UNDERSTANDING BIODIVERCITIES FROM A TRANSFORMATIVE CHANGE APPROACH

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INTRODUCTION

ARENAS FOR TRANSFORMATION OR SYSTEM OPTIMIZATION?

The redefinition of cities as centers of world population growth worldwide highlights the urgency of understanding how ecological, economic and social functions in urban areas can work together to benefit the environment and human society alike. **BiodiverCities** offer a vision of the city where human beings can live, work and evolve in harmony with their environment. We will argue that this represents a transformative concept of city futures that can avoid environmental degradation of ecosystems and the negative impacts on natural environments and human welfare. Cities are centers of creativity and lifestyle, culture, and learning. They can also be drivers of a new ecological infrastructure in which parks, gardens, open spaces, and water catchment areas thrive and support healthy ecosystems and biodiversity. Examples of these include the work by van der Jagton (2020) and others on "nature-based solutions" (NBS), where green roofs, bioswales, and urban agriculture offer promising ways in which innovative use of nature can help address sustainability challenges in cities.

A central message of this publication is that, especially for cities in the Global South, addressing challenges of sustainable development requires a new approach to policy that goes beyond "optimizing systems" through top-down technocratic approaches. **Transformations** involve radical changes in **socio-technical** and **social-ecological systems** and how these relate. The term "radical" refers to the scope of change rather than its speed (Grin et al., 2010). This is embodied in the sustainable development goals that highlight the link between environmental and social sustainability. Transformations also refer to multi-actor processes that entail interactions between different social groups such as firms, user groups, scientific communities, and social movements.

We draw upon a substantial body of academic literature that discusses how to steer transition dynamics and help create the basis of a new policy approach (Rohracher & Späth, 2017; Sengers et al., 2016; Torrens & Schot, 2017). These are based on three basic principles: **directionality, experimentation, and learning.**

- Transformation is about establishing new *Directions*: This is important because historical studies have shown that most innovations are cumulative and, therefore, can be said to have a direction that is seen as natural or inevitable. For this reason, only certain solutions are looked for and others are ignored. Transformative innovation proposes that not all innovations are positive; some can be highly damaging and create social inequality. Therefore, new directions must be considered, and new development trajectories opened to fulfill societal and environmental goals.
- Early phases of transition are often characterized by *experimentation*. It is not clear which different developmental paths are the best options for society. Experiments can be a mechanism for building niches. These can be important for socio-technical change by challenging existing approaches, setting up new collective priorities, and guiding transformations.
- Experimenting with different options should generate 2nd order *learning*, the process of questioning existing routines, rethinking how problems are defined and what solutions are considered appropriate. This involves reflexivity – the ability of actors to reflect on their practices and assumptions and those of others. It should also stimulate actors to engage with each other to allow 2nd order learning.

This first introduction chapter delivers a valuable contribution that outlines systemic change and sustainability transitions literature. It presents the main concepts, rationales, and values of socio-technical

LATIN AMERICAN HUB

The Latin American Hub of the Transformative Innovation Policy Consortium (TIPC) is a community of practice that brings together organizations based in Latin America in a joint venture to implement methodologies of experimental policy and formative evaluation developed in TIPC. It works with the ideas and methods of transformative innovation policy to build a new approach to science, technology, and innovation policy relevant to addressing significant challenges in the region.

Members undertake transformative experiments whose objective is to advance transformations of socio-technical systems, for example, in energy, transport, and access to clean water and food. These experiments focus on transforming practices within the system by applying a common framework and methodology.

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and socio-ecological systems and the connections between them. Next, we discuss the complexity of biodiverse urban transitions and how visions of optimization or transformation can lead to different outcomes, particularly when considering Global South urban dynamics. In addition, it discusses the challenges around the governance of BiodiverCities, which are intrinsically linked to questions over who governs, whose vision of sustainability is prioritized, and the value of promoting urban planning. Finally, we present conclusions about the implications of a transition towards BiodiverCities. As the first introduction for this publication, this chapter, sets out the underlying themes that mark the overall guiding framework for the subsequent publication.

UNLOCKING SYSTEM TRANSFORMATION

WHAT IS A SOCIO-TECHNICAL SYSTEM?

Transitions theory has emphasized the notion of socio-technical systems to understand processes of change. These systems exist in areas that fulfill basic social needs such as energy, mobility, food, education, and healthcare. Each system involves a wide range of human and non-human actors, different regulations and policies, a mix of market dynamics, a collection of scientific and lay knowledge, and a series of technologies and recurrent practices (F. Geels, 2002). An example of socio-technical systems in urban settings is the water system. Cities depend on their water supply quantity, quality, reliability, and affordability for drinking, food production, sanitation services, manufacturing, and industrial activities. A systems approach to managing water resource systems can help urban planners and practitioners by providing a comprehensive picture of the social, environmental, technical, economic, and political dimensions involved. That is, acknowledging the role and interaction between human actors, non-human actors, policies, market dynamics, infrastructure, technologies, and social practices (see Figure 1, for example). Together, these actors and elements illustrate urban water systems as complex systems in which technology, society, and natural components are in constant co-evolution. (See Geels (2005) for a historical example of water supply socio-technical system transition in the Netherlands).

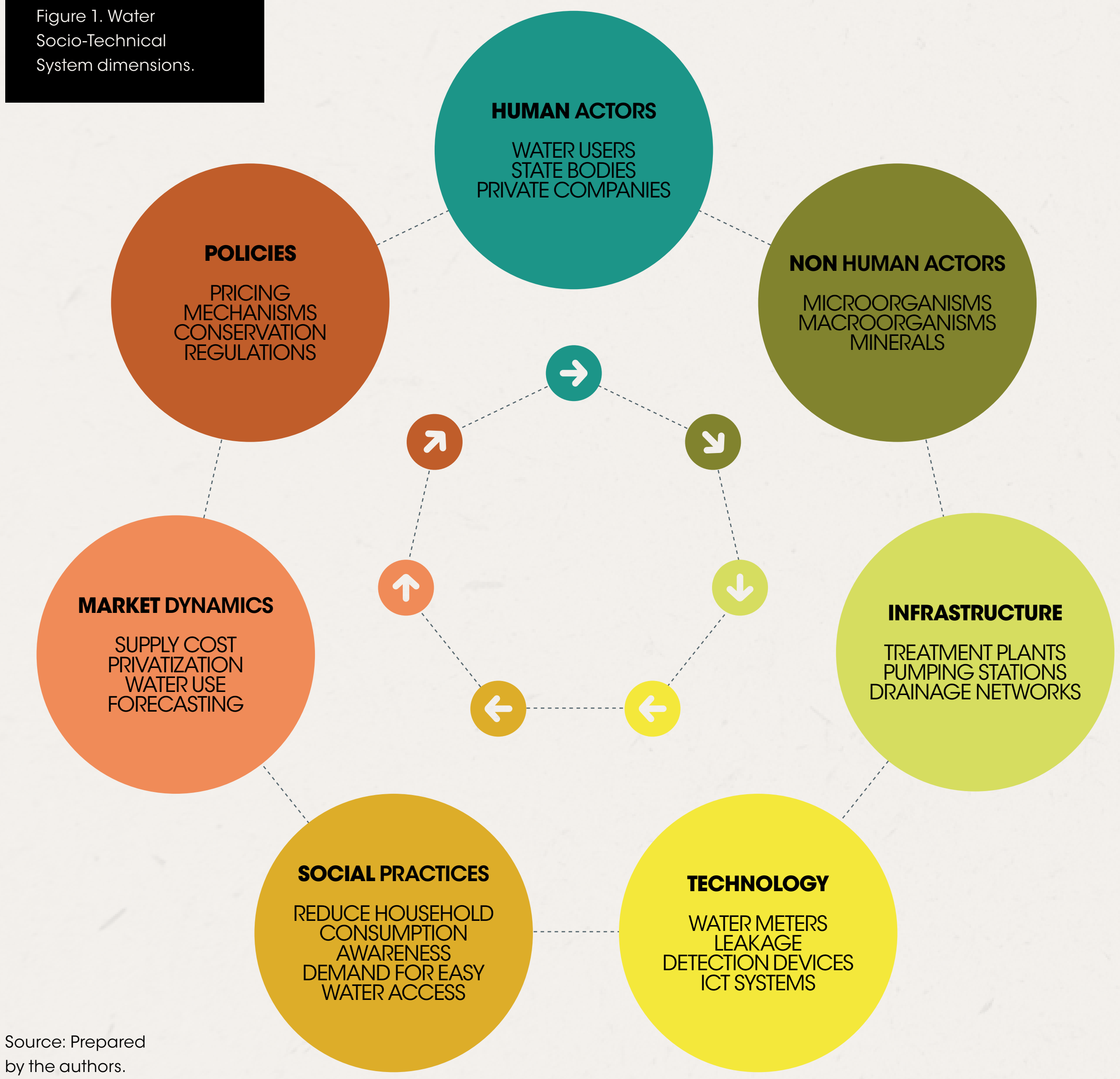
The urban water system has been affected by rapid urbanization rates, population growth, and climate change consequences. Hence, water scarcity, pollution, and high supply costs are increasingly disrupting social, economic, and environmental conditions. Urban planning often fails to deliver appropriate solutions for extreme weather conditions such as heat stress, droughts, or flooding (Güneralp et al., 2015) but assume constant urban extent. Similarly, flawed water disposal mechanisms induce water stress and have negative implications for coastal or river ecosystems in urban and peri-urban areas (Sabater et al., 2018; Wear et al., 2021). Due to increasing pressure on the provision, quality, and cost of water resources, cities are engaging with nature-based solutions that support natural water cycles and increase urban water system resilience. These include alternative innovations such as recycling mechanisms for rain, storm, and wastewater, reconnecting rivers with their floodplains, and supporting urban watersheds that function as catchment basins (Butler et al., 2017). For example, in Italy's Lombardy region, the Gorla Maggiore water park project is an urban wetland development that protects and improves water quality and promotes socioenvironmental co-benefits (Masi et al., 2018). The project includes a sedimentation tank, vertical water flow wetlands, a large pond, green open spaces, cycling, and walking recreational paths. These elements combined prevent flooding, support domestic water treatment, and enable noise reduction and temperature control. Ultimately, the park promotes biodiversity conservation and supports human wellbeing.

UNDERSTANDING REGIMES, NICHES, AND LANDSCAPE

As stated before, complex problems require comprehensive approaches. Transitions theory has developed a now well-recognized approach to describe and provide heuristics for socio-technical system change known as the multi-level perspective (MLP) (F. Geels & Schot, 2007); see figure 2 below for a graphical representation of the mobility system using MLP. This describes the change process in socio-technical systems as arising from interactions in three different and interconnected levels: regimes, niches, and landscape. *Regimes* are dominant configurations expressed in a series of practices, rules, and behaviors that define production and consumption dynamics in a given system. This is similar to that described above, with the dominant preference for car-based mobility. *Niches*, by contrast, are alternative system practices that challenge the incumbent regime by developing shared visions and different socio-technical innovations within a "protected space," in other words, a space where the rules of the incumbent system do not predominate. Non-fossil-based fuel mobility alternatives such as electric cars and scooters and water-resilient innovations such as nature-based solutions have emerged as niche experiments. The landscape also influences *this process*, an exogenous environment that pressures the system through trends or shocks (F. Geels & Schot, 2007). For instance, climate change, macro-economic trends, or the COVID-19 pandemic are considered landscape events. Thus, transformation occurs due to external pressures and emerging niches that co-evolve through time and space and create new configurations for existing socio-technical systems.

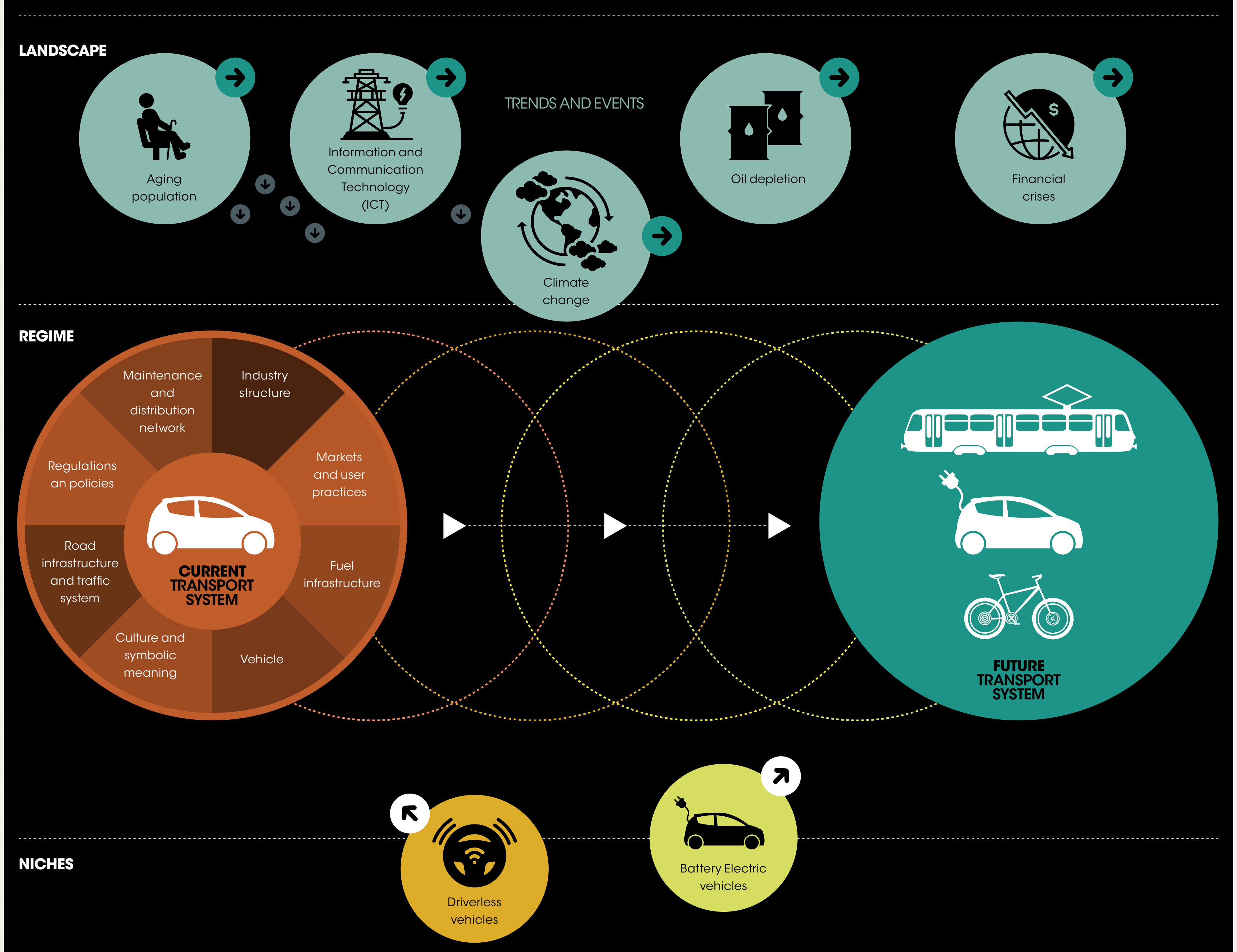
Depending on the desired vision of systemic change, the interaction between regimes, niches, and landscapes can lead to alternatives of either **system optimization** (Di Maio, 2014) or **system transformation** (R. Byrne et al., 2011; F. Geels & Kemp, 2007). In both cases, technology and innovation play a fundamental role. However, in system optimization, change originates mainly from reacting to specific problems using the practices of existing systems. Policymakers often find this approach more convenient as it is supported by rationales of efficiency, competitiveness, and market-led dynamics. Actions of system optimization are often based on traditional managerial methods such

Figure 1. Water Socio-Technical System dimensions.



Source: Prepared by the authors.

Figure 2. Landscape, regime, and niches in the mobility socio-technical system.



Source: Geels et al., (2017).

as strategic planning, cost-benefit analysis, and target monitoring. They usually emphasize technical and technological advances as tools that contribute to system change.

By contrast, system transformation emphasizes the need to reconfigure systems and requires a shared vision of change. Such a reconfiguration requires changes in the rules and practices of the existing system. This means working to change system features, such as the nature of markets, infrastructures, and technologies, and some of the values, expectations, and preferences that guide the choices and actions of actors in the system (Geels & Schot, 2007).

WHAT IS A SOCIO-ECOLOGICAL SYSTEM?

The concept of BiodiverCities needs to address transformations in both socio-technical and socio-ecological systems. These are similar concepts regarding their focus on system transformation but differ in terms of the system definition. Socio-ecological systems are composed of two primary domains – social and ecological– that hold several sets of interdependent and dynamic elements in constant interaction (Fischer et al., 2015). These elements are reflected in the economic and socio-cultural institutions that support our communities in the social domain. As seen in figure 3, people can modify how they use and care for natural elements. In the ecological field, they involve biological processes related, for instance, to geological, water, air, and mineral cycles which provide the necessary materials and benefits to support human life –and human lifestyles. As interactions between people and nature increase in their scale and intensity, it becomes clear that the boundaries between human and environmental structures are artificial (Berkes & Folke, 1998). They are all part of the same system and thus can be affected by

IDENTIFYING DIFFERENCES BETWEEN SYSTEM OPTIMIZATION AND SYSTEM TRANSFORMATION

- Are you having a dialogue with traditional actors or involving a broad and diverse set of actors? (Diversity)
- Are you recognizing different opinions, interests, and needs among stakeholders? (Inclusion)
- Are you mimicking a solution developed for a specific setting or adjusting it to your geographical and social context? (Context-based)
- Are you encouraging different actors to meet with each other and create lasting bonds? (Networking)
- Are they co-creating new narratives, visions, and goals for the desired future? (Co-creation)
- Are actors sharing knowledge or ideas and reflecting on the system change process? (Learning)
- Are you promoting development solutions that exhibit links between practices, technologies, and knowledge? (Experimentation)

changes in any of the two primary domains.

A vital characteristic of the intertwined relation between social and ecological domains is that they are governed by **feedback loops** (Knoot et al., 2010). According to their potential, loops can be positive or negative to enhance change and support the system's natural dynamism. When ecological systems are disturbed (intervened by humans), it creates an imbalance and forces the system to adapt and self-regulate. For instance, while human-made dams can be intended for irrigation or renewable energy purposes, they also influence migratory movements of several species, as well as changes in temperature, oxygen, and sediment conditions that alter water cycles and riverine wildlife (Mcallister et al., 2001; Wu et al., 2019). It is constant interaction between the social and ecological domains that enables further variation through the exchange of matter, energy, and information that pushes the system away from a state of equilibrium and into one of continuous change.

The socio-ecological analytical framework focuses on the linkages between ecosystems and social institutions. This framework reflects on socio-ecological interactions, feedback loops, tensions, and mutual benefit dynamics across different scales (Berkes & Folke, 1998). For instance, while exceptional ecosystem conditions promote tourism and foster local economic development, overexploitation can degrade the very same landscape qualities that attract most tourists. Similarly, the growth of informal urban settlements —most of which are driven by vulnerable people's desire to improve their livelihood— can lead to economic benefits for those migrating while at the same time creating damaging footprints on urban ecology (Aguilar & Santos, 2011). Research has advanced our understanding of how decision-making can align nature's conditions and attributes with human preferences, values, and needs by exploring the complexity of social and ecological interactions.

Because humans and nature are embedded in the same system, any change in one part of the system's components affects another. Thus, socio-ecological systems are in a constant process of co-evolution. This means that people, economies, and culture depend on (and are shaped by) the biosphere around them and vice versa. Such interdependence occurs across multiple scales that range from an individual level to the local, national, regional, and global levels. For example, within urban settings, green spaces provide habitats with essential characteristics for a wide range of organisms and microorganisms. At the same time, the biodiversity in these urban settings provides core goods and services that city dwellers depend on.

An essential aspect of socio-ecological interactions is the so-called **ecosystem services** (Gómez-Baggethun & Barton, 2013). These are benefits that humans obtain from the ecosystems that support different societies' development and sustainability. They include:

- Provisioning services and goods obtained from ecosystems. For instance, food production in peri-urban farm fields, backyards, community gardens, or water supply for drinking, sewage, or industrial uses.
- Regulation services that provide benefits obtained from ecosystem processes. Urban vegetation in parks often provides climate regulation, water purification, and erosion control.
- Supporting services are those that allow other ecosystems to function, such as nutrient cycles, crop pollination, and enabling living habitats for species.
- Cultural services related to recreational, spiritual, or cognitive activities. Such as ecotourism, outdoor sports, or even using nature as inspiration for artistic or creative purposes.

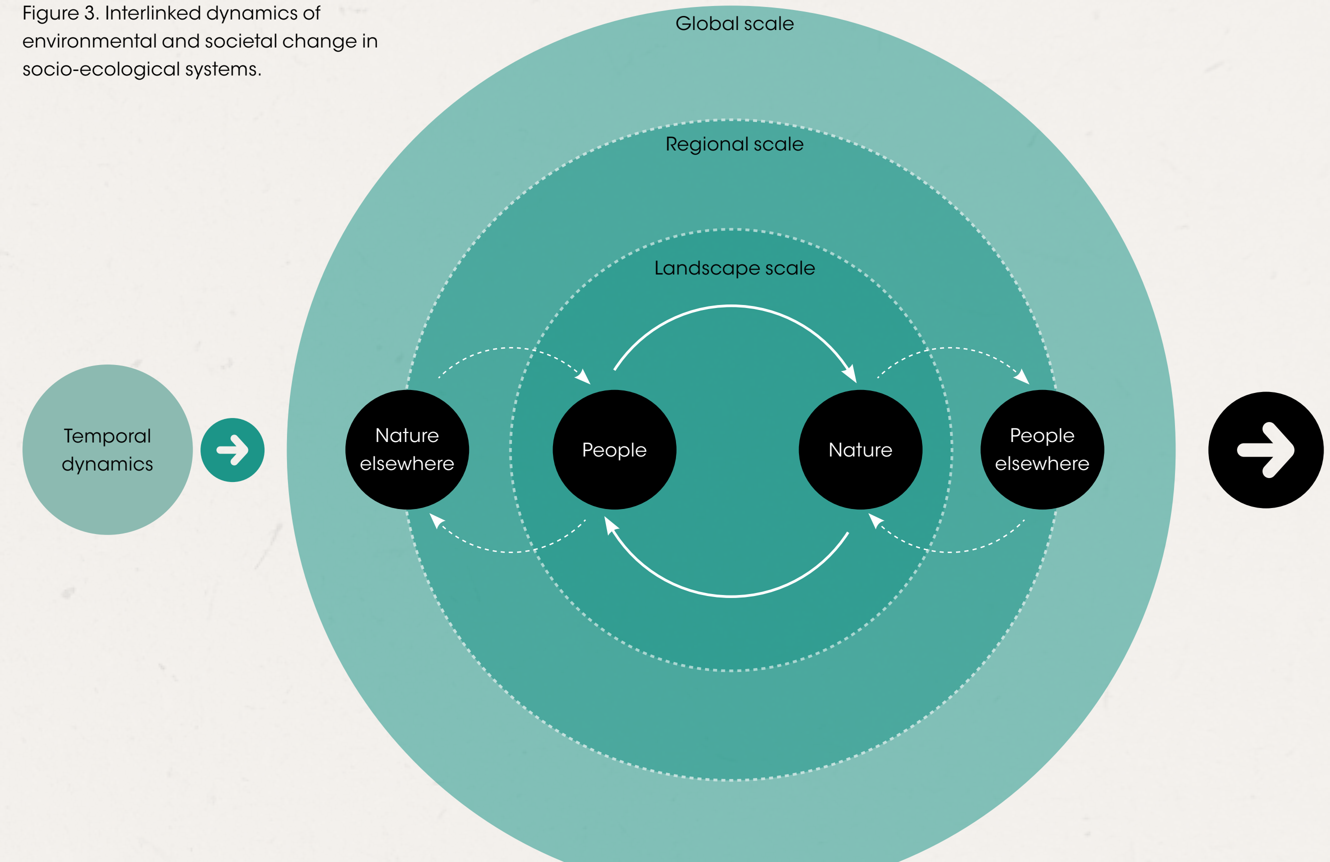
In urban settings, ecosystem services are fundamental for human health, and humans are less prone to physical and mental diseases by supporting air purification, noise reduction, and temperature cooling. Ecosystem services can also enhance or avoid economic costs. For example, homes near green cover often have higher market value, and those shaded by trees often have lower energy costs (Byrne & Houston, 2020).

SUPPORTING THE "COMMONS"

An important aspect of the discussion of the transformation of cities as sustainable socio-ecological spaces and systems is supporting, building, and managing the "Commons" as an alternative representation of urban areas (Foster, 2011; Foster & Iaione, 2015). Commons are either spaces or natural resources that are finite and non-excludable to rivals, that is, resources that anyone can use but with a limited amount available. When it is in the best interest of each individual to overuse a resource with no regard for others, these are prone to overexploitation or to what Hardin called the "Tragedy of the Commons" (1968). Forestry, pasture, and fisheries are classic examples of these shared resources as they can exhibit clear signs of overexploitation through deforestation, soil erosion, water scarcity, and species extinction. In urban settings, the Tragedy of the Commons becomes apparent in areas such as automobiles congestion rates. In cities such as Moscow, Mumbai, and Bogotá, the number of cars exceeds the capacity of urban arterials and leads to some of the world's worst traffic jams (TomTom, 2021) and thus to vehicle emission air pollution (Zhang & Batterman, 2013). According to Hardin, amid the failure of trust in one another and the absence of strong social institutions to enable cooperation, the tragedy is only solved by the state's intervention that regulates resource usage by fostering long-term preservation or extending the private property to individuals. Therefore, the owners will reap the consequences of over-exploitation and reduce over-exploitation.

As the discussion over BiodiverCities extends, policymakers, activists, and scholars are increasingly embracing the notion of **Urban Commons.** This notion is guided by principles of solidarity, active citizen engagement, inclusion, and social justice (Borch & Kornberger, 2015; Foster, 2011). Urban Commons offers a wide range of resources in the cities that can be made accessible and used by all dwellers, especially those who have difficulty accessing these types of services. Examples of Urban Commons include material resources such as parks, community gardens, streets, and abandoned buildings. They also include intangible aspects such as culture, public services, and community bonds (Hess, 2008).

Figure 3. Interlinked dynamics of environmental and societal change in socio-ecological systems.



Source: Fischer et al. (2015).

REIMAGINING CITIES AS HUBS OF BIODIVERSITY AND RESILIENCE

Historically cities have been vibrant centers of political, social, cultural, and economic activities. All around the world, the clustering of these activities contributes to the provision, distribution, and access of numerous essential services around housing, transportation, communication, education, health, sanitation, and other everyday human needs. Similarly, within every urban area, the interaction between people, firms, and governments shapes the formal and informal rules that guide the way dwellers live and how they relate to the services mentioned above. Therefore, the high density of activities and interactions within the same geographical space strengthens interdependence and feedback loops among socio-technical and socio-ecological systems. In turn, this makes urban dynamics more complex.

This complexity emerges partly because, since industrialization, the dynamics of urban services have constantly changed. With the introduction of new technologies also came changes in user preferences reflected -among others- in higher demands for a wide range of products and services (Dholakia, 2012; Gaile-Sarkane, 2009). This led to significant economic growth and a shared notion of opportunities that attracted people to cities. In the global south, urban development is shaped today by urban expansion and increasing migration of people from rural to urbanized areas. Current urbanization trends indicate that by 2050, 68% of the global population will settle in urban areas. This means an increase of 2.5 billion people in 30 years, nearly 90% of which will be living in Asian and African cities (United Nations, 2019). Cities like Lagos, Nigeria, are struggling to accommodate the needs of an increasing influx of dwellers. The housing deficit is currently estimated at 2.5 million units, which is why there are now over 200 informal settlements, with 66% of the population living in slums (Wallace & Alake, 2019). Not to mention insufficient amenities for mobility and social security.

Additionally, as cities expand, they have also become a focus of environmental concern. Issues such as air pollution, land degradation, water stress, and loss of biodiversity can all be linked (at least to some extent) to urban dynamics (Seto et al., 2011). Automobiles, industries, and construction infrastructure all provide essential services to dwellers. However, in doing so, a contradiction emerges as they also entail higher demands for natural resources, higher energy needs, and higher waste production (Inostroza & Zepp, 2021). This increased pressure on the biophysical environment leads to significant climate change consequences when poorly managed or overlooked. Paradoxically, it is the cities and their dwellers who experience the effects. In Mexico City, air pollution is climbing as the cause of death of its inhabitants (Cromar et al., 2021). In Sao Paulo, water management infrastructure collapsed as the city grew faster than expected, and in 2015 it suffered a significant drought leading to socioeconomic tensions (Romero, 2015). Similarly, in Mumbai, the pollution of rivers with industrial materials has increased water scarcity, provoking severe health issues, particularly in the city's slums (Subbaraman et al., 2013; Subbaraman & Murthy, 2015). On many occasions, these damaging consequences affect not only city dwellers but extend to a greater geographical region. Thus, preserving the natural environment and protecting human health and wellbeing are intrinsically intertwined across time and spatial scales.

THE ROLE OF BIODIVERCITIES IN SUSTAINABLE URBAN DEVELOPMENT

While it is true that cities have played a significant role in creating and reproducing many societal challenges, they can also be part of the solution. Urban economic growth and development entail environmental challenges and knowledge production and innovation sources. As more people access education, communication tools, and financial means, they hold greater potential to make critical reflections, discuss imaginaries of future BiodiverCities and build solutions that can contribute to sustainable development pathways. Hence, cities are not passive scenarios where transitions can happen (Bouzarovski & Haarstad, 2018) but rather fundamental actors that can influence the process of transition.

Recent urban agendas have introduced narratives of "regeneration," an idea that draws insights from socio-ecological relations to deliver real-world solutions for urban planning (Raymond et al., 2004). For example, an increasingly diverse set of nature-based solutions aim to protect, restore, or manage natural ecosystems inside and around cities. These actions are discussed by local communities and adapted to their context, so they focus first on understanding the societal needs and then exploring alternatives to address them. Green-blue infrastructures such as green roofs and walls, urban canals, and urban allotments are typical examples of nature-based solutions with some interventions in ecosystems and landscapes (Muller et al., 2010; Tarsitano et al., 2021). However, many communities have also expanded these initiatives to activities with minimal intervention, such as "no-grass mow" seasons to contribute to pollination and protection of marine areas to conserve biodiversity.

New forms of interaction between citizens can also stimulate alternative urban governance. Cities can push forward sustainable solutions by facilitating citizen engagement, encouraging the creation of communities of practice, and supporting existing networks and associations. Thus, cities function as platforms for a diverse group of people –from different backgrounds and with different knowledge– to come together, participate, share ideas and explore their creativity. This can create an atmosphere where it is more likely to build constructive and innovative ways to positively impact urban development (Sutz & Tomasini, 2013). However, as people come together, they can envision different ways to tackle urban challenges. Depending on the imaginaries or expectations of what future BiodiverCities will be like, the change process can lean towards optimization or transformation, representing two entirely different approaches.

URBAN SUSTAINABILITY IN THE GLOBAL SOUTH: CHALLENGES AND OPPORTUNITIES

Urban areas of the global south often face additional and more profound pressing challenges in poverty and inequality, with fragile institutions and a lower set of financial resources (Dobbs et al., 2018; Olken & Pande, 2012). Many of these cities also face unstable governance due to weak democratic processes and poor administration. Likewise, governmental financial capacity for policy design and implementation tends to be lower. While these challenges apply in different scopes to each city, the most common societal challenges involve insufficient physical infrastructure, inadequate housing, high unemployment rates, inefficient resources management, rising crime rates, illiteracy, and increasing pollution (Datta & Shaban, 2017; Moncada, 2013). Moreover, many cities experience tension between pursuing economic growth while minimizing adverse environmental impact and, at times, social inequality.

Despite these negative external factors of the urbanization process, cities of the global south have also shown strong capacities to innovate and experiment with alternative pathways to urban sustainability. Still, their endogenous capabilities, creativity, and problem-solving orientation are often overlooked (Nagendra et al., 2018). A young population and demand for environmental solutions have encouraged policymakers, businesses, and ordinary citizens to experiment with different ideas and reach creative solutions. The well-known Bus Rapid Transit system originated in Curitiba, Brazil, and has spread to other Global South cities, providing an example of efficiently using limited funds to address a mobility challenge (Rodriguez & Vergel Tovar, 2013). Likewise, low-income households dealing with high pressures due to inequality, poverty, and infrastructure deficits increasingly use frugal innovations. These are often bottom-up, disruptive, and low-cost solutions that minimize the use of materials to address fundamental service provision gaps (Khan, 2016). In Nairobi, Kenya, the lack of an adequate sanitary system has forced dwellers to create decentralized community solutions such as shared on-site sanitation, community or privately owned sanitation in public spaces, portable toilets, and container-based toilets (van Welie et al., 2018). Clearly, there are several opportunities to proactively deal with unsustainability and South cities' vulnerabilities that strengthen resilience-building in emerging urban centers. All without necessarily reproducing the same discourses and solutions that the North has established, thus avoiding path-dependency and lock-in effects.

CREATING A LOCAL COMMUNITY OF PRACTICE FOR ENVIRONMENTAL SUSTAINABILITY

Transition to biodegradable packaging materials

The municipality of Iza, Colombia, is famous for its local deserts. The production of deserts makes a significant contribution to the local economy as it supports small food businesses and constantly attracts tourists. However, as producers used polystyrene for packaging deserts, in 2018, the municipality's success turned into an environmental crisis. Over 4.500 monthly polystyrene packaging exceeded the capacity of waste management landfills.

The landfill crisis motivated local authorities to consider alternative solutions for food packaging. In partnership with Iza Desserts Production Association, they experimented with several packing materials and raised the importance of responsible and sustainable consumption. Since desert production is such a relevant activity for the municipality, the process was highly driven by the participation and interaction of tourists and many local citizens, part of which led to tensions and negotiations. As a result, in 2019, a new policy prohibiting polystyrene food containers in Iza was enacted. Following this example, other municipalities in the region passed similar policies. They are now using compostable containers made from rice fiber or corn cane.

This illustrates an interesting case of bottom-up social innovation. By building a multi-actor, transdisciplinary and local community of practice, producers, consumers, and policymakers were able to co-create a shared vision for transitioning to environmentally sustainable solutions.

Source: "Social Innovation and the polystyrene prohibition policy in Iza" (Marin, 2019)

HOW TO DEFINE THE GOVERNANCE OF BIODIVERCITIES?

Questions of governance of technology and innovation are associated with questions about who science and technology are for, who does it benefit, who benefits, who gets a say, and whose agenda is being followed. When confronting questions of the environment, it is also about asking who benefits from biodiverse initiatives (environmental justice), who gets access to these services – such as green spaces - and who participates in the distribution of these benefits? In addition, how does one deal with differences of opinion and possible conflicts of interest, and which investments in science and technology are prioritized? This is a topic that, to a large extent, has been ignored within mainstream policies for technology and innovation and by large parts of the academic literature on science, technology, and innovation.

Our specific interest here is to discuss how to materialize new thinking of governance for policy and how new forms of policy governance can act as a spur for transitions in BiodiverCities. The work of Jessops (2016) is relevant here. He argues that the scale and depth of a sustainability transition cannot be top-down and based on technocratic principles or founded on innovation based on technology-push. New approaches to policy governance have emerged to support these approaches. These include, for example, the work on formative evaluation by Molas-Gallart et al. (2021), which seek to support partnerships between policymakers and stakeholders through formative (rather than auditive) assessment principles that encourage mutual learning. A significant change in policy practice is also the principle of policy experimentation to support transformation processes (Schot et al., 2019). Experimentation as a policy governance concept has become increasingly influential in broad policy circles (beyond transformative innovation). Growing recognition of the need to address sustainability challenges in complex environments requires processes of experimentation that encourage learning by a range of actors. This is particularly the case in cities and large urban environments that require integrated systems thinking.

Schot et al. (2019) summarizes five ways in which experimental policy engagements for transformation can take place (see table 1) (see in https://www.tipconsortium.net/resource/transforming-experimentation-experimental-policy-engagements-and-their-transformative-outcomes/).

- **Policymakers can initiate policy instruments and policy processes.** They could include experiments with public dialogues in the context of public participation, explorative planning processes, and policy pilots for climate risk adaptation.
- **Experimental spaces involve creating platforms for new interactions.** This is the case of a growing number of Urban Living Labs or Fablabs and Makerspaces and 'transition arenas' where stakeholders are hosted to envision a transformation.
- **Supporting, connecting, and reviewing societal experiments focuses on supporting already existing (often bottom-up) entrepreneurial experimentation and grassroots initiatives.** According to Schot et al. (2019), such an effort may also entail measuring or evaluating unfolding transformation and identifying specific needs to establish new or support existing intermediaries.
- **Experimental governance culture is promoted as a deliberate strategy or activity to encourage an experimental governance culture.** This may involve promoting disruptive technologies for tackling climate change and other complex societal challenges. This mode of empirical policy engagement may provide the learning required for the emergence of a new culture of governance that embraces and relies on experimentation.

Well-known examples of experimentation in niche urban areas include transdisciplinary approaches to initiate, monitor, and evaluate novel bus-rapid transit systems addressing traffic, air pollution, climate change, and affordability of public-transportation infrastructures (Sengers et al., 2016). In terms of BiodiverCities, there have also been important initiatives on urban food sovereignty (the right to healthy and culturally appropriate food, produced ecologically by using sustainable methods) encouraged by small-scale urban farms. These make locally sourced food and positively affect the absorption of urban waste.

KEY MESSAGES

➔ **Relationship transformation of biodiversity and cities.** Cities and urban conurbations were originally constructed and designed to further industrial production and economic development. Their design initially paid little attention to social aspects and even less to the ecological damage, they could produce. The reconstruction of cities based on principles of biodiversity requires broader approaches that offer a multidimensional, multi-actor, and context-based vision of development and sustainability.

➔ **BiodiverCities as socio-ecological systems.** Systems of mobility, housing, water, and electricity need to work together and integrate biodiversity within notions of development. Ecologists and biologists can work together with planners, architects, and other social scientists to unravel the complexity of coupled socio-ecological systems and understand the relationships between biodiversity and socio-technical systems.

➔ **The importance of transdisciplinary and intersectoral approaches.** It is urgent to open the process of knowledge production to transdisciplinary collaboration from non-academic actors such as citizens of local communities. While sustainable, innovative ideas emerge in nature-based solutions, those ideas that effectively reach cross-sector and cross-actor partnerships will most likely open spaces for alternative directionalities and encourage positive links between urban, peri-urban, and rural settings.

➔ **The meeting point between cities and biodiversity.** For Just city transitions based on principles of biodiversity to emerge, it is essential that "the commons" and urban collaborative governance are strengthened. Moreover, social organizations and social movements can play a central role in generating new ways of developing conservation practices and restoration of nature through experimentation and collective learning.

➔ **The shared vision of biodiversity.** Urban regeneration initiatives integrating biodiversity and ecosystem services can benefit from shared visions of the future city and practical efforts towards collective goals. They also benefit from community-led networks that push for institutional and behavioral changes around biodiversity conservation values, wellbeing, sufficiency, and inclusion.

Table 1. Modes of experimental engagements.

MODES OF EXPERIMENTAL POLICY ENGAGEMENT	MODE 1: POLICY DESIGN ELEMENTS	MODE 2: POLICY INSTRUMENT AND POLICY PROCESS EXPERIMENTS	MODE 3: CREATING EXPERIMENTAL SPACES	MODE 4: SUPPORTING, CONNECTING AND EVALUATING SOCIETAL EXPERIMENTS	MODE 5: EXPERIMENTAL GOVERNANCE CULTURE
Role of experimentation in policy	Assists in the formulation, calibration and justification of policy instruments	Setting up of specific experimental policy interventions in the form of new policy instruments or policy processes tried out temporally or in a small scale	Creates dedicated environments and a constituency for experimentation, where the normal conditions (e.g. regarding permits, taxation) are relaxed	Articulates existing experiments carried out by multiple actors, facilitates learning from and between experiments, and supports the development of networks	Creates flexible and proactive governance arrangements, including open-ended goals, allowing decentralised and experimental interventions by multiple actors
Actors involved	Policymakers, and recipients of the policy treatment	Policymakers and policy analysts, stakeholders involved in the experiments	Lead users, entrepreneurs, technology advocates, designers, civil society actors, policymakers	Networks implicated in experiments, intermediaries and policymakers	As others, but with aim of broadening participation to actors normally expluded from policy process
Approaches	Randomised Control Trial, Behavioural Experiments	Experimenting with new formats in established policy instruments / processes (programmes, subsidies, regulation)	Urban living Labs, policy labs, walk-shops, transition arenas	Intermediary organisations and platforms, workshops, online resources	Strategies and iniciatives to promote experimental culture; rewarding reflexivity and learning

Source: Schot et al. (2019).