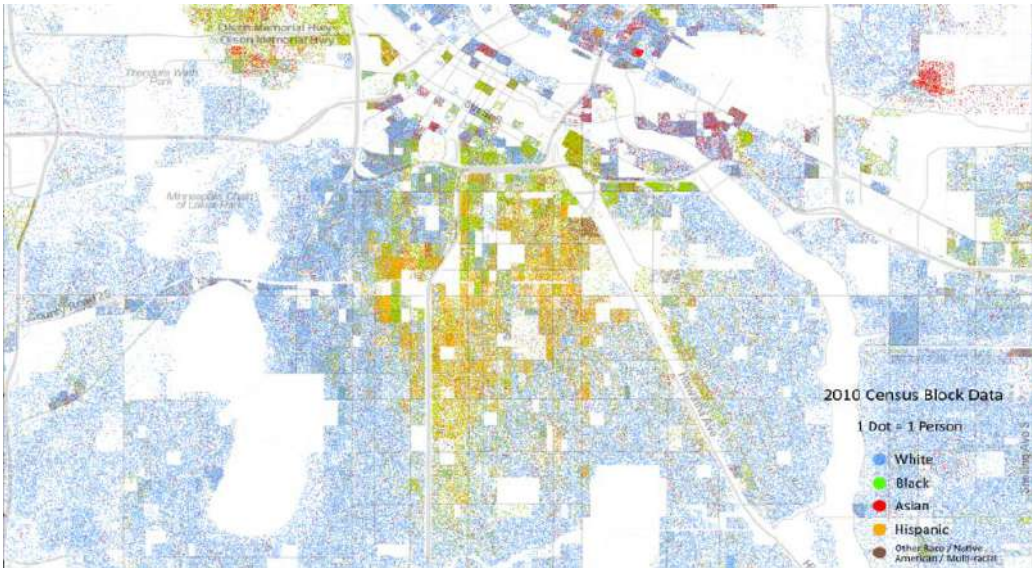


Figure 3 – Racial dot map in Minneapolis and St. Paul using 2010 population census data. Source: <https://streets.mn/2013/08/14/racial-dot-map/>

Together with population-based data and maps, cadastral maps also emerged as important information to support the planning and governance of cities and territories. These include detailed maps of cities showing buildings footprints, streets, roads, parks, and civic institutions (e.g., churches, schools). In the past, they were largely used for taxation or insurance purposes, also in combination with socio-demographic data (e.g., Figure 4).



Figure 4 – Charles Booth's social demographic maps of London. Source: <https://booth.lse.ac.uk/map/14-0.1326/51.5068/100/0>

Further, they started to be used as a basis for developing zoning and land use plans, until modern times.

As a technological milestone, after World War II, and with the arrival of cybernetics (human-machine inter-communications), a lot of military technologies were applied to civilian use, including urban and regional planning. These include satellite images. In the last decades, commercial and non-commercial satellite missions multiplied, providing plenty of remotely sensed data that supports many geographical applications. But it is with the advent of desktop computing in the 1980s and 1990s, which led to the development of Geographic Information Systems (GIS), that digital geographical-spatial applications started to emerge not only for collecting, storing, and mapping data (as it was with handwritten maps) but also to perform interactive queries and manipulate the data to extract new insights. While the technologies are evolving, plenty of opportunities are available today to collect multiple types of spatial data from multiple sources, manipulate them to create new information/insights, and finally build relevant knowledge for supporting decisions. Nowadays we can collect not only the data that are made openly available by organizations, public institutions, and private companies, but also the data we produce every day. For example, social media posts or other types of posts/photos in webpages that are published using geotags (e.g., geo-localization of the location of the post/photo), or web applications that allow users to upload/download information about the location of amenities, economic activities, services, among others. These information can be then spatially combined with other spatial information to extract new information/insights (e.g., Figure 5 from Balzan & Debono, 2018).

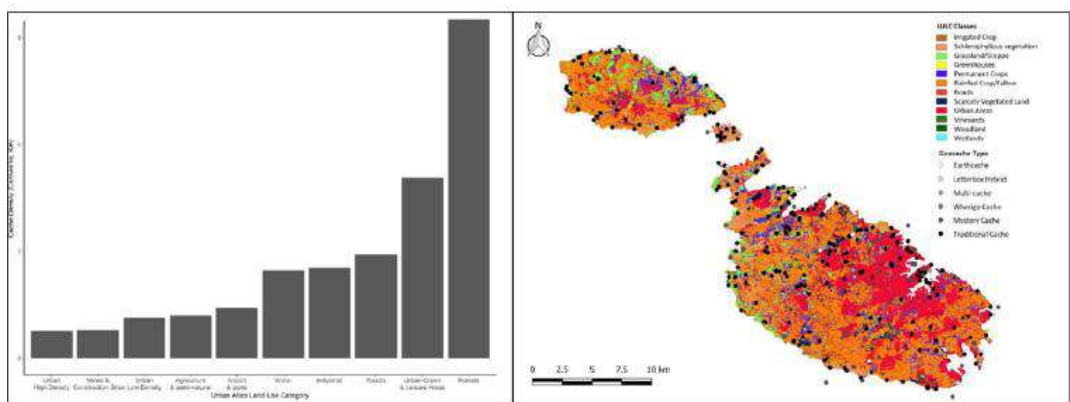


Figure 5 – Land use and cover map of Malta with the location of geocaches investigated (right) and the number of geocaches broken down per land use and cover class intersected (left) (Balzan & Debono, 2018).

Today’s GIS softwares can process large amounts of data (“big data”) of different types in 2D from various sources, and even in 3D (e.g., digital terrain and surface models), for the design, planning, management, and monitoring of urban and non-urban environments in their multifaceted aspects (e.g., environmental, social, economic). Given that spatial data analytics are increasingly considered essential for proper governance, supporting policy design and planning decisions, spatial Information and Communication Technologies like GIS softwares are becoming essential in this field.

2. BASICS OF GEOGRAPHIC INFORMATION SYSTEMS (GIS)

A GIS can be described as a powerful computer/ technological system that enable the storage, visualization, creation/edit, and analysis of spatial (georeferenced) 2D and 3D data representing the real world, since they have coordinate systems that locate them in the right position in a real-world cartographic representation within a GIS software. These data are connected to maps that integrate location and descriptive information.

Common definitions of Geographic Information Systems (GIS)

A GIS is a computer system that analyzes and displays geographically referenced information. It uses data that is attached to a unique location (source: U.S. Geological Survey).

A GIS consists of integrated computer hardware and software that store, manage, analyze, edit, output, and visualize geographic data (source: various authors in Wikipedia).

GIS is a technology that is used to create, manage, analyze, and map all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there) (source: ESRI - Environmental Systems Research Institute).

Main types of spatial data that can be elaborated in GIS include vector and raster formats. Vector data represent well defined geometric elements (points, lines, polygons) that integrate an attribute table that stores all the descriptive information related to each object. This format is often used to represent discrete elements (e.g., roads, buildings, measure points, trees, etc.). Raster data instead is composed by a cell matrix of pixels (i.e., image format). Each cell has a specific numeric value and is useful to represent continuous phenomena in the space (e.g., temperature, terrain elevation, distribution of a chemical element, etc.). GIS softwares include a number of tools that enable users to perform a lot of elaborations involving both one single layer (i.e., vector or raster data) and more than one layer (of the same type or of different formats).

In the last decades, along with GIS, GIScience has emerged as a scientific discipline at the crossroads of computational science, social science, and natural science that studies geographic information, including how it represents phenomena in the real world, how it represents the way humans understand the world, and how it can be captured, organized, and analyzed. It can be contrasted with GIS, which are the actual repositories of geospatial data, the software tools for carrying out relevant tasks, and the profession of GIS users. That said, one of the major goals of GIScience is to find practical ways to improve GIS data, software, and professional practice; it is more focused on how GIS is applied in real life as opposed to being a GIS tool in and of itself (see also Goodchild, 2009).

3. THE USE OF SPATIAL DATA ANALYTICS TO CREATE ACTIONABLE KNOWLEDGE TO SUPPORT DECISIONS

It is in this context that GIS users seek to transform raw digital data into actionable knowledge that can be applied to support real-life decisions, including in urban planning and governance, in the so-called data-information-knowledge cycle (or path) (Figure 6).

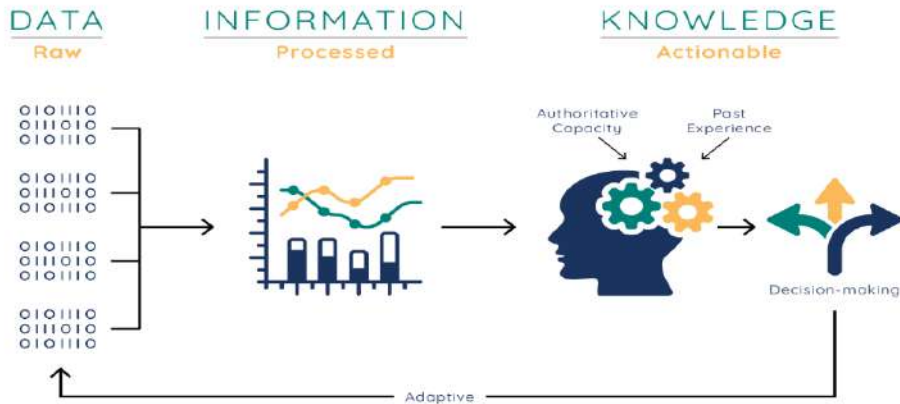


Figure 6 – The data-information-knowledge cycle (or path) to transform raw data into actionable knowledge.
Image source: Internet of Water Coalition (internetofwater.org).

"Data" is the fundamental component of information and knowledge. Data typically consists of raw, unprocessed facts, often lacking context or immediate meaning. On its own, data has limited utility: it is only through interpretation, classification, and contextualization that its value emerges. Users must engage in a process of filtering, organizing, and structuring data before it can serve any practical purpose. This is especially true in urban contexts, where data streams are numerous, heterogeneous, and sometimes conflicting. When data are cleaned, categorized, and elaborated in a structured and meaningful way, they become "information"-a more intelligible form that reveals patterns, relationships, and contextual insights. Information can be seen as an intermediary step between raw data and applied understanding. It is a collection of consistently structured facts that convey a narrative or highlight a specific trend. For planners, policymakers, and analysts, information reduces the cognitive burden required to identify key issues or priorities. It allows users to access relevant content more efficiently and make sense of complex urban phenomena.

The next phase in this continuum is the creation of "knowledge", which is the result of applying information to solve problems, guide decisions, or inspire action. In other words, when information is contextualized, interpreted through specific lenses (e.g., spatial, temporal, social), and aligned with real-world questions or needs, it becomes actionable knowledge. This knowledge informs strategies, shapes policies, and ultimately drives change.

In the context of Geographic Information Systems (GIS), this data-to-knowledge cycle can be summarized through three key steps:

- **Raw data collection and organization:** This involves identifying relevant data types and understanding how they are gathered, stored, and structured. The process may rely on existing datasets from public or private repositories, or it may require producing new data through ground-based sensors, citizen science, remote sensing, or other methods. Metadata-information about the data-is essential here to ensure quality and reliability.
- **Information generation and processing:** Once collected, data undergo various operations-cleaning, transformation, aggregation, and analysis-to generate meaningful outputs. These operations vary depending on the data format (vector, raster, tabular), and on the specific objectives of the analysis. Data fusion techniques, spatial overlays, and classification algorithms are common tools used in this phase to enrich the informational value of the original datasets.
- **Knowledge visualization and dissemination:** The final step is about turning processed information into knowledge that can support decisions. This often involves spatial representation through maps, graphs, dashboards, or interactive platforms, accompanied by explanatory narratives. The way knowledge is communicated-its clarity, transparency, and accessibility-is crucial to ensure that it is understood and effectively used by different stakeholders, from decision-makers to local communities.

Regarding the first step-data collection and production-the choice between using existing datasets and generating new ones depends on the availability, granularity, and suitability of the data in relation to the goals at hand. For example, air quality assessments might leverage open datasets such as those provided by environmental agencies in cities like London. However, when real-time data is needed, or when coverage is insufficient, mobile sensors or IoT networks may be deployed, as illustrated by Beijing's street-level air quality monitoring during the 2008 Olympics (see Figure 7). In either case, the quality of the initial data strongly influences the accuracy and usefulness of the final insights.

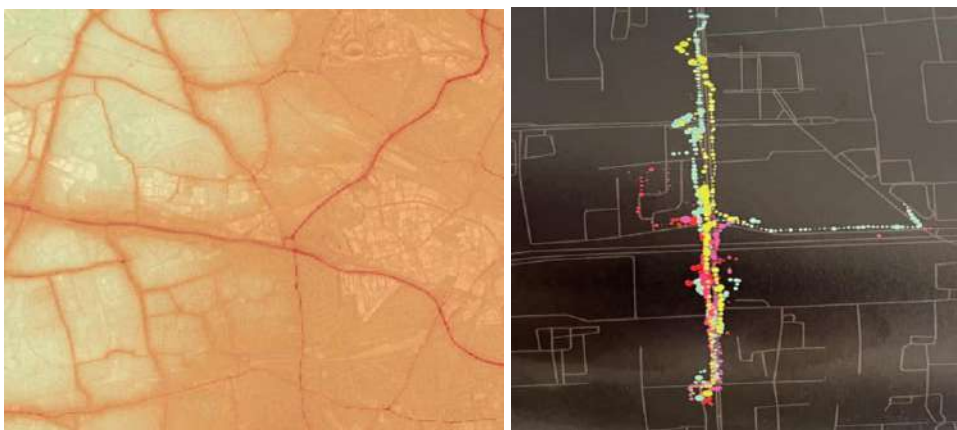


Figure 7 – Left: PM10 concentrations based on the data published by the London Atmospheric Emissions Inventory (LAEI) 2019 (author's elaboration). Dark red colour means higher concentrations. Right: PM10 concentrations measured using mobile sensors in Beijing's streets during the 2008 Olympics (Williams, 2020). The colours represent the air quality measurements in different times; the larger the circle the higher the concentration of pollutants.

As regards the second point (creation of new information), basically, every data manipulation action that enhances the informative value of the collected data contributes to transforming (raw) data into a piece of valuable information. These manipulations may include the editing of single data properties, the extraction of new data/information from a source data, or spatial elaborations that involve two or more sets of data (see examples in Figure 8).

Finally, regarding the third point, actionable knowledge is built by applying/fine-tuning the created spatially explicit information to answer a question or solve a problem that has a spatial dimension and/or implication. This is visualized and shared principally through digital (geographic) maps, often accompanied by other visuals (see an example in Figure 9).

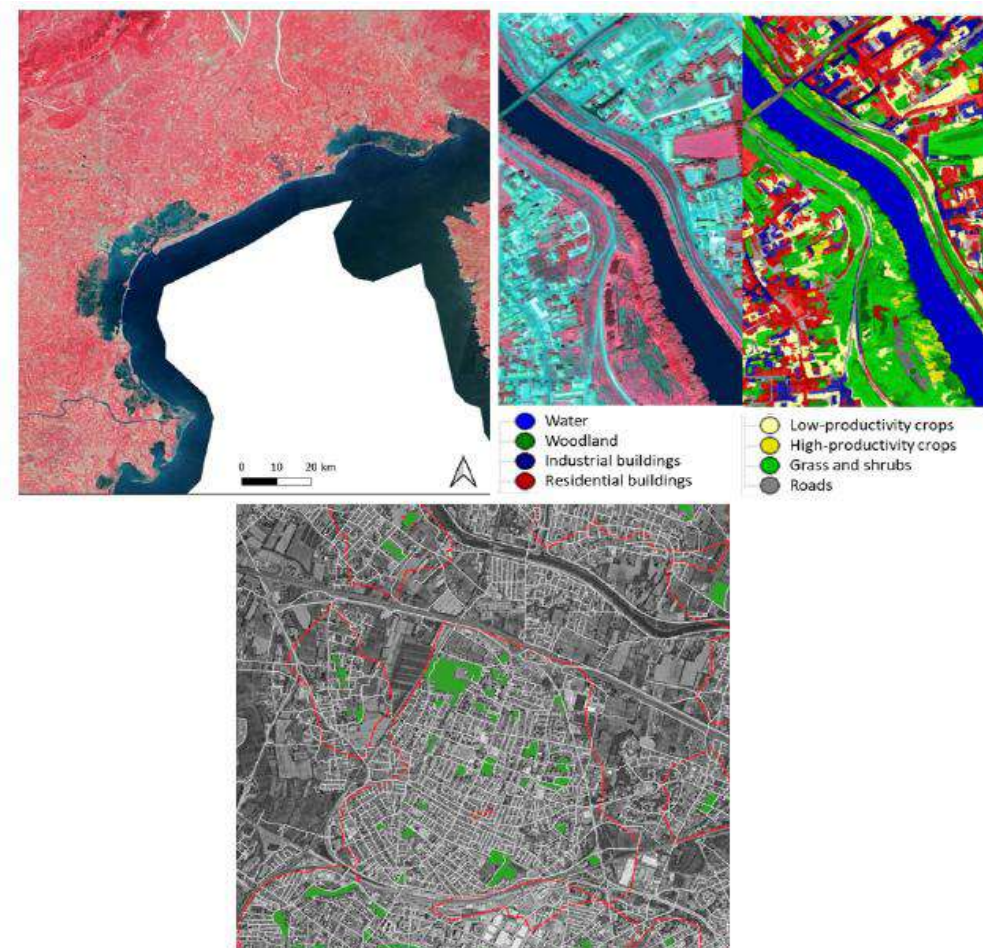


Figure 8 – From left to right. An image obtained manipulating the original satellite image’s spectral bands to visualize it in false colours that emphasize in red the vegetation cover (example of editing of single data properties, author’s elaboration). A supervised land use classification from a satellite/LIDAR image (example of extraction of new data/information from a source data, author’s elaboration). The identification of areas (red lines) falling within a 300-m distance via the road system from the existing urban green spaces (in green) (example of spatial elaborations that involve two or more sets of data, author’s elaboration).

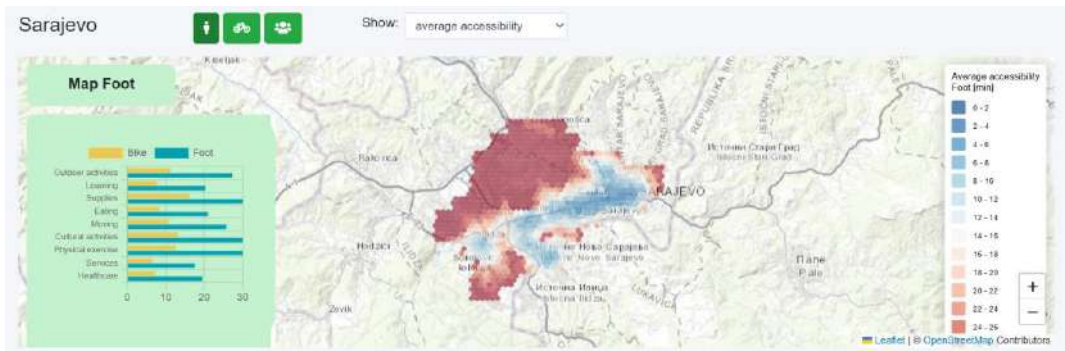


Figure 9 – Geographical web tool showing the spatial distribution of accessibility times (by foot or bike) to the main urban services across many cities worldwide (the image above is centered in the Sarajevo area).
 Source: <https://whatif.sonycs1.it/15mincity/>. Based on Bruno et al. (2024).

As it can be seen, maps are a powerful communication tool. Sharing data through maps and visuals is immensely effective because images allow us to quickly understand a topic. The process of knowledge sharing through maps and visuals simplifies insights found in data, so that anyone can, in principle, understand them. However, one must always remember that:

- maps could come with bias (due to the data used or subjective interpretation made by the authors) that people and decision-makers cannot fully capture since they perceive that those maps/images hold the legitimacy of data. People usually tend to believe data visualizations to be fact, not something to be questioned;
- the same data in different hands can produce different outcomes because of how people use and communicate the data to show their vision. Maps and images are often subjective and can reflect all kinds of political and social ideologies or beliefs that an author wants to communicate (especially maps that are based on social data).

4. USING GIS TO INVESTIGATE CITY CHALLENGES AND SUPPORT EFFECTIVE URBAN PLANNING AND GOVERNANCE: SOME EXAMPLES

There are many applications that can be considered relevant for supporting real-life urban planning decisions through the creation of useful information and the building of actionable knowledge using spatial data analytics and GIS softwares. GIS in fact enables spatial analysis, visualization, and modeling, which are crucial decision support tools for evidence-based planning across sectors (e.g., environmental sustainability, transport, energy, land use, climate action, etc.). The following GIS-based mappings (Figures 10 to 13) provide some non-exhaustive examples that may be considered relevant for their potential contribution to support proper urban planning and governance with the aim to address key challenges affecting cities and their surroundings, which are aligned with several sustainable development goals, including (but not limited to): SDG 10 – Reduced Inequalities, SDG 11 - Sustainable Cities and Communities, SDG 13 - Climate Action, SDG 15 - Life on Land.

4.1. Example 1 – Mapping inequalities

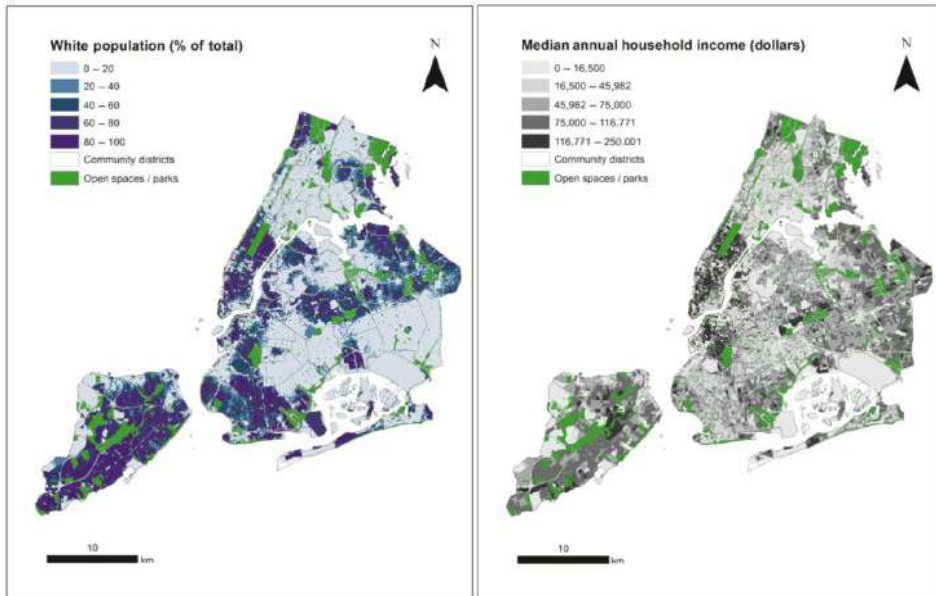


Figure 10 – Census-based population data related to the spatial distribution of residents according to the share of white people and the median annual household income compared with the location of green spaces in NYC (Herrerros-Cantis & McPhearson, 2021).

4.2. Example 2 – Mapping climate-city interactions

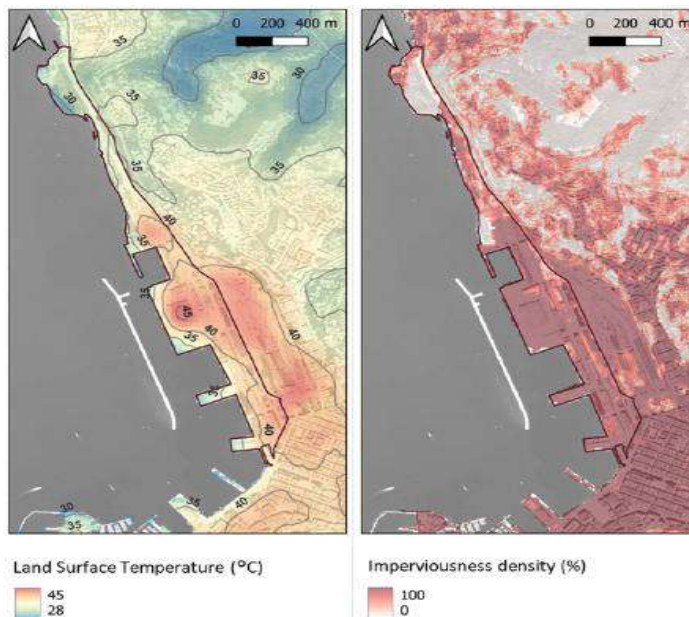


Figure 11 – Comparison of remotely sensed data of Land Surface Temperatures (left) and imperviousness density (right) distribution in the same location (author's elaboration)

4.3. Example 3 – Mapping climate impacts



Figure 12 – A map of Houston (US) showing flood hazard extent change over the next 30 years. Blue areas are today’s 100-year flood-hazard zones. The red areas represent the same zones in 2050. Source: <https://theconversation.com/new-flood-maps-show-us-damage-rising-26-in-next-30-years-due-to-climate-change-alone-and-the-inequity-is-stark-175958>. Based on Wing et al., 2022.

4.4. Example 4 – Mapping the access to nature/green space’s benefits

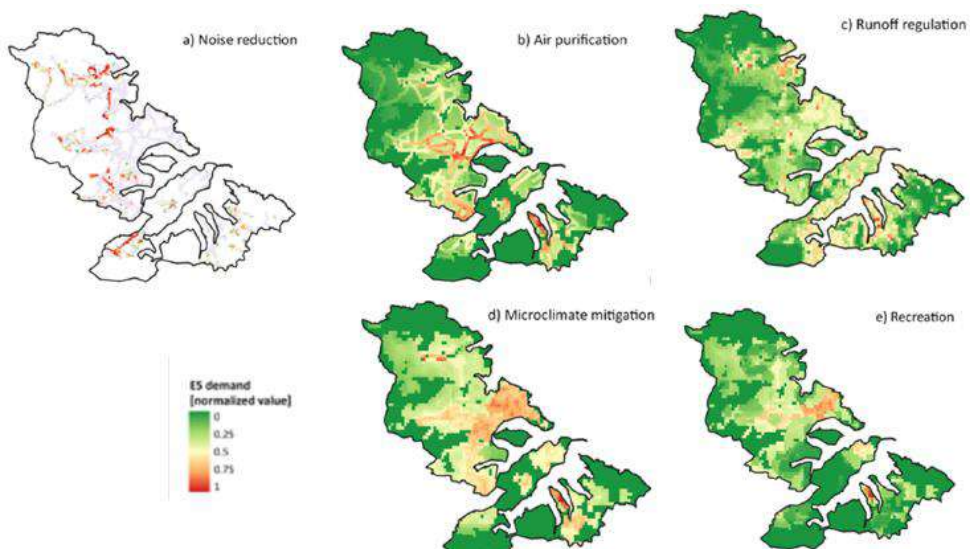


Figure 13 – Spatial assessment of the demand by residents for five ecosystem services (i.e., the benefits provided by ecosystems to humans) to address main urban challenges in Valletta urban agglomeration, Malta (Longato et al. 2023). The higher the value the higher the demand for nature/green space’s benefits, meaning the higher the level of exposure to environmental risks (i.e., noise, air pollution, pluvial flood, heat island effect) or of deprivation to nature-based recreation opportunities demanding appropriate interventions.

5. MAIN TAKE-HOME MESSAGES

- Data in its raw data form cannot perform well on its own; rather how data is transformed into useful information and operationalized into actionable knowledge can make the difference in supporting decisions in the “digital city” era.
- Operationally, working with data requires the ability to ask the right questions, find or collect the appropriate data, correctly analyze and interpret them to create meaningful information, and visualize results in a way that the shared knowledge can be understood by the target audience.
- In urban planning and governance, spatial data elaboration with GIS can help a lot, since it enables many applications to show spatially varying and interplayed dynamics in a city and inform effective and targeted solutions. With GIS you can investigate any factors having a spatial dimension/implication. In particular, using/combining environmental and socioeconomic data is essential for properly supporting decisions that will affect people’s everyday lives.
- Keep in mind that the knowledge shared (e.g., through maps) can come with bias and/or convey subjective ideologies or beliefs of the authors. For this reason, always try to be critical when interpreting data and maps shared by others; and always try to minimize these issues when working with data and maps.
- While visually appealing maps may capture one’s attention, they are just the starting point. It is just a small part of the journey; the real power lies in uncovering the insights concealed within the data and maps to support real-life decision-making processes. By understanding the data, asking the right questions, and actively seeking knowledge, proper (urban planning) tools and policies can be leveraged to make more informed and impactful decisions.

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