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Sustainable approach for socio-ecological development of urban areas

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Abstract. *Resilient and inclusive city design has become essential for a sustainable future for urban areas in ecologically sensitive zones in the face of rapidly increasing urbanization and development. This paper explores the multifaceted dimensions of resilient and inclusive urban planning, focusing on its significance amidst urban expansion and socio-economic disparities affecting the corresponding ecologically sensitive areas. Drawing upon interdisciplinary literature and case studies, the paper examines the theoretical underpinnings and practical applications of resilience and inclusivity within urban planning frameworks. The ability of cities to endure and rebound from a variety of shocks and strains, such as natural disasters, the effects of climate change, and socioeconomic upheavals, is referred to as resilience. In contrast, inclusivity emphasizes the equitable distribution of resources, opportunities, and decision- making power among diverse urban populations, including marginalized groups and vulnerable communities. This study clarifies the relationship between resilience and inclusivity in the planning of urban areas by synthesizing theoretical discourse and actual evidence. It highlights the importance of integrating eco-sensitive approaches, adaptive strategies, and participatory mechanisms to foster resilience and inclusiveness in urban development processes. Furthermore, the paper underscores the role of governance structures, policy frameworks, and stakeholder engagement mechanisms in promoting resilient and inclusive urban environments. By critically examining the challenges, opportunities, and best practices associated with resilient and inclusive city planning, this paper contributes to advancing knowledge and informing policy discourse toward fostering sustainable and equitable urban development pathways.*

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1. Introduction

Urbanization is a widespread and irreversible global trend, whereby more than half of the world's population now lives in urban areas. The rapid expansion of cities poses significant challenges to environmental sustainability, particularly in regions with delicate ecosystems that are prone to degradation. Nonetheless, these challenges present opportunities for implementing sustainable urban development practices prioritizing resilience and inclusivity.

Cities depend on complex, interdependent social, ecological, and technological systems to function. People in urban areas rely on complex networks of institutional frameworks and technological infrastructure to access basic services like food, water, power, and healthcare. However, this approach frequently ignores the interdependence between the provision of urban resources and the ecosystems that sustain them. Disruptions can be extensively propagated through the interconnectedness of these systems, leading to unforeseen crises. Shocks may spread through transportation networks, chains of supply, and across various industries, including healthcare and finance, impacting local and global scales through nonlinear feedback mechanisms (Levin, 1999). These occurrences, coupled with issues of systemic racism and environmental justice, underscore the necessity for coordinated action across various scales and sectors. Additionally, urban areas are integrated into trade networks all around the world, impacting on resilience and sustainability at both local and global levels through decision-making processes at various scales (Chini, 2018; Krueger, 2020).

The urgency of these challenges is particularly pronounced in ecologically sensitive urban areas, which encompass diverse landscapes such as wetlands, forests, coastal regions, and biodiversity hotspots. While these areas hold substantial ecological value, they are also highly vulnerable to human-induced pressures. Achieving sustainable development in these contexts necessitates a balanced approach that preserves ecological integrity while meeting the needs of urban populations. This requires adhering to core principles of sustainable development, including maintaining environmental health, promoting social equity, ensuring economic viability, and safeguarding cultural heritage. Addressing these intertwined challenges and opportunities will be crucial in advancing resilient and inclusive urban development.

This paper analyzes sustainable development strategies in urban areas characterized by ecological sensitivity, emphasizing the interconnected nature of resilience and inclusivity in urban planning. Here the concept of resilience refers to the capacity of these urban systems—including their inhabitants, infrastructure, and institutions—to absorb, adapt, and transform in response to various shocks and stresses, while maintaining their essential functions and structures. This concept is integral to achieving urban sustainability, as it emphasizes the ability of cities to endure and thrive amidst environmental, social, and economic challenges. Whereas inclusivity refers to the deliberate integration of diverse populations—encompassing various socioeconomic, cultural, and demographic groups—into the planning, development, and governance processes of these urban environments.

This approach ensures equitable access to resources, opportunities, and decision-making, thereby fostering sustainable urban development that is socially just and environmentally conscious. Integrating inclusivity into resilience planning enhances the adaptive capacity of urban areas. When diverse community members are actively involved in decision-making, the resulting policies are more comprehensive and reflective of the population's needs, leading to more effective and sustainable resilience strategies. This participatory approach ensures that marginalized groups, who are often disproportionately affected by environmental challenges, have a voice in shaping interventions that directly impact their lives (Habitat UN, 2007). Moreover, inclusive urban planning promotes social cohesion and trust among community members, which are essential components of social resilience. Strong social networks facilitate collective action and resource sharing during times of crisis, enhancing the community's overall ability to withstand and recover from adverse events. In ecologically sensitive zones, where environmental risks may be heightened, fostering inclusivity ensures that all residents are prepared and can contribute to resilience-building efforts (Alsayed, 2024; Zhang et.al., 2024).

The research intends to fill critical gaps in urban sustainability literature by focusing on multi-scalar and multi-dimensional interactions between resilience and inclusivity. Additionally, it seeks to contribute to policy discourse and inform the development of inclusive and resilient urban governance systems. Thus, the following are the research questions:

- How do resilience and inclusivity interact within different potential frameworks to foster sustainable urban development in ecologically sensitive areas?
- What are the key governance mechanisms and participatory strategies that enhance resilience and inclusivity in urban planning?
- How can regional frameworks be applied to address localized sustainability challenges while maintaining global ecological balance?
- What role do top-down and bottom-up approaches play in achieving urban sustainability transitions, and how can they be effectively integrated?

To answer and to fill the above-mentioned questions and gaps, the study adopts a mixed-methods approach comprising an extensive literature review and case study analysis including different conceptual frameworks, empirical studies, government models, sectoral and interdisciplinary approaches.

2. Potential frameworks

2.1 A regional framework

The conceptual framework of planetary boundaries, as introduced by Rockstrom (2009a), has exerted a considerable influence on the discourse surrounding global sustainability at the international level. This framework delineates nine interconnected biophysical, or ecological, thresholds at the planetary scale (Figure 1a), which humanity should observe to avert "disastrous consequences." The introduction of planetary boundaries has spurred discussions within scientific and policy circles. Refinements to freshwater use (De Vries, Kros, 2013), nitrogen (Carpenter, 2011), and phosphorus (Rockstrom, 2009b) boundaries have been published recently, along with thoughts on a possible change in the global biosphere's status (Rockstrom & Karlberg, 2010). Additionally, there have been analyses of the governance implications (Biermann, 2012; Running, 2012; Sorace, 1993), recommendations for a unique method of defining land-related boundaries using net primary plant production (Barnosky, 2012) and critical assessments of the concept of the planetary boundaries. The expansion of the planetary boundary concept by Raworth (2012) and Nordhaus et al. (2012), incorporating social objectives into sustainability policy and practice, has resulted in the development of the 'Oxfam doughnut' framework, emphasizing the social justice prerequisites of sustainability (see Figure 1b). This framework facilitates the development of multi-metric 'compasses' to guide decision-making. The 'doughnut' framework uses the ideas of social foundation' and 'environmental ceiling' to symbolize respective social and ecological boundaries as it evaluates societal well-being levels and ecological process conditions within regional social-ecological systems at the regional scale. Planetary boundaries that are both socially and ecologically just can be used at several levels, including nation-states, national parks, watersheds, and subnational administrative divisions. The original paradigm for planetary boundaries acknowledges that crucial transitions can happen at any scale (Brook, 2013; Raworth, 2012; Scheffer, 2001). It also acknowledges that the consequences of surpassing several thresholds at regional scales might add up to global issues (Rockstrom, 2009a). However, long before these consequences become apparent on a global scale, the cumulative effects of environmental deterioration (Folke, 2004) can have a significant impact on the sustainability of localized systems. This underscores the necessity for addressing both regional and planetary dimensions to ensure global sustainability. Therefore, concepts refined through the consideration of regional scales can iteratively inform the Planetary Boundaries refinement or redefinition. Substantial equality and governance considerations support the justification for taking regional-scale borders into account. Within the framework of planetary boundaries, protecting human welfare informs the scientific evaluation of restricting the use and deterioration of natural resources to avert major shifts in Earth system processes. Human welfare is contingent upon people having access to the natural resources required to meet their basic physiological needs, which include food, water, shelter, and sanitary conditions. Thus, planetary and regional borders should be placed in opposition to social foundations (Peters, 2011). The concept of planetary boundaries faces new transdisciplinary, intellectual, and ethical concerns when regional boundaries are addressed. These challenges arise from the need to explicitly address human drivers of change and social distributional issues. To ensure that resources are available and used to meet everyone's needs, many countries and areas face formidable and urgent challenges, highlighting the necessity of sustainable use of regional assets for the benefit of all people. Research indicates that the accompanying degradation of ecosystem processes may not be sustainable, even though agricultural expansion in developing nations is frequently seen as promoting fast economic growth and the reduction of poverty (Folke, 2011; Tilman, 2002). Analytical tools that map ecological processes at these scales are more likely to be relevant and useful for policy formation and resource governance, since natural resource management mostly takes place at regional levels as part of national and regional development planning.

It is imperative to challenge the constraints of dominant political-strategic timelines, which often give priority to short-term views and near-term actions. It would be in line with predictions of converging tendencies by mid-century if it were possible to recognize and abide by ecological boundaries across longer durations (Dearing, 2012a; Godfray, 2010). Communities living in areas already operating within risk thresholds may benefit from a new framework that considers several timescales and provides a prioritized list of restorative actions based on scientific evidence.

Depending on its goals, a regional boundaries framework can be created through a variety of methods. One method could be to compute the share of global resource consumption (like water) and effects on planetary boundaries (like CO2 emissions) that are specific to a certain region based on socioeconomic conditions (like in less developed countries). An alternative strategy may concentrate on the connections between regional resource management (like sustainable fish farming) and social well-being (like food security). Both strategies place a strong emphasis on equality concerns and call for social and ecological data integration.

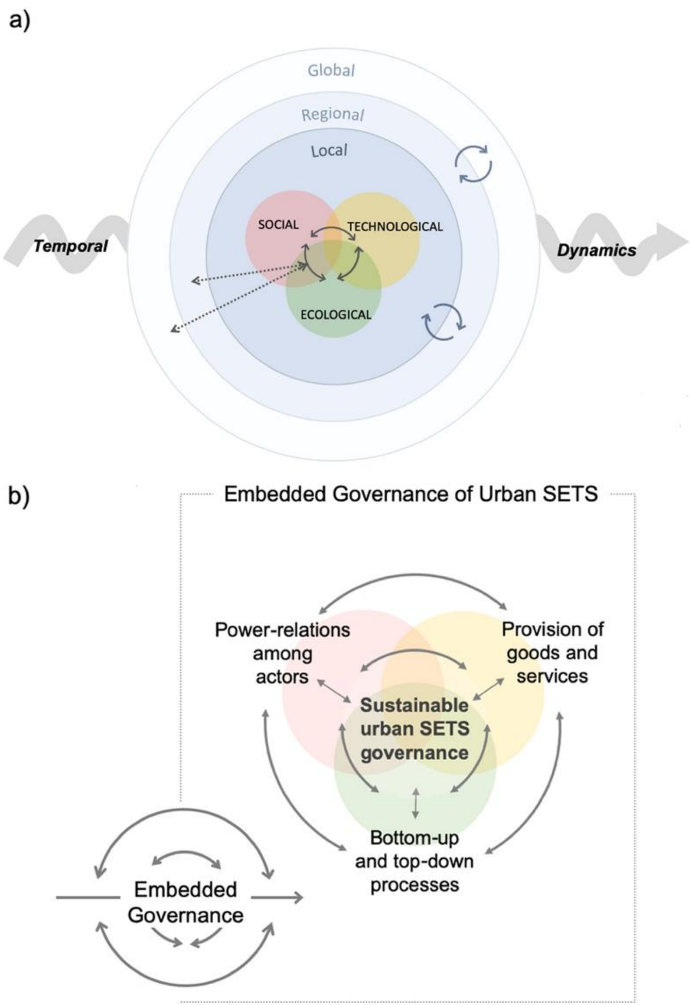

Figure 1: Merging (a) Planetary boundary framework; (b) Social 'doughnut' framework (Raworth, 2012) into a new method for defining safe operating sustainable spaces (regional level). Source: Rockstrom et al., 2009 & Raworth, 2012

2.1.1. Interrelationships on spatial and temporal scales. This framework emphasizes that resilience and inclusivity are inseparable in addressing regional sustainability. For example, while maintaining ecological boundaries ensures resilience by safeguarding critical ecosystem functions, inclusivity ensures that resources are distributed equitably, preventing social inequities.

Spatial: At a regional level, boundaries such as freshwater use or nutrient cycles can be managed more effectively by integrating localized ecological data with social metrics like food security or access to clean water (Barnosky et al., 2012; De Vries & Kros, 2013;). These boundaries reflect how cumulative regional actions impact global systems.

Temporal: Long-term adherence to ecological limits requires inclusive governance that prioritizes intergenerational equity and mitigates risks from developmental pressures in sensitive zones (Dearing et al., 2012a; Peters, 2011).

Thus, this regional framework reconciles ecological constraints with social justice imperatives, underscoring how inclusive policies reinforce resilience through equitable access and sustainable practices.

2.2 Social-Ecological-Technological Systems

Our subsequent framework is government-led, recognizing that effective coordination across intricate and interconnected urban systems necessitates appropriate forms of governance. Given projections indicating that nearly all future population growth will occur in urban areas, it is imperative to identify governance structures that facilitate inclusive decision-making, management, and planning, while enabling comprehensive system-wide transformations. This is crucial not only for the welfare of urban inhabitants but also for attaining climate objectives and preserving the biosphere (Dearing, 2012b). Despite the pressing need for governance mechanisms aimed at enhancing urban sustainability, there exists a lack of research on the intricacies of governing urban systems across various sectors and scales (Krumme, 2016).

Approaching the governance of urban sustainability transformations through a social-ecological-technological systems (SETS) perspective (McPhearson, 2016; Ostrom, 1990) underscores the complex and interconnected nature of urban systems, highlighting specific governance challenges and emphasizing the importance of identifying governance frameworks capable of coordinating across different sectors, spatial domains, and temporal dimensions. Figure 2. illustrates the concept of interdependent urban SETS and delineates the role of governance in shaping the evolution of such systems.

The figure underscores three interacting elements of particular significance. (1) Equitable and dependable access to resources in Urban areas ('Provision of goods and services'), which form a crucial foundation for the livelihoods of Urban areas and facilitate inclusive political, economic, and social processes. (2) The interplay between bottom-up processes and economic activities with top-down initiatives by governmental actors ('Bottom-up and top-down processes'), wherein local experimentation and innovation can be encouraged by a balance between both forces, which can result in systemic changes. (3) The distribution of social influence, resource allocation, policy decisions, and urban SETS trajectories are all influenced by the power dynamics between the various actors. The arrows in (a) and (b) show how deeply ingrained governance is in these procedures.

2.2.1 <u>Interrelationships on spatial and temporal scales</u>. Resilience in urban systems depends on maintaining balance across these dimensions, while inclusivity ensures that diverse social actors actively participate in decision-making processes. SETS highlights governance as a critical element for managing system-wide transformations and fostering equitable development.

Spatial: At local and regional levels, SETS illustrates how urban governance must coordinate infrastructure (e.g., flood protection) with social well-being (e.g., housing equity) and ecological preservation (e.g., wetland restoration).

Temporal: The trajectory of urban systems depends on governance mechanisms that address immediate challenges (e.g., resource scarcity) while building resilience for future risks, such as climate change (Fischer et al., 2015; Ostrom, 1990).

Effective governance within SETS balances top-down policies with bottom-up initiatives, fostering adaptive capacities and inclusivity, essential for long-term urban sustainability in sensitive zones.

2.3 Multiple scales for urban Social-Ecological-Technological Systems

The ecosystem component within SETS encompasses the physical space or land that sustains urban economies and serves as the foundation for urban development. The social system is made up of different actors and how they interact, such as the government, private citizens, academics, corporate entities, and civil society organizations. These actors participate in decision-making processes related to ecosystem management, resource distribution and access, SETS spatial structure, and the use of goods and services produced from ecosystems. In addition to their technological and ecological surroundings, conventions, rules, cultural elements, and power dynamics all influence how actors interact with one another.

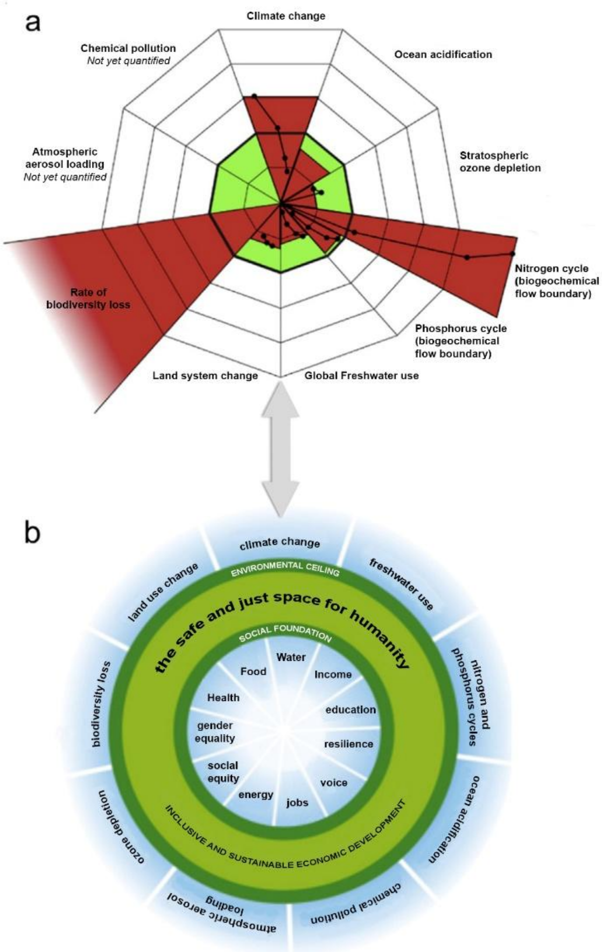

Figure 2. (a) Urban Social-Ecological-Technological Systems (SETS) involves intricate interdependencies among temporal & spatial dimensions. Shocks and stressors possess the capacity to influence individual or collective components of the SETS across various spatial scales, thereby shaping the trajectory of the urban system over time (denoted by the arrow indicating 'Temporal Dynamics'), (b) Embedded Governance refers to the intricate interplay between embedded actors and elements within Social-Ecological-Technological Systems (SETS), which collectively influence the governance of urban SETS. These actors navigate the interfaces among SETS elements, negotiating their interactions and coordinating processes of transformation aimed at sustainability across spatial and temporal scales. Source: Fischer et al., 2015.

The technological system, represented by the physical infrastructure, encompasses networks, facilities, and buildings that facilitate the flow of resources, people, and information, represents the technological system. This infrastructure mediates interactions between ecosystems and social actors. For instance, flood protection infrastructure, designed and implemented by decision-makers, serves to safeguard urban populations from natural hazards such as storm surges and riverine flooding. Another example is food supply chains, which involve ecological components like soils, water, plants, and animals, technological infrastructure for production, processing, and transportation, as well as social actors and consumers dependent on food delivery into urban areas. Effective governance of these systems necessitates inclusive design and planning processes, along with balanced and environmentally sustainable manufacturing and delivery of goods and services. In this context, governance shapes the overall evolution of SETS, influencing how communities coexist within their social-ecological-technological environment. It determines decisions regarding flood protection measures, food production and distribution, and technological advancements.

Beyond official laws and regulations, governance includes informal and group action mechanisms such as information availability, efficient communication, rule enforcement, monitoring, and dispute resolution procedures (Clark, 2020; Ostrom, 2010), as well as incentives to encourage sustainable behavior, the establishment of supportive environments for community-based projects, the development of responsive functions, and collaborative production and management structures (Constantino, 2021; Frantzeskaki, 2019; Galuszka, 2019; Nyborg, 2016; Patel, 2017; Sparkman, 2021).

Efforts by governments and private actors to address sustainability challenges within SETS may encounter resistance, trade-offs, or unintended consequences across different system elements and scales (Bai, 2016). For instance, initiatives to reduce greenhouse gas emissions may lead to technological innovations throughout the supply chain but also raise concerns about resource exploitation and human rights abuses in distant locations (Riofrancos, 2019; Vandenbergh, 2018; Xu, 2020).

Incentives or programs which are only focused on a particular aspect of SETS may exacerbate imbalances across social, ecological, and technological dimensions of sustainability goals. Therefore, sustainability transformation efforts should consider all elements of SETS, recognizing their interconnections among various scales and sectors.

2.3.1 Interrelationships on spatial and temporal scales: The urban SETS framework underscores that resilience is contingent on managing interactions among ecological processes, technological systems, and social dynamics across scales. Technological innovations, such as circular economy initiatives, promote resource efficiency, but their success depends on inclusive governance structures that ensure benefits are distributed equitably (Newell & Cousins, 2015).

Spatial: Managing urban water, energy, and food systems requires spatially integrated solutions that link urban centers with their resource catchment areas (Simpson & Jewitt, 2019).

Temporal: Urban transformations involve iterative processes where long-term planning aligns technological advancements with social inclusivity goals (Larsen, 2016; Markolf et al., 2018).

By fostering collaboration among diverse actors, SETS frameworks highlight how resilience and inclusivity converge to support urban sustainability transitions.

2.4 Managing resources and delivery of service provision in urban areas

Urban areas reside most of the Global population, exert significant pressure on natural resources, and contribute substantially to CO2 emissions and other environmental pollutants (Bai, 2018). Because of this, controlling the movements and demands of resources inside metropolitan areas is essential to maintaining both their own sustainability and the sustainability of the global ecological systems that provide them with goods and services. Resources are harvested, used, and then discarded into the environment as trash in traditional urban frameworks, which function in a linear manner (Van der Leer, 2018). Cities, for example, draw electricity from vast networks, extract metals and sand for construction and industry, import food from different parts of the world, and draw water from far-off groundwater reserves, lakes, and rivers. Nevertheless, the feedback mechanisms that are required to indicate the deterioration or the overexploitation of ecosystems between consumers and ecosystems are absent from these linear supply systems (Barthel, 2019; Floerke, 2018).

Conversely, cross-sectoral techniques place more emphasis on the connections across both inputs and outputs in various sectors (Liu, 2018). Reuse and recycling are two strategies that have been used to address scarcity issues. Both Singapore's NEWater recycling system and Namibia's Windhoek water delivery system distribute recycled water to consumers (Lahnsteiner, 2007; Lenouvel, 2014). Coordinated efforts can result in mutual advantages from coordinated systems of water, energy, and food (WEF) management (Newell, 2020; Simpson, 2019). WEF nexus techniques combine the agricultural and wastewater industries by collecting nutrients for fertilizing crops and using treated wastewater for irrigation (Larsen, 2016). However, a great deal of coordination between ecosystems, technology, and social actors is needed for such cross-sectoral systems (Bai, 2016; Markolf, 2018). For instance, cooperation between wastewater management and water suppliers is necessary to guarantee the correct treatment and release of water, as well as to ensure its quality standards to prevent crop and soil contamination prevent soil. In the discourse on urban sustainability, ideas like the circular economy (CE), ecology of industry, urban metabolism, cradle-to-cradle, and life-cycle assessment are frequently discussed and offer alternatives to traditional linear systems (Newell, 2020; Newell & Cousins, 2015; Niero, 2017). Like the networked WEF nexus, CE techniques promote minimizing, recovering, reusing, and recycling resources and materials among all sectors (Obersteg, 2019). Furthermore, inclusion and well-being are emphasized as objectives in CE interpretations, highlighting the necessity of societal change to separate resource use from economic growth (Calisto Friant, 2020). Safe operating space models, for example, acknowledge the possibility for rising inequality and the disproportionate effect of climate change and environmental degradation on urban poor groups ((Bavel et al. 2021; Dearing, 2014; Krueger, 2020; Raworth, 2017; Ziervogel, 2019). They also combine ecological boundaries with social well-being.

Diverse social and political environments take distinct stances on sustainability issues. For example, circular city concepts have been adopted by China and Europe, though with different motivations and approaches to execution (Gravagnuolo, 2019). Although these approaches have different roots, some come from the social sciences and others from the natural/engineering sciences [66], there is a continuing convergence of CE principles among domains (Ben-David, 2021; Porkka, 2017). But there are still many real-world obstacles to overcome, like societal, technological, and legal impediments and the requirement for dietary shifts to plant-based diets. These call for well-thought-out governance and policy measures (Boyer & Ramaswami, 2020; Marsh et al., 2021; Obersteg, 2019; Ranganathan, 2016; Weber, 2015). Accompanying the top-down incentive frameworks and laws, governance systems that place a high priority on inclusive policy-making procedures can help support bottom-up behavioral changes. Preventing externalities from problem-shifting and outsourcing requires a thorough grasp of sustainability goals that takes into consideration cross- scale and cross-sector connections (Chini, 2017; 2018).

2.4.1 Interrelationships on spatial and temporal scales: Linear resource consumption in traditional urban systems often leads to ecological degradation and social inequalities. Circular economy approaches, which promote reuse, recycling, and resource recovery, offer an inclusive pathway toward urban resilience. For instance, Singapore's NEWater project ensures water security through advanced recycling, benefiting all residents equitably (Lahnsteiner, 2007).

Spatial: Cross-sectoral coordination ensures resource flows are managed holistically, benefiting both urban and rural areas that contribute to resource supply chains (Barthel et al., 2019).

Temporal: Sustainable resource management supports long-term resilience by mitigating resource depletion while addressing social inequities (Raworth, 2017).

This framework demonstrates that inclusivity in resource governance is crucial for maintaining urban resilience and ecosystem integrity.

2.5 Transformations in urban sustainability through top-down and bottom-up approaches

Different governance contexts show preferences for social or technical innovations, and they also determine whether these developments are imposed from above, originate from the ground up, or come from a combination of the two (Bauwens, 2020). Urban planning within Social-Ecological-Technological Systems (SETS) has a significant impact on socio-political processes, including the emergence of social movements, the inclusivity of urban development and local interest groups. It also affects CO2 emissions, public health outcomes, and the efficiency with which land and resources are utilized (Bassolas, 2019; Depietri, 2018; Sennett, 2018). Transformational forces can be aided or hindered by large-scale technology deployment and spatial planning in metropolitan environments, which are frequently typified by top-down approaches. Throughout history, physical spaces have played crucial roles as sites for public gatherings and expression of demands, as well as for the repression and segregation of social groups (Sennett, 2018).

Identifying supportive settings for local experimentation is a key theme in the research on urban sustainability transitions since it offers a way to get over entrenched systems and path- dependencies that support the current quo (Elmqvist, 2018). This strategy, known as "urban tinkering," highlights the importance of decentralized, bottom-up change and the participation of a variety of different social actors in the continuous SETS transformation process. This viewpoint is consistent with resilient systems in ecology, which benefit from redundancy, open exchange, diversity, modular organization, and other factors that increase their ability for adaptation (Carlisle & Gruby, 2019; Levin, 2019). Through the development of context-specific solutions, bottom-up efforts utilize the innovation and broad expertise of local players to nurture such traits. These programs and organizations create self-sufficient, modular structures that function best when they are moderately networked, allowing for coordination and communication (Carlisle & Gruby, 2019). Modularity, redundancy, and diversity strengthen buffering capacity, which reduces the propagation of shocks among modules and increases overall resilience (Levin, 1999; Nordbotten, 2108).

Different capacities are needed at different stages of urban change, such as the capacity to eliminate unsustainable practices and develop innovations that support resilience and sustainability and integrate these innovations into discourse, practices, and governance structures (Nordbotten, 2019). Furthermore, to guarantee that transformative processes continue to be flexible and in line with changing reflexive stakeholder action, social learning and sustainability goals, are essential (Castán Broto, 2019). Managing the complex dependencies of urban SETS, which need a synthesis of data across scales and sectors and are difficult for a single actor or entity to understand, requires social learning, especially collective learning (Johannessen, 2018).

Even among democratic regimes that appear to be comparable, there are significant differences in the capacities and enabling conditions for local administration at the urban scale. For example, in the 1980s, cities in the biggest democracies in the world, South Africa, Brazil, and India, experienced similar physical and social upheavals characterized by significant levels of inequality and divided citizenship. Divergent developmental outcomes, however, have been brought about by variations in the level of state-civil society embeddedness and the interactions among top-down and bottom-up processes. Brazil has strong, independent local capacity and participatory governance procedures, while South Africa is technocratic and centrally controlled and has good local government capacities (Heller, 2017). India is still mostly elite-dominated and has limited local governance capacities.

The actual conditions of urban governance frequently deviate from theoretical considerations of the prerequisites for urban development. Government initiatives are usually short-term and responsive rather than long-term and anticipatory; sectors are frequently handled by separated entities, disconnected across spatial scales and sectors; local sustainability initiatives are often fragmented, underfunded, and dependent on individual engagement, posing obstacles to lasting impacts and system-wide transformations (Hölscher, 2019).

2.5.1 Interrelationships on spatial and temporal scales: Urban transformations require the integration of top-down policies with bottom-up innovations. Top-down governance provides the regulatory framework for large-scale sustainability initiatives, while bottom-up approaches leverage local knowledge and community participation to address contextual challenges (Elmqvist et al., 2018).

Spatial: Local experimentation in urban neighborhoods (e.g., community gardens) complements broader municipal strategies, fostering system-wide resilience (Levin et al., 2019).

Temporal: Bottom-up initiatives encourage incremental, flexible changes that adapt to evolving social and environmental conditions, while top-down policies ensure alignment with long-term sustainability goals (Carlisle & Gruby, 2019).

Together, these approaches exemplify the interconnectedness of resilience and inclusivity, promoting equitable urban transformations.

2.6 Role of governance and power relations in urban SETS

Power dynamics and embeddedness play pivotal roles in determining the effectiveness of both bottom-up and top-down initiatives in transforming urban Social-Ecological-Technological Systems (SETS) (Borgström, 2019; Heller, 2017; Westman, 2019). This section concentrates on examining the interplay between governance embeddedness, power dynamics across sustainability and actors among actors of urban systems. Embeddedness, as discussed in scholarly literature, refers to the interdependence and relationships among societal actors and is closely linked with capacity and agency in governance processes (Heller, 2017; Kok, 2021). It provides the framework for organizing, resolving disputes, and tackling issues related to collective action. To ensure a participatory political process in urban contexts, it is imperative to consider the degree of embeddedness and the interconnection of actor connections among governance levels and sectors (Heller, 2017).

The idea of relational power is intimately related to the relational component of embeddedness (Kok, 2021). Relational power is generative, influencing, producing, and changing practices, social relationships, and institutional arrangements. It is braided into social- ecological-technological relations and embedded in social activities (Cooper, 1994; Kok, 2021). The integration of complex adaptive systems theory into the management of sustainability transitions emphasizes the need for a power relations concept based on SETS interactions as well as social agent interactions (Kok, 2021). Embeddedness is the term used to describe the connections between governance actors at different levels and in different sectors, as well as how they interact with ecological and technical components of the metropolitan system.

Inclusive, multi-level, democratic and multi-scale characteristics are frequently found in the governance of sustainable urban transitions (Dahiya & Das, 2020). Embeddedness differs according on the context. A certain level of governance embeddedness is ensured both horizontally and vertically in Europe through local initiatives and authorities working with state, corporate, academic actors, and non-governmental, and organizations across different governance scales (Fratini, 2019). States have a big say in creating environmental regulations under the federal system of the United States; some of these policies can even be implemented and enforced locally. States with sizable marketplaces have the power to shape businesses and set norms across the country. For instance, California has taken the lead in establishing vehicle emissions regulations and in developing laws pertaining to plastic trash and air pollution (Rosner & Markowitz, 2019; Vogel, 2019). Due to insufficient cross-level integration between the central state, municipalities, and civil society, as well as an uneven distribution of power concentrated in the central state, urban areas in India frequently lack the potential for local self- governance (Heller, 2017; 2019).

Ensuring that local sustainability advancements do not jeopardize global sustainability can be achieved by integrating governance horizontally, spanning sectors, cities, and regions, as well as vertically, from the local level to the regional and global levels (Krueger, 2020; Hickmann, 2016). Over the past few decades, city networks have grown dramatically, encouraging cooperation between municipal governments around the world. Given the fact that choices made at the urban scale have an impact on many global processes, these networks have become crucial in forming and pushing global sustainability agendas (Acuto & Leffel, 2020; Mocca, 2017). In contrast to initiatives aiming at reaching a worldwide consensus among national entities, theoretical models imply that voluntary coalitions, such as these urban networks, may be more successful in solving the issue of climate change and other global ecological concerns (Hannam, 2017; Vasconcelos, 2020). These interconnected urban governance systems facilitate knowledge sharing and collaboratively pursue set goals to assist sustainability initiatives. Decentralized initiatives embedded within broader coalitions offer diverse responses to sustainability challenges, allowing successful approaches to diffuse to other locations. However, gaps between civil society initiatives and local governance bodies can hinder the spread of innovations across regions (Borgström, 2019).

The vital responsibilities that social actors—both state and non-state—assume in governance processes are what make the urban sustainability ecosystem system SETS possible (Evans et al., 2017). In controlling uncertainty, maintaining the supremacy of law, redistributing wealth & resources, and coordinating policies, the state and other actors in regulatory or management roles are crucial (Evans et al., 2017). Civil society and Non-state actors must keep an eye on the state and hold it responsible through legislative and public actions, creating feedback loops between the state and civil society to prevent unbridled state power (Evans et al, 2017; Heller P., 2017). Loss of embeddedness between the state and society can lead to concentration of power at the national or state level, resulting in weak local governance despite significant economic growth (Heller, 2017; Meckling & Nahm, 2018). This can manifest in inequitable provision of public services, environmental degradation, and social inequalities. For instance, cities like Chennai in India face water scarcity and pollution issues, while cities like East Chicago and Flint in the US experience social inequalities exacerbated by out-of-balance power relations (Krishnamurthy & Desouza, 2015; Sampson, 2017). Regulation by the state can support the preservation of social cohesiveness when sustainability changes. The reciprocal relationships between top-down and bottom-up processes, the balance of power within the governance system, and equitable urban service supply are illustrated by the urban governance cycle shown in Figure 2(b).

In addition to being crucial for preserving human well-being, critical infrastructure services help the state maintain law and order, encourage economic growth, and advance social inclusion (Centeno et al., 2017). On the other hand, efforts towards sustainability may be hampered by suspicion of the state and rejection of state power (Vandenbergh & Gilligan, 2018). It is a difficult task to rebuild inclusive government systems in environments where reciprocity and trust have been undermined. In these situations, government must strike a balance between the need for swift changes toward ecological sustainability and the gradual process of mending social ties, especially regarding excluded groups (Whyte, 2020). To summarize, the combination of power dynamics, governance framework, and embeddedness within SETS interactions can either facilitate or hinder sustainability transitions from local to global levels.

3. Discussion

The term "development" in the context of sustainable (urban) development, extends beyond the traditional focus on economic growth to encompass a multidimensional approach that integrates environmental sustainability, social equity, and economic viability. This type of approach is necessary because economic growth has been critiqued for its potential to undermine the very principles of sustainability. Economic growth, in its traditional form, frequently leads to overexploitation of natural resources, ecological degradation, and exacerbation of social inequities. Whereas the concept of "economic viability," as referenced in this study, differs from mere growth in that it promotes an economic system capable of sustaining livelihoods while preserving environmental integrity and fostering social inclusiveness. This emphasizes that sustainable urban development needs to involve fostering resilience and inclusivity while addressing ecological sensitivity and socio-economic disparities. This approach contrasts with the conventional association of development with economic growth, which often overlooks the adverse environmental and social implications of unchecked urban expansion.

The increasing divergence between the functional realities of urban governance systems and the normative aspirations articulated in sustainability discourses highlights the need for a more methodical understanding of how urban governance can support the integration and modification of urban SETS. The body of existing literature has made a significant contribution to our understanding of the interactions between service delivery, top-down interventions, bottom-up efforts, sustainable resource management, and power dynamics among the factors influencing the changing pathways of urban SETS in various locations.

3.1 Regional framework

Establishing a Regional Framework provides an aesthetically coherent method for comparing different regions, and it can also be used to evaluate how a region affects planetary borders. The SDGs, particularly in the "Post-2015 UN Development Agenda," have been critiqued for their broad scope and insufficient integration of localized contexts. While the SDGs provide a global framework for sustainability, their design and implementation have been criticized for several reasons like the lack of clarity in defining "development" often leads to conflicting priorities between economic growth and environmental sustainability; overemphasis on quantifiable targets; implementation challenges in ecologically sensitive areas and the SDGs often fail to address the systemic power imbalances that influence resource distribution and decision-making, limiting inclusivity and equity. These issues could be addressed and may benefit from the insights of the study like tailoring SDG implementation to regional context and expanding the SDG indicators to include qualitative measures of resilience, inclusivity, and cultural preservation to provide a more comprehensive evaluation of sustainability, etc. Though there is strong evidence to support its implementation, especially in rural developing countries, there are a few warnings and ongoing difficulties that should be considered, for example the linear resource consumption model in many cities often contradicts the circular economy principles emphasized in SDG 12 (Responsible Consumption and Production). Similarly, systemic inequalities in resource access must be addressed to achieve the equity envisioned in SDG 10 (Reduced Inequalities). Addressing these challenges requires a shift from theoretical goals to actionable strategies that align with local realities.

3.2 Urban sustainability through ecosystem services

Within societal contexts, the utilization of technological tools by social actors to engage with ecosystems and manage resource extraction and allocation constitutes foundational elements for delivering essential services encompassing water, energy, food, health, and transportation. A substantial portion of scholarly discourse on sustainable service provisioning and resource governance adopts linear, circular, and nexus paradigms, predominantly targeting environmental or societal objectives. However, amalgamating these objectives necessitates mitigating pressures on natural ecosystems induced by climate change and global ecological degradation, alongside ensuring equitable access and fair resource distribution. Hence, sustainable service delivery surpasses mere material cycle management and ecological conservation, extending to addressing socio-economic disparities and understanding cross-dimensional impacts on social, ecological, and technological systems. The intricate interplay of diverse resource fluxes within the urban metabolic framework, intertwined with stakeholder interests, renders delineating and attaining sustainability objectives a complex political endeavor within the governance framework of SETS.

3.3 Bottom-up and top-down approach

In the quest for effective sustainability transformations, engaging in experimentation processes spanning social, ecological, and technological domains is crucial. Notably, bottom-up approaches yield a spectrum of diverse, contextually adapted responses. Through embedded governance mechanisms, successful experimentation can propagate via dynamics of social learning. Consequently, grassroots initiatives and voluntary alliances play pivotal roles in overcoming entrenched patterns and disrupting dependency trajectories. Local endeavors can catalyze widespread behavioral shifts and normative framework alterations, disseminating across horizontally interconnected urban networks. Moreover, serving as modular components within polycentric governance frameworks, locally driven bottom-up initiatives, when interconnected across scales, provide systemic redundancies and resilience capacities essential for navigating flux periods and transformative change processes.

3.4 Governmental and hierarchical support

Governmental and hierarchical support is vital for fostering sufficient arenas for social dialogue and expanding promising local innovations conducive to sustainability transition. Governmental organizations must also create and implement regulations that minimize power imbalances between interested parties and guarantee the judicial, legislative, and executive branches' functional separation of powers. Widespread sustainability changes are mostly caused by the interaction of social processes, digital and physical surroundings, and grassroots initiatives and centralized control systems. Grassroots initiatives can drive sustainability transformations when embedded within a SETS governance framework and supported by infrastructures forged through multilevel engagements.

3.5 Power and urban governance

Urban SETS governance is characterized as multilayered, boundary-spanning, and multiscale frameworks, influenced by a heterogeneous array of actors. Power dynamics within this governance structure are susceptible to imbalance unless preemptively safeguarded. The authority wielded by cities in navigating internal shifts and external perturbations hinges upon power distribution and integration across various governance levels. Within urban settings, the inclusivity of decision-making processes, influenced by vertical integration and power dynamics, impacts levels of trust, consent, and societal well-being among residents. Evolution of SETS interactions, service delivery mechanisms, and social dynamics is contingent upon integrated governance across SETS components spanning local to global scales.

4. Conclusions

In conclusion, achieving sustainable development in urban areas while considering ecological sensitivity requires a comprehensive approach that recognizes the interdependence between resilience and inclusivity. By incorporating risk-aware methodologies, adaptable strategies, and participatory approaches, urban centers can enhance their resilience to adverse events and societal pressures while promoting fair distribution of resources and opportunities. The design of governance systems, formulation of policy frameworks, and engagement of stakeholders play crucial roles in shaping resilient and inclusive urban environments. Moving forward, concerted efforts are essential to mainstream sustainability principles into urban planning and decision-making processes, ensuring the development of cities that are resilient, inclusive, and sustainable for present and future generations.

The frameworks presented in this study collectively illustrate that resilience and inclusivity are mutually reinforcing pillars of sustainable urban development. Across spatial and temporal scales, their interconnections shape governance, resource management, and urban transformations, ensuring that cities in ecologically sensitive zones can adapt to rapid urbanization while safeguarding social equity and ecological integrity.

A comprehensive and multifaceted viewpoint on the management of socio-ecological- technological systems enables a more profound comprehension of the intricacies entailed in tackling issues related to urban sustainability. By synthesizing insights from various academic disciplines, we underscore key principles conducive to fostering sustainable governance and transitioning from unsustainable to sustainable systems. The following is the main takeaway from the discussed literature:

(1) The best way to formulate links and interactions hypotheses for further empirical validation and investigation is using the regional framework. An extensive collection of socio-ecological models, for instance, could be useful in locating critical points in ecosystem services and processes, which would help identify areas that are vulnerable to pressures during development. Furthermore, the framework offers a solid foundation for creating systems dynamics models that can identify feedback loops, enabling the investigation of ecological consequences linked to various social paths.
(2) Achieving sustainable urban resource allocation and service delivery requires a holistic approach that extends beyond material flow management to incorporate social equity considerations, inclusivity, and the impacts of technological development, physical infrastructure, and urban planning into strategic planning and administration. While localized efforts targeting global sustainability concerns are underway, they must acknowledge and address the cross-dimensional impacts arising from global supply chains and resource distribution networks.

(3) Developing urban systems that are flexible and adaptive—capable of enduring shocks and disturbances while enabling revolutionary changes in the interplay between SETS—is crucial. The hierarchical interventions and governance frameworks that support regionally customized and diverse responses resulting from grassroots activities are essential to this endeavor. Urban settings and technologies are important mediators of these dynamics, functioning as interrelated elements of polycentric governing frameworks. Bottom-up approaches are effective in accelerating systemic reforms and scalable breakthroughs.

(4) The integration of the urban governance framework across local, regional, and global dimensions is necessary for all aspects of the process, such as the equitable provision of basic services, the promotion of grassroots initiatives and creative practices, and the development of resilience to disruptions and changing urban dynamics. However, equitable allocation of power among stakeholders and the prevention of opportunistic conduct are necessary for this integration to be effective. Since numerous actors with different interests affect the long-term course of urban SETS, it is necessary to develop safeguards to monitor and correct power imbalances at all levels.

Additionally, for the successful implementation of the framework for sustainable urban development, which emphasizes resilience and inclusivity in ecologically sensitive areas, hinges on some facilitating factors like integrated governance structures, technological innovations, community participation etc. and impeding factors such as institutional fragmentation, socio-economic inequities, financial constraints, climate risks etc. that may either hinder or expedite its progress. Some of the above-mentioned impeding factors may lead to potential conflicts of interest between stakeholders with different priorities. For instance, developers and policymakers may prioritize economic growth, while environmentalists and local communities emphasize ecological preservation and social equity. Such conflicts could delay or derail the implementation of sustainability initiatives, particularly in areas where vested interests in resource exploitation conflict with conservation goals. Balancing these competing interests requires transparent dialogue, negotiation, and the establishment of shared objectives that align with long-term sustainability. To address the such and other multifaceted challenges of sustainable urban development, all the involved actors should hold a strong leadership & commitment, have access to robust institutions with adequate resources, ability to foster collective learning and should encourage bottom-up approaches.

4.1 Contribution and future potential research

The main contribution of this study is the synthesis of interdisciplinary insights to provide a comprehensive framework for resilient and inclusive urban planning. It primarily includes 1) development of a multi-scalar and integrated approach to urban sustainability that links resilience and inclusivity, 2) providing actionable recommendations for policymakers and urban planners to enhance governance and participatory processes in urban systems, and 3) proposing strategies to balance ecological preservation with socio-economic development, particularly in regions where urban expansion threatens sensitive ecosystems.

The study's findings offer practical applications in urban policy formulation, governance, and resource management. For instance, the integration of SETS principles into urban planning can guide the design of resilient infrastructure and equitable service delivery. Furthermore, the study lays a foundation for future research to:

- Investigate the long-term impacts of governance models on urban resilience and inclusivity.
- Develop quantitative models to assess the effectiveness of urban sustainability interventions.
- Explore the role of digital technologies in enhancing participatory urban governance.

By addressing these areas, the study promotes the development of sustainable, resilient, and inclusive urban systems that can withstand environmental and social pressures while supporting equitable growth.

References

Acuto, M. (2016). Give cities a seat at the top table. *Nature, 537*, 611–613. https://doi.org/10.1038/537611a

Acuto, M., & Leffel, B. (2020). Understanding the global ecosystem of city networks. *Urban Studies, 58*(9), 1758–1774. https://doi.org/10.1177/0042098020929261

Acuto, M., & Rayner, S. (2016). City networks: Breaking gridlocks or forging (new) lock-ins? *International Affairs, 92*(5), 1147–1166. https://doi.org/10.1111/1468-2346.12700

Alsayed, S. S. (2024). Urban human needs: Conceptual framework to promoting urban city fulfills human desires. *Frontiers in Sustainable Cities, 6*, 1395980. https://doi.org/10.3389/frsc.2024.1395980

Bai, X., et al. (2016). Defining and advancing a systems approach for sustainable cities. *Current Opinion in Environmental Sustainability, 23*, 69–78. https://doi.org/10.1016/j.cosust.2016.11.010

Bai, X., et al. (2018). Six research priorities for cities and climate change. *Nature, 555*(7694), 23–25. https://doi.org/10.1038/nature25745

Barnosky, A. D., Hadly, E. A., Bascompte, J., Berlow, E. L., Brown, J. H., Fortelius, M., ... & Smith, A. B. (2012). Approaching a state shift in Earth's biosphere. *Nature, 486*(7401), 52–58. https://doi.org/10.1038/nature11018

Barthel, S., et al. (2019). Global urbanization and food production in direct competition for land: Leverage places to mitigate impacts on SDG2 and on the Earth System. *Anthropocene Review, 6*(1-2), 71–97. https://doi.org/10.1177/2053019619856672

Bassolas, A., et al. (2019). Hierarchical organization of urban mobility and its connection with city livability. *Nature Communications, 10*, Article 12809. https://doi.org/10.1038/s41467-019-12809-y

Bauwens, T., Hekkert, M., & Kirchherr, J. (2020). Circular futures: What will they look like? *Ecological Economics, 175*, 106703. https://doi.org/10.1016/j.ecolecon.2020.106703

Bavel, B. van, & Scheffer, M. (2021). Historical effects of shocks on inequality: The great leveler revisited. *Humanities and Social Sciences Communications, 8*, Article 763. https://doi.org/10.1057/s41599-021-00763-4

Ben-David, I., Jang, Y., Kleimeier, S., & Viehs, M. (2021). Exporting pollution: Where do multinational firms emit CO2? *Economic Policy, 36*(107), 377–437. https://doi.org/10.1093/epolic/eiab009

Biermann, F. (2012). Planetary boundaries and Earth system governance: Exploring the links. *Ecological Economics, 81*, 4–9. https://doi.org/10.1016/j.ecolecon.2012.02.016

Borgström, S. (2019). Balancing diversity and connectivity in multi-level governance settings for urban transformative capacity. *Ambio, 48*, 463–477. https://doi.org/10.1007/s13280-018-01142-1

Boyer, D., & Ramaswami, A. (2020). Comparing urban food system characteristics and actions in US and Indian cities from a multi-environmental impact perspective: Toward a streamlined approach. *Journal of Industrial Ecology, 24*(4), 841–854. https://doi.org/10.1111/jiec.12985

Brook, B. W., Ellis, E. C., Perring, M. P., Mackay, A. W., & Blomqvist, L. (2013). Does the terrestrial biosphere have planetary tipping points? *Trends in Ecology & Evolution, 28*(7), 396–401. https://doi.org/10.1016/j.tree.2013.01.016

Bruckner, M., Giljum, S., Lutz, C., & Wiebe, K. S. (2012). Materials embodied in international trade: Global material extraction and consumption between 1995 and 2005. *Global Environmental Change, 22*(3), 568–576. https://doi.org/10.1016/j.gloenvcha.2012.03.011

Carlisle, K., & Gruby, R. L. (2019). Polycentric systems of governance: A theoretical model for the commons. *Policy Studies Journal, 47*(4), 921–946. https://doi.org/10.1111/psj.12212

Carpenter, S. R., & Bennett, E. M. (2011). Reconsideration of the planetary boundary for phosphorus. *Environmental Research Letters, 6*(1), Article 014009. https://doi.org/10.1088/1748-9326/6/1/014009

Castán Broto, V., Trencher, G., Iwaszuk, E., & Westman, L. (2019). Transformative capacity and local action for urban sustainability. *Ambio, 48*, 449–462. https://doi.org/10.1007/s13280-018-1086-z

Chini, C. M., Djehdian, L. A., Lubega, W. N., & Stillwell, A. S. (2018). Virtual water transfers of the US electric grid. *Nature Energy, 3*(12), 1115–1123. https://doi.org/10.1038/s41560-018-0266-1

Chini, C. M., Konar, M., & Stillwell, A. S. (2017). Direct and indirect urban water footprints of the United States. *Water Resources Research, 53*(1), 316–337. https://doi.org/10.1002/2016WR019473

Clark, W. C., & Harley, A. G. (2020). Sustainability science: Toward a synthesis. *Annual Review of Environment and Resources, 45*, 331–356. https://doi.org/10.1146/annurev-environ-012420-045208

Constantino, S. M., Pianta, S., Rinscheid, A., Frey, R., & Weber, E. U. (2021). The source is the message: The impact of institutional signals on climate change–related norm perceptions and behaviors. *Climatic Change, 166*(3), 35. https://doi.org/10.1007/s10584-021-03095-z

Cooper, D. (1994). Productive, relational and everywhere? Conceptualising power and resistance within Foucauldian feminism. *Sociology, 28*(2), 435–454. https://doi.org/10.1177/0038038594028002005

Dahiya, B., & Das, A. (2020). New urban agenda in Asia-Pacific: Governance for sustainable and inclusive cities (pp. 3–36). *Springer Singapore.* https://doi.org/10.1007/978-981-13-6709-0_1

De Vries, W., Kros, J., Kroeze, C., & Seitzinger, S. P. (2013). Assessing planetary and regional nitrogen boundaries related to food security and adverse environmental impacts. *Current Opinion in Environmental Sustainability, 5*(3-4), 392–402. https://doi.org/10.1016/j.cosust.2013.07.004

Dearing, J. A., Wang, R., Zhang, K., Dyke, J. G., Haberl, H., Hossain, M. S., ... & Poppy, G. M. (2014). Safe and just operating spaces for regional social-ecological systems. *Global Environmental Change, 28*, 227–238. https://doi.org/10.1016/j.gloenvcha.2014.06.012

Dearing, J. A., Bullock, S., Costanza, R., Dawson, T. P., Edwards, M. E., Poppy, G. M., & Smith, G. (2012). Navigating the perfect storm: Research strategies for social-ecological systems in a rapidly evolving world. *Environmental Management, 49*(4), 767–775. https://doi.org/10.1007/s00267-012-9833-6

Dearing, J. A., Yang, X., Dong, X., Zhang, E., Chen, X., Langdon, P. G., ... & Dawson, T. P. (2012). Extending the timescale and range of ecosystem services through paleoenvironmental analyses: The example of the lower Yangtze basin. *Proceedings of the National Academy of Sciences, 109*(13), E1111–E1112. https://doi.org/10.1073/pnas.1118263109

Depietri, Y., Dahal, K., & McPhearson, T. (2018). Multi-hazard risks in New York City. *Natural Hazards and Earth System Sciences, 18*(12), 3363–3381. https://doi.org/10.5194/nhess-18-3363-2018

DeRolph, C. R., McManamay, R. A., Morton, A. M., & Nair, S. S. (2019). City energysheds and renewable energy in the United States. *Nature Sustainability, 2*(5), 412–420. https://doi.org/10.1038/s41893-019-0271-9

Elmqvist, T., Siri, J., Andersson, E., Anderson, P., Bai, X., Das, P. K., ... & Vogel, C. (2018). Urban tinkering. *Sustainability Science, 13*, 1549–1564. https://doi.org/10.1007/s11625-018-0611-0

Erb, K.-H., Haberl, H., DeFries, R., Ellis, E. C., Krausmann, F., & Verburg, P. H. (2012). Pushing the planetary boundaries. *Science, 338*(6113), 1419–1420. https://doi.org/10.1126/science.338.6113.1419

Evans, P., Huber, E., & Stephens, J. D. (2017). The political foundations of state capacity. In M. Centeno, A. Kohli, & D. J. Yashar (Eds.), *States in the developing world* (pp. 380–408). Cambridge University Press. https://doi.org/10.1017/9781316163246.016

Fischer, J., Gardner, T. A., Bennett, E. M., Balvanera, P., Biggs, R., Carpenter, S. R., ... Tenhunen, J. (2015). Advancing sustainability through mainstreaming a social–ecological systems perspective. *Current Opinion in Environmental Sustainability, 14*, 144–149. https://doi.org/10.1016/j.cosust.2015.06.002

Floerke, M., Schneider, C., & McDonald, R. I. (2018). Water competition between cities and agriculture driven by climate change and urban growth. *Nature Sustainability, 1*(1), 51–58. https://doi.org/10.1038/s41893-017-0006-8

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L. H., & Holling, C. S. (2004). Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution, and Systematics, 35*(1), 557–581. https://doi.org/10.1146/annurev.ecolsys.35.021103.105711

Folke, C., Jansson, A., Rockström, J., Olsson, P., Carpenter, S. R., Chapin III, F. S., ... Westley, F. (2011). Reconnecting to the biosphere. *Ambio, 40*(7), 719–738. https://doi.org/10.1007/s13280-011-0184-y

Frantzeskaki, N., Buchel, S., Spork, C., Ludwig, K., & Kok, M. T. J. (2019). The multiple role of ICLEI: Intermediating to innovate urban biodiversity governance. *Ecological Economics, 164*, Article 106350. https://doi.org/10.1016/j.ecolecon.2019.106350

Frantzeskaki, N. (2019). How city-networks are shaping and failing innovations in urban institutions for sustainability and resilience. *Global Policy, 10*(4), 712–714. https://doi.org/10.1111/1758-5899.12786

Fratini, C. F., Georg, S., & Jørgensen, M. S. (2019). Exploring circular economy imaginaries in European cities: A research agenda for the governance of urban sustainability transitions. *Journal of Cleaner Production, 228*, 974–989. https://doi.org/10.1016/j.jclepro.2019.04

Friant, M. C., Vermeulen, W. J., & Salomone, R. (2020). A typology of circular economy discourses: Navigating the diverse visions of a contested paradigm. *Resources, Conservation and Recycling, 161*, Article 104917. https://doi.org/10.1016/j.resconrec.2020.104917

Galaz, V. (2012). Geo-engineering, governance, and social-ecological systems: Critical issues and joint research needs. *Ecology and Society, 17*(1), Article 24. https://doi.org/10.5751/ES-04677-170124

Galuszka, J. (2019). What makes urban governance co-productive? Contradictions in the current debate on co-production. *Planning Theory, 18*(2), 143–160. https://doi.org/10.1177/1473095218780535

Geng, Y., Sarkis, J., & Bleischwitz, R. (2019). How to globalize the circular economy. *Nature, 565*(7738), 153–155. https://doi.org/10.1038/d41586-019-00017-z

Ghosh, S. K., et al. (2020). Circular economy: Global perspective. *Springer Nature Singapore.* https://doi.org/10.1007/978-981-15-1052-6

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science, 327*(5967), 812–818. https://doi.org/10.1126/science.1185383

Gordon, D. J., & Johnson, C. A. (2018). City-networks, global climate governance, and the road to 1.5 °C. *Current Opinion in Environmental Sustainability, 30*, 35–41. https://doi.org/10.1016/j.cosust.2018.02.011

Gravagnuolo, A., Angrisano, M., & Girard, L. F. (2019). Circular economy strategies in eight historic port cities: Criteria and indicators towards a circular city assessment framework. *Sustainability, 11*(12), Article 3512. https://doi.org/10.3390/su11123512

Hannam, P. M., Vasconcelos, V. V., Levin, S. A., & Pacheco, J. M. (2017). Incomplete cooperation and co-benefits: Deepening climate cooperation with a proliferation of small agreements. *Climatic Change, 144*(1), 65–79. https://doi.org/10.1007/s10584-017-2030-9

Heller, P. (2017). Development in the city: Growth and inclusion in India, Brazil, and South Africa. In M. Centeno, A. Kohli, D. J. Yashar, & D. Mistree (Eds.), *States in the developing world* (pp. 309–338). Cambridge University Press. https://doi.org/10.1017/9781316163246.014

Heller, P., Mukhopadhyay, P., & Walton, M. (2019). Cabal city: Urban regimes and accumulation without development. In C. Jaffrelot, A. Kohli, & K. Murali (Eds.), *Business and politics in India* (pp. 151–182). Oxford University Press.

Hickmann, T. (2021). Locating cities and their governments in multi-level sustainability governance. *Politics and Governance, 9*(2), 211–220. https://doi.org/10.17645/pag.v9i2.3973

Hölscher, K., Frantzeskaki, N., McPhearson, T., & Loorbach, D. (2019). Capacities for urban transformations governance and the case of New York City. *Cities, 94*, 186–199. https://doi.org/10.1016/j.cities.2019.05.037

Johannessen, Å., et al. (2018). Transforming urban water governance through social (triple-loop) learning. *Environmental Policy and Governance, 29*(2), 144–154. https://doi.org/10.1002/eet.1842

Kabisch, N., & Haase, D. (2014). Green justice or just green? Provision of urban green spaces in Berlin, Germany. *Landscape and Urban Planning, 122*, 129–139. https://doi.org/10.1016/j.landurbplan.2013.11.016

Kok, K. P. W., Loeber, A. M. C., & Grin, J. (2021). Politics of complexity: Conceptualizing agency, power and powering in the transitional dynamics of complex adaptive systems. *Research Policy, 50*, Article 104183. https://doi.org/10.1016/j.respol.2020.104183

Krishnamurthy, R., & Desouza, K. C. (2015). Chennai, India. *Cities, 42*, 118–129. https://doi.org/10.1016/j.cities.2014.10.006

Krueger, E. H., Borchardt, D., Jawitz, J. W., & Rao, P. S. C. (2020). Balancing security, resilience, and sustainability of urban water supply systems in a desirable operating space. *Environmental Research Letters, 15*(3), Article 035007. https://doi.org/10.1088/1748-9326/ab6af6

Krumme, K. (2016). Sustainable development and social-ecological-technological systems (SETS): Resilience as a guiding principle in the urban-industrial nexus. *Journal of Renewable Energy and Sustainable Development, 2*(1), 70–90. https://doi.org/10.21622/RESD.2016.02.2.070

Kuramochi, T., et al. (2020). Beyond national climate action: The impact of region, city and business commitments on global greenhouse gas emissions. *Climate Policy, 20*(3), 275–291. https://doi.org/10.1080/14693062.2020.1740150

Lahnsteiner, J., & Lempert, G. (2007). Water management in Windhoek, Namibia. *Water Science and Technology, 55*(1), 441–448. https://doi.org/10.2166/wst.2007.129

Larsen, T. A., Hoffmann, S., Luethi, C., Truffer, B., & Maurer, M. (2016). Emerging solutions to the water challenges of an urbanizing world. *Science, 352*(6288), 928–933. https://doi.org/10.1126/science.aad8641

Lenouvel, V., Lafforgue, M., Chevauché, C., & Rhétoré, P. (2014). The energy cost of water independence: The case of Singapore. *Water Science and Technology, 70*(5), 787–794. [https://doi.org/10.2166/wst.2014.318] https://doi.org/10.2166/wst.2014

Lenton, T. M. (2013). Environmental tipping points. *Annual Review of Environment and Resources, 38*, 1–29. https://doi.org/10.1146/annurev-environ-102511-084654

Levin, S. A. (1999). *Fragile dominion.* Perseus Books.

Levin, S. A. (2019). The architecture of robustness. In V. Galaz (Ed.), *Global challenges, governance, and complexity* (pp. 16–23). Edward Elgar Publishing. https://doi.org/10.4337/9781788115421.00007

Liu, J., et al. (2018). Nexus approaches to global sustainable development. *Nature Sustainability, 1*(9), 466–476. https://doi.org/10.1038/s41893-018-0135-8

Markolf, S. A., et al. (2018). Interdependent infrastructure as linked social, ecological, and technological systems (SETSs) to address lock-in and enhance resilience. *Earth's Future, 6*(12), 1638–1659. https://doi.org/10.1029/2018EF000926

Márquez, A. J. C., & Rutkowski, E. W. (2020). Waste management drivers towards a circular economy in the global south: The Colombian case. *Waste Management, 110*, 53–65. https://doi.org/10.1016/j.wasman.2020.05.025

Marsh, K., McKee, N., & Welch, M. (2021). Opposition to renewable energy facilities in the United States. *Sabin Center for Climate Change Law, Columbia Law School.*

McDonald, R. I., et al. (2014). Water on an urban planet: Urbanization and the reach of urban water infrastructure. *Global Environmental Change, 27*, 96–105. https://doi.org/10.1016/j.gloenvcha.2014.04.022

McPhearson, T., Haase, D., Kabisch, N., & Gren, Å. (2016). Advancing understanding of the complex nature of urban systems. *Ecological Indicators, 70*, 566–573. https://doi.org/10.1016/j.ecolind.2016.02.032

Meckling, J., & Nahm, J. (2018). The power of process: State capacity and climate policy. *Governance, 31*(4), 741–757. https://doi.org/10.1111/gove.12331

Mocca, E. (2017). City networks for sustainability in Europe: An urban-level analysis. *Journal of Urban Affairs, 39*(5), 691–710. https://doi.org/10.1080/07352166.2017.1328975

Newell, J. P., & Cousins, J. J. (2015). The boundaries of urban metabolism: Towards a political-industrial ecology. *Progress in Human Geography, 39*(6), 702–728. https://doi.org/10.1177/0309132514558442

Newell, J. P., & Ramaswami, A. (2020). Urban food-energy-water systems: Past, current, and future research trajectories. *Environmental Research Letters, 15*(5), Article 050201. https://doi.org/10.1088/1748-9326/ab7419

Niero, M., Olsen, S. I., & Laurent, A. (2017). Renewable energy and carbon management in the cradle-to-cradle certification: Limitations and opportunities. *Journal of Industrial Ecology, 22*(4), 760–772. https://doi.org/10.1111/jiec.12650

Nordbotten, J. M., Levin, S. A., Szathmáry, E., & Stenseth, N. C. (2018). Ecological and evolutionary dynamics of interconnectedness and modularity. *Proceedings of the*

National Academy of Sciences, 115(4), 750–755. https://doi.org/10.1073/pnas.1716078115

Nordhaus, T., Shellenberger, M., & Blomqvist, L. (2012). The planetary boundaries hypothesis: A review of the evidence. *Breakthrough Institute, Oakland, CA.*

Nyborg, K., et al. (2016). Social norms as solutions. *Science, 354*(6308), 42–43. https://doi.org/10.1126/science.aaf8317

Obersteg, A., et al. (2019). Urban regions shifting to circular economy: Understanding challenges for new ways of governance. *Urban Planning, 4*(3), 19–31. https://doi.org/10.17645/up.v4i3.2180

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action.* Cambridge University Press. https://doi.org/10.1017/CBO9780511807763

Ostrom, E. (2010). Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change, 20*(4), 550–557. https://doi.org/10.1016/j.gloenvcha.2010.07.004

Patel, Z., et al. (2017). Local responses to global sustainability agendas: Learning from experimenting with the urban sustainable development goal in Cape Town. *Sustainability Science, 12*(5), 785–797. https://doi.org/10.1007/s11625-017-0470-0

Peters, G. P., Minx, J. C., Weber, C. L., & Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences, 108*(21), 8903–8908. https://doi.org/10.1073/pnas.1006388108

Porkka, M., Guillaume, J. H. A., Siebert, S., Schaphoff, S., & Kummu, M. (2017). The use of food imports to overcome local limits to growth. *Earth's Future, 5*(4), 393–407. https://doi.org/10.1002/2016EF000477

Ranganathan, J., et al. (2016). Shifting diets for a sustainable food future. *Working Paper, Installment 11 of "Creating a Sustainable Food Future."* World Resources Institute.

Raworth, K. (2012). *A safe and just space for humanity: Can we live within the doughnut?* Oxfam Discussion Paper. Oxfam, Oxford, UK.

Raworth, K. (2017). *Doughnut economics: Seven ways to think like a 21st-century economist.* Random House Business.

Rice, J. L., Cohen, D. A., Long, J., & Jurjevich, J. R. (2020). Contradictions of the climate-friendly city: New perspectives on eco-gentrification and housing justice. *International Journal of Urban and Regional Research, 44*(1), 145–165. https://doi.org/10.1111/1468-2427.12833

Riofrancos, T. (2019). What green costs. *Logic, 9.* Available at: https://logicmag.io/nature/what-green-costs/

Rockström, J., et al. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2), Article 32. https://doi.org/10.5751/ES-03180-140232

Rockström, J., & Karlberg, L. (2010). The quadruple squeeze: Defining the safe operating space for freshwater use to achieve a triply green revolution in the Anthropocene. *Ambio, 39*(3), 257–265. https://doi.org/10.1007/s13280-010-0033-4

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., De Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R. W., Fabry, V. J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., & Foley, J. (2009a). A safe operating space for humanity. *Nature, 461*(7263), 472–475. https://doi.org/10.1038/461472a

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., De Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R. W., Fabry, V. J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., & Foley, J. (2009b). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2), Article 32. http://www.ecologyandsociety.org/vol14/iss2/art32/

Rosner, D., & Markowitz, G. (2019). An enormous victory for public health in California: Industries are responsible for cleaning up the environments they polluted. *American Journal of Public Health, 109*(2), 211–212. https://doi.org/10.2105/AJPH.2018.304881

Running, S. (2012). A measurable planetary boundary for the biosphere. *Science, 337*(6101), 1458–1459. https://doi.org/10.1126/science.1227620

Salman, H., & Alkinani, N. (2023). Preserving the past and building the future: A sustainable urban plan for Mosul, Iraq. *ISVS e-journal, 10*(6), June 2023.

Sampson, R. J. (2017). Urban sustainability in an age of enduring inequalities: Advancing theory and ecometrics for the 21st-century city. *Proceedings of the National Academy of Sciences, 114*(34), 8957–8962. https://doi.org/10.1073/pnas.1614433114

Sarmento dos Muchangos, L. (2021). Mapping the circular economy concept and the global south. *Circular Economy and Sustainability*. https://doi.org/10.1007/s43615-021-00095-0

Scheffer, M., Carpenter, S. R., Foley, J. A., Folke, C., & Walker, B. (2001). Catastrophic shifts in ecosystems. *Nature, 413*(6856), 591–596. https://doi.org/10.1038/35098000

Sennett, R. (2018). *Building and dwelling: Ethics for the city*. Penguin Random House.

Simpson, G. B., & Jewitt, G. P. W. (2019). The development of the water-energy-food nexus as a framework for achieving resource security: A review. *Frontiers in Environmental Science, 7*, Article 1. https://doi.org/10.3389/fenvs.2019.00008

Sparkman, G., MacDonald, B. N. J., Caldwell, K. D., Kateman, B., & Boese, G. D. (2021). Cutback or give it up? The effectiveness of reduce and eliminate appeals and dynamic norm messaging to curb meat consumption. *Journal of Environmental Psychology, 75*, Article 101592. https://doi.org/10.1016/j.jenvp.2021.101592

Sonnino, R., Faus, A. N. A. M., & Maggio, A. (2014). Sustainable food security: An emerging research and policy agenda. *International Journal of Sociology of Agriculture and Food, 21*(2), 173–188.

Sorace, E., Reinhardt, V. S., & Vaughn, S. A. (1993). The spread spectrum concept. In N. Abramson (Ed.), *Multiple access* (pp. 121–123). IEEE Press.

Tellman, B., et al. (2018). Adaptive pathways and coupled infrastructure: Seven centuries of adaptation to water risk and the production of vulnerability in Mexico City. *Ecology and Society, 23*(1), Article 1. https://doi.org/10.5751/ES-09912-230101

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature, 418*(6898), 671–677. https://doi.org/10.1038/nature01014

Torres, B. A., & Brandt, J. (2017). A looming tragedy of the sand commons. *Science, 357*(6355), 970–971. https://doi.org/10.1126/science.aao0971

UN Habitat. (2007). *Inclusive and sustainable urban planning: A guide for municipalities.* Nairobi, Kenya: UN Habitat.

UNEP. (2016). *A snapshot of the world's water quality: Towards a global assessment.* United Nations Environmental Program.

Van der Leer, J., van Timmeren, A., & Wandl, A. (2018). Social-ecological-technical systems in urban planning for a circular economy: An opportunity for horizontal integration. *Architectural Science Review, 61*(5), 298–304. https://doi.org/10.1080/00038628.2018.1505599

Vandenbergh, M. P., Gilligan, J., Harper, S., Roberts, J., & Phillips, C. (2018). Beyond politics: The private governance response to climate change. *Environmental Law Reporter News & Analysis, 48*, 11049. https://doi.org/10.2139/ssrn.3182152

Vasconcelos, V. V., Hannam, P. M., Levin, S. A., & Pacheco, J. M. (2020). Coalition-structured governance improves cooperation to provide public goods. *Scientific Reports, 10*(1), 9194. https://doi.org/10.1038/s41598-020-65960-8

Vogel, D. (2019). Promoting sustainable government regulation: What we can learn from California. *Organization & Environment, 32*(2), 145–158. https://doi.org/10.1177/1086026618756611

Weber, E. U. (2015). Climate change demands behavioral change: What are the challenges? *Social Research: An International Quarterly, 82*(3), 561–580. https://doi.org/10.1353/sor.2015.0050

Westman, L. K., Broto, V. C., & Huang, P. (2019). Revisiting multi-level governance theory: Politics and innovation in the urban climate transition in Rizhao, China. *Political Geography, 70*, 14–23. https://doi.org/10.1016/j.polgeo.2019.01.002

Wijesundara, J., Weerasinghe, U. D., & Perera, L. S. (2021). Inhabitants' satisfaction in neighbourhood sustainability: Insights from Colombo. *ISVS e-journal, 8*(1). https://isvshome.com/pdf/ISVS_8-1/ISVS_ej_8.1.5_Jeeva_Published.pdf

Whyte, K. (2020). Too late for indigenous climate justice: Ecological and relational tipping points. *Wiley Interdisciplinary Reviews: Climate Change, 11*(1), e603. https://doi.org/10.1002/wcc.603

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landscape and Urban Planning, 125*, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017

Xu, V. X., Cave, D., Leibold, J., Munro, K., & Ruser, N. (2020). Uyghurs for sale: 'Re-education,' forced labour and surveillance beyond Xinjiang. *La Trobe.* https://doi.org/10.26181/17102783.v1

Ziervogel, G. (2019). Building transformative capacity for adaptation planning and implementation that works for the urban poor: Insights from South Africa. *Ambio, 48*, 494–506. https://doi.org/10.1007/s13280-018-1141-9

Zhang, S., Chen, Y., & Zhang, X. (2024). Spatial restructuring and development characteristics of villages and the revitalization path: A case study of the X County of Zhejiang Province in China. *Frontiers in Sustainable Cities, 6*, 1441750. https://doi.org/10.3389/frsc.2024.1441750

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