SUSTAINABLE URBAN ECONOMIES: TRANSITIONS BASED ON BIODIVERSITY KNOWLEDGE

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The New Urban Agenda, adopted by the United Nations Conference on Housing and Sustainable Development in October 2016, provides a roadmap to guide efforts toward developing more inclusive, compact, and connected cities. To this end, it puts forward three transformative commitments: ensuring that no one is left behind (considering principles of justice and equity), developing sustainable and inclusive urban economies, and ensuring environmental sustainability (UN, 2017).

The interest in ensuring the development of sustainable urban economies is not surprising. Cities and metropolitan areas are central axes of economic growth as they contribute 60% of the world's gross domestic product (GDP). However, they are also responsible for about 70% of global carbon emissions and more than 60% of natural resource use (UN, n. d.). Food, water, energy, and raw materials are demanded daily by urban centers to provide goods and services to a population that has been growing on a global scale. Today, this represents over 55% of the planet's inhabitants, but in regions such as Latin America and the Caribbean (LAC), it may exceed 80% (UNEP, 2021).

Thus, the growth of cities is a phenomenon that has been putting pressure on ecosystems and the biodiversity linked to those services demanded by the majority of the world's urban population. This situation is worrying, given the growing evidence that suggests that human activities have been pushing the Earth system outside its ecological limits, thus altering the stable environmental state of the last 10,000 years, with detrimental or even catastrophic consequences for a large part of the planet (Rockström et al., 2009).

One of the limits crossed has been precisely the transformation of ecosystems and the loss of biodiversity, which has driven the high consumption of resources derived from it, as well as the degradation of environmental conditions as a result of economic growth itself (Otero et al., 2020). This has put at risk the possibility that these ecosystems and their biodiversity can continue to provide the goods and services that meet the needs of a growing human population and, therefore, the economy and the well-being of communities living mainly in urban centers.

The economic and social crisis caused by the COVID-19 pandemic, coupled with the evidence that we are increasingly close to crossing planetary boundaries that threaten our survival as a species, suggests that we must rethink business and our relationship with nature in order to achieve a resilient and sustainable economic recovery. Urban economies can play a leading role in this scenario, given their contributions to GDP, human well-being, and planetary sustainability.

This chapter presents some conceptual frameworks developed around sustainable economies. The discussion contemplates the transformation required for urban centers to move towards BiodiverCities in which it is possible to establish a positive economy with nature based on knowledge, generating well-being for the communities that live there, without losing sight of the global scope required for this purpose. This proposal for change towards sustainable urban economies includes integrating a bioecological vision from a systemic approach. Through transformative innovation, research and development efforts are directed to provide answers to urban and rural populations' social and environmental needs.

HOW TO ACHIEVE SUSTAINABLE KNOWLEDGE-BASED URBAN ECONOMIES?

The search for alternatives that allow the sustainable use of natural resources and thus avoid future ecological collapse (due to the destruction of ecosystems and the mass extinction of species), climate (given global climate change), or economic collapse (due to the lack of natural resources that sustain it) has been mainly supported by research and innovation processes that seek to use the knowledge generated and new technologies to guide the way in which these elements can be comprehensively managed. An example of this is using raw materials such as biomass or molecules derived from biodiversity in biorefineries to replace fossil fuel derivatives that are considered non-renewable resources. Biomass, whether from biodiversity or residues from these productive and industrial processes, thus becomes a great asset for all countries, especially those with high concentrations of biodiversity, such as those located in tropical and neotropical regions.

It is recognized that biodiversity is essential for sustainable development and the well-being of humans and non-humans alike since it provides us with fundamental goods and services such as food supply and the regulation of climate and life on the planet. In fact, it is also considered to be a source of employment opportunities in activities such as agriculture or biotechnology. Therefore, without adequate measures to conserve biodiversity and sus-

tainably use its components, associated goals like the 2030 Agenda for Sustainable Development will not be achievable (CBD, 2018).

In this context, the development of built environments in urban centers and industrial progress have been shown to contribute significantly to the dynamics of ecosystem degradation and biodiversity loss that are evident on a planetary scale. For this reason, it is precisely in these spaces that the search for opportunities to enable a planetary transition towards the desired sustainability becomes urgent. A fluid interaction between built and natural environments that converge in cities will be essential in maintaining and improving human well-being (Opoku, 2019).

A transformative vision such as that proposed by BiodiverCities offers a new paradigm that can promote sustainable development in urban environments from a perspective that recognizes as central pillars the links that cities and their human well-being have with ecosystems, biodiversity, and their ecosystemic services at different scales. However, moving towards a BiodiverCity will necessarily imply talking about a knowledge society and economy, which means a permanent connection with the discussions and dialogues between the social and economic sciences (Krüger, 2006).

According to Chen and Dahlman's (2005) proposal, in what we can call the new knowledge economies, "knowledge is acquired, created, disseminated and used effectively to improve economic development." Thus, knowledge, applied to production, is determining the standards of living and welfare beyond the availability of land, machinery, infrastructure, and labor that a country has (Information Society Commission, 2002), making the factors of production established in the classical economy more efficient.

Terms such as "bioeconomy," "circular economy," "green growth and economy," "nature-based solutions," and "doughnut economy" are becoming more and more frequent in the public discussion agenda. These describe proposals for economic transformation and ecological relationships that lead us towards sustainable development models and economies at the level of cities, regions, and societies. These new "green" or "sustainable" economies focus on the dilemma between economic growth and sustainability. Within the BiodiverCity development framework, this dilemma leads to the need to use approaches such as those proposed by bioecology, which focus on seeking gradual transitions to achieve the social and economic transformations required for planetary stability and sustainability.

Urban environments offer favorable scenarios for developing innovations and structural changes that promote these sustainable economies since they group most of the economic activity and have a high concentration of institutions that generate and transfer knowledge (e.g., universities and research centers). Although different forms of sustainable economies have been proposed on a global scale, those that can be directly articulated to the transformative vision described by BiodiverCities are described below.

CIRCULAR BIOECONOMY

There is no single narrative around the bioeconomy. It is often associated with an economy that uses natural resources, especially biomass, to sustainably produce goods and services, mediated by innovations resulting from knowledge generation. At the urban-regional level, this can generate integrated, sustainable, and profitable value chains and networks, such as those associated with using biological assets to obtain economic value (e.g., the use of commercialized wild plants). Also, this can contribute to the generation of integrated, sustainable, and profitable value chains and networks, such as those associated with the use of biological assets to obtain economic value (*e.g.*, the use of wild plants marketed in urban distribution centers), development of controlled environments (*e.g.*, urban agriculture) or generating new products from biomass (*e.g.*, biorefineries) (Taylor and While, 2021).

It is worth noting that an essential part of the developments around the urban bioeconomy has been aimed at promoting a circular bioeconomy. This perspective integrates circular economy principles aimed at reducing and closing material resource loops based on renewable energies and non-toxic materials with a sustainable bioeconomy, which transcends the replacement of fossil resources with renewable biological resources (Tan and Lamers, 2021). In fact, the European Union's Bioeconomy Strategy proposes that cities be turned into major centers of circular bioeconomy. Some examples of these initiatives can be found in the HOOP project (https://hoopproject.eu/).

Building a sustainable bioeconomy in a BiodiverCity will be possible if research-mediated sustainable uses of biodiversity are integrated with new converging technologies and innovation to create new high value-added goods and services, business sophistication, and new industries. Figure 1 shows different examples of how the intensification of

Figure 1. R&D&I intensity and technology-based transformation to produce value-added goods and services from biodiversity.

	PRODUCTIVE DEVELOPMENT	BASE BIODIVERSITY (RAW MATERIALS)	LOW ADDED VALUE	INTERMEDIATE ADDED VALUE	HIGH ADDED VALUE
Pharmaceutical	Creation of phytomedicine industries	Anamú (Petiveria alliacea)	Commercialization of Anamú-based infusions, which are believed to have medicinal properties for cancer treatment	Development of a phytomedicine based on Anamú for cancer treatment	Isolation and commercialization through biotechnology of the active anti-cancer compound from Anamú (dibenzyl trisulfide)
Tourism	Development of routes and tourist packages based on urban biodiversity	Urban-regional protected areas	Nature tourism in urban-regional ecosystems	Avitourism	Scientific tourism or specialized Avitourism (e.g. Avitourism for the visually impaired)
Agrobusiness	Use of residual biomass	Residual forest or agro-industrial biomass	Digester bales for the production of organic fertilizer	Obtaining energy from residual biomass	Biorefinery

R&D&I INTENSITY AND TECHNOLOGY-BASED TRANSFORMATION — R&D&I INTENSITY AND TECHNOLOGY-BASED TRANSFORMATION

Source: Prepared by authors.

research, technological development, and innovation (*R&D&I*) management systems can lead to achieving these value-added products or services from urban biodiversity.

NATURE-BASED ECONOMIES

This conceptual framework proposes a nature-based economy perspective, which explicitly recognizes that nature is a fundamental input for producing and generating valuable products in the economy (McQuaid et al., 2021). This conceptual proposal emerges in the new concept of nature-based solutions (NbS).

NbS makes a direct link to the dimensions of sustainable development, putting social, environmental, and economic dimensions at the same level of importance (Nesshöver et al., 2017). Recently, NbS have been described as contributing co-benefits such as improved attractiveness of places, health, and quality of life. Also, these solutions are considered to represent open innovations that require the engagement of multiple stakeholders, bringing together social and economic interests and thus stimulating new green economies and jobs (Raymond et al., 2017). Examples of the above are the INNOQUA project in Quito (Ecuador) and the Green Corridors initiative in the city of Medellin (Colombia). In addition to generating solutions to social challenges in urban environments (wastewater treatment and urban heat islands, respectively), these aim to create new jobs required to implement and maintain these NbS over time.

The COVID-19 pandemic generated an unprecedented social and economic crisis characterized by the loss of many jobs. At one of the most critical moments of the pandemic (June 2020), it is estimated that as many as 31 million jobs were lost in the LAC region alone (Azuara et al., 2021). Therefore, creating new jobs is an urgent priority in light of the economic recovery. In this regard, it has been proposed that NbS can play a leading role (Kopsieker et al., 2021). The World Wild Foundation (WWF) and the International Labor Organization recently published a detailed analysis of how NbS can drive the recovery of green employment (Lieuw-Kie-Song and Perez-Cirera, 2020).

Green businesses or bio-businesses that generate sustainable goods and services from natural resources can also be framed within this concept of a nature-based economy. Considering the urgency of the current environmental crisis, this type of business is becoming increasingly relevant in the global context since they are associated with value chains with maximized profits and optimized practices, which generate positive impacts on the use of natural resources and contributions to social welfare (Hasan et al., 2019).

Another example is biomimicry. According to the Biomimicry Institute (https://biomimicry.org/), it values nature for what we can learn, not for what we can extract. That is, through patterns and strategies tested throughout the evolutionary history of living organisms, sustainable innovations to human challenges can be generated. According to this premise, biomimicry could become a way to create solutions to urban challenges and develop new designs that materialize in products or services harmonized with nature that can sustainably generate economic returns (Fig. 2).

DOUGHNUT ECONOMICS

This approach recognizes that public policies of the last century were mainly oriented to promote constant GDP growth, resulting in degenerative economies that have led to the depletion of the natural resources on which human welfare depends. Furthermore, this approach argues that inequities and concentrated wealth in a small percentage of the population have been generated (Raworth, 2017a). The doughnut economy recognizes in this context that human well-being depends on each person being able to lead a life of dignity and opportunity while safeguarding the integrity of life-support systems (Raworth, 2017b). This approach then establishes the parameters of an economy for it to function sustainably. In that regard, it identifies that the economic system is restricted by two limits defined by ecological and social aspects so that only an economy that is located within those two limits (called environmental ceiling and social foundation, respectively) will approach real sustainability.

The city of Amsterdam, for example, has decided to adopt this sustainable economy framework to become a pioneering city seeking a systemic transformation towards a prosperous, regenerative and inclusive city for all citizens while respecting the limits of the planet (Maldini, 2021). Likewise, Philadelphia and Portland have adopted this framework by joining the *Thriving Cities Initiative* (TCI), which seeks to test new ways of thinking, governance, and collaboration to foster community-led action for a green and just future.

HOW CAN THE IMPACT OF NEW SUSTAINABLE ECONOMIES IN A BIODIVERCITY BE ASSESSED?

Although sustainable economies are based on a conceptual framework that suggests learning from mistakes made in the development practices that have led to environmental deterioration and social problems, it is necessary to evaluate whether we are genuinely achieving sustainability goals through their implementation. Therefore, a BiodiverCity must promote the use of adjusted monitoring metrics that allow it to identify its progress in terms of sustainability in all its dimensions and scales (*e.g.*, local, regional, global). In this way, it will be possible to determine whether the decisions made and actions undertaken are on the right track or whether it is necessary to concentrate efforts on reorienting policies (Robert et al., 2020) and promoting more efficient public-private investment.

It is important to highlight that within these metrics proposed to measure the impact of sustainable economies in a BiodiverCity, some concerning the stock and flow of natural capital should be included. These should consider the returns to its conservation and build comprehensive indicators for decision-making. Currently, there are models used to map and value the goods and services of nature proposed by the Natural Capital Project with the help of the InVEST software (Stanford University, 2021). The results of these exercises would be beneficial for defining indexes that estimate the economic, social, and environmental performance of cities in a comprehensive manner.

Regarding indicators related to sustainable economies, our research shows the relationship between 11 indexes that classify the performance of cities, evaluated in four pillars and ten thematic areas. As a result, it is evident that cross-cutting indicators from human capital, innovation, and the market help develop sustainable economies (Figure 2). However, there are no robust indicators to evaluate the performance of a city based on sustainable economies from the perspective of biodiversity. Their estimates are only based on measuring a city's stock of supplies (*e.g.*, number of waste products generated, amount of area protected, strategic area), and not the flows between ecosystem services and economic activities, nor their returns to conservation, which would be more effective indicators for making decisions at that level.

HOW SHOULD SUSTAINABLE URBAN-REGIONAL ECONOMIES BASED ON BIODIVERSITY KNOWLEDGE BE PROMOTED?

Below, we propose some approaches or principles that would allow the creation of policies oriented to the consolidation of sustainable economies based on biodiversity knowledge in urban-rural contexts:

Systemic approach: promotes recognizing the connections between nature and people in their multiple dimensions and interdependencies, which requires an approach based on complexity. To this end, is required:

- Socio-ecological systems in which human beings, society, and all their activities are understood as embedded in an ecological system. This means that the source-sink vision of the economy on nature, where its impacts are treated as externalities, must disappear so that they can be internalized in the intrinsic feedback loop of nature.
- Socio-technical systems in which the complexity of interactions between society, organizations, and economic sectors is addressed, together with their evolution and possible transformations from the different types of innovation.
- Creation of value networks incorporating principles of industrial symbiosis, cleaner production, circular economy (*e.g.*, RedES-CAR initiative), and connection between different complementary and supplementary value chains. This will make it possible to create more efficient and productive value networks that will stimulate competitive and high value-added commercial circuits at the local, regional, and even international levels.

Multiscale approach: seeks to understand that planetary boundaries, economy, and sustainability are expressed at different scales: local, regional (subnational), national and planetary. To this end, is required:

- *Telecoupling* as a way of understanding that the positive and negative processes of urban systems at local scales have repercussions at regional and planetary scales, as well as on two-way scales.
- Functional territories as a way of focusing policies, economies, and actions, not only on people but also on spatial relationships, which requires understanding and analyzing the functions and connections between scales, as evidenced by the *Functional Urban Areas* (FUA) methodology.

ECOINCREMENTAL LABORATORY.
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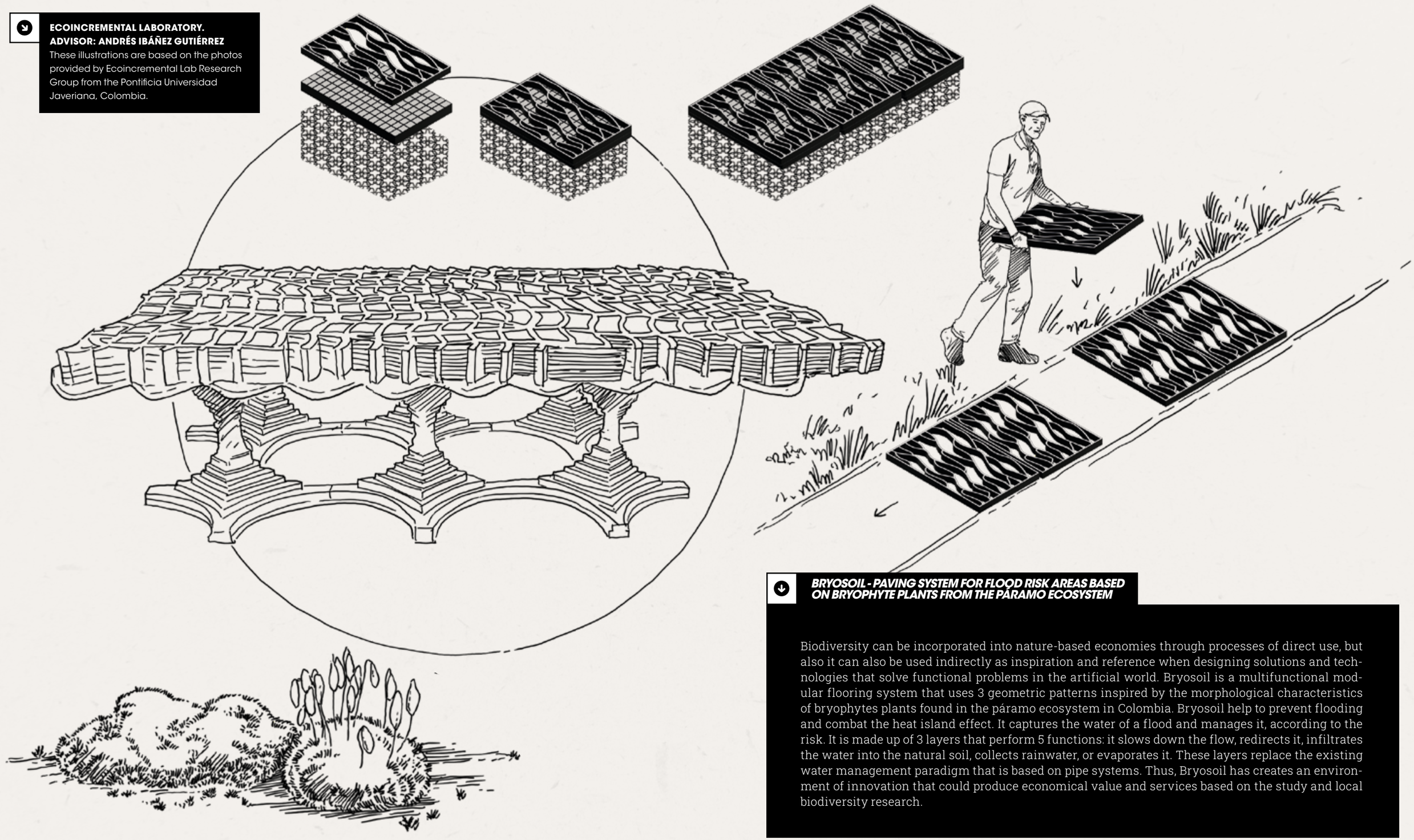
These illustrations are based on the photos provided by Ecoincremental Lab Research Group from the Pontificia Universidad Javeriana, Colombia.



BRYOSOIL - PAVING SYSTEM FOR FLOOD RISK AREAS BASED ON BRYOPHYTE PLANTS FROM THE PÁRAMO ECOSYSTEM

Biodiversity can be incorporated into nature-based economies through processes of direct use, but also it can also be used indirectly as inspiration and reference when designing solutions and technologies that solve functional problems in the artificial world. Bryosoil is a multifunctional modular flooring system that uses 3 geometric patterns inspired by the morphological characteristics of bryophytes plants found in the páramo ecosystem in Colombia. Bryosoil help to prevent flooding and combat the heat island effect. It captures the water of a flood and manages it, according to the risk. It is made up of 3 layers that perform 5 functions: it slows down the flow, redirects it, infiltrates the water into the natural soil, collects rainwater, or evaporates it. These layers replace the existing water management paradigm that is based on pipe systems. Thus, Bryosoil has creates an environment of innovation that could produce economical value and services based on the study and local biodiversity research.

Biointensification approach: seeks that biodiversity becomes a central factor of production and competitiveness while generating returns to conservation and social welfare in all economic processes, under aspects such as:

- Focus economies on technological and innovative uses of biodiversity in more innovative and sustainable value chains, value networks, and businesses.
- Seek new ways to incorporate biodiversity as a value factor in value chains and networks, businesses, corporations, and industries, fostering more sustainable and regenerative economies.
- Fair and equitable benefit distribution under the framework of the Nagoya Protocol, which becomes the key to developing sustainable biodiversity-based economies that ensure social justice in monetary exchanges.

Environmental accounting approach: it is necessary that metrics at all economic levels - micro, meso, and macro - incorporate natural capital as a source of analysis and orientation of transformations. This implies:

- Developing national and subnational accounts with all types of metrics for these sustainable economies.
- Incorporating natural capital into GDP measurements.
- Promoting the inclusion of natural capital or environmental factors more forcefully in corporate accounting and sustainability metrics.
- Including biodiversity or natural capital metrics in the innovation, competitiveness, city, and functional subregion analysis indexes.

Plurality, heterogeneity, and diversity approach: promotes equity and social justice in the development of these sustainable economies based on:

- Each region and territory has its own capacities and potential to develop transformative niches that mobilize socio-technical changes, which in turn lead to socio-ecological transitions towards sustainability. It implies the development of both top-down and bottom-up policies with a pluralistic approach.
- It is necessary to consider that nature's contributions to people are not exclusively mediated by the market but recognize different levels of value and contribution to human well-being.
- Other forms of local and welfare economies, among others, that also contribute to short commercial circuits and better sustainability from a territorial point of view must be respected.

Post-consumption and market regulation approach: arises from policies to generate extended responsibility to both producers/businesses and consumers to become responsible for the waste derived from their production and consumption. This requires focusing not only on public policies but also on generating more significant market incentives. It also implies:

- Conduct life cycle analysis of products to increase efficiency, circularity, and returns to natural heritage conservation.
- Generate incentives such as green taxes that induce a positive change for the planet, both for the consumer and the productive sector.
- More efficiently regulate the negative impacts of the economy on ecosystems and climate change.
- Decarbonization of economic activities and society that guide socio-ecological transitions towards sustainability.

Research, technological development, and innovation approach: within the framework of transformative changes, this implies recognizing the niches of innovation and socio-technical changes that can occur at different levels, guided by economic and competitiveness objectives and incorporating social and environmental goals. To this end, it is required:

- Respect and incorporate all forms of knowledge in society under a pluralistic approach to building knowledge societies and economies.
- Recognize and stimulate all forms of innovation in favor of transitions to sustainability, such as technological innovation, process innovation, social innovation, and frugal innovation, among others.

Multi-level and polycentric governance approach: recognizes that the actors of change are not only governments or companies but also different community, ethnic and social representative organizations. This includes:

- Participation, equity, and social justice policies.
- Policies that favor the organization and its participation in the changes in the economy and society.

Figure 2. Components and pillars of indexes that measure the performance of cities.

Source: Prepared by the authors.

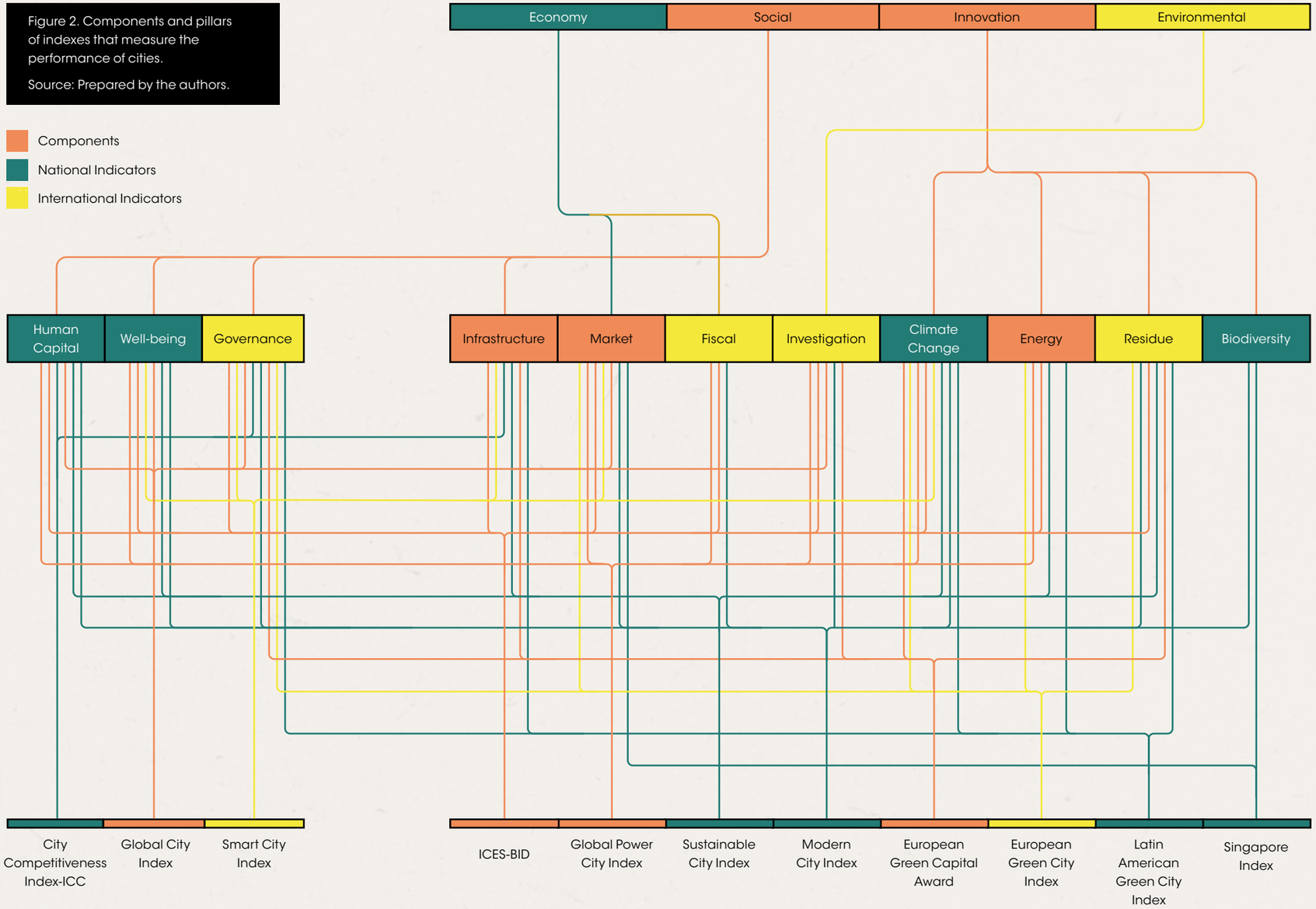
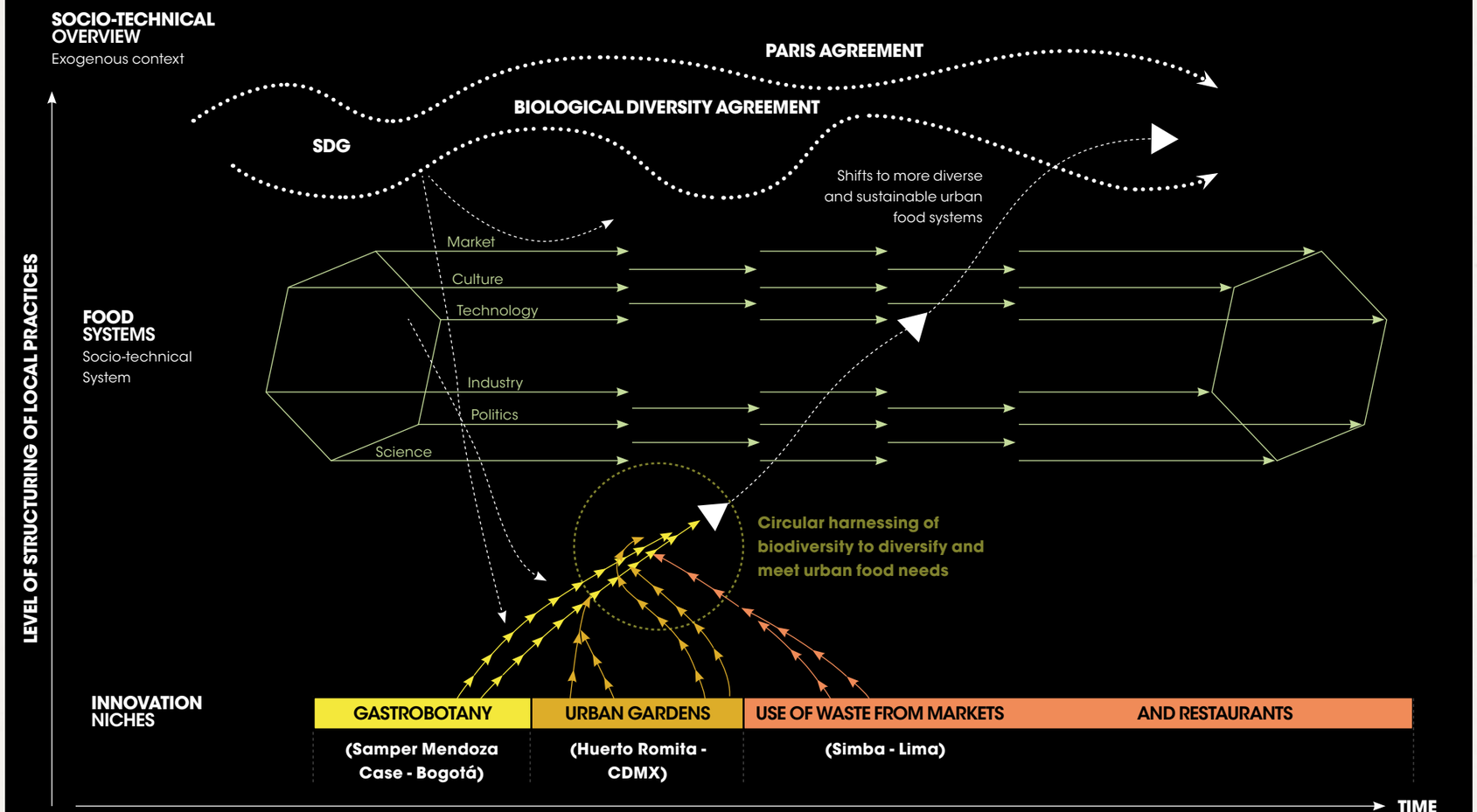


Figure 3. Multi-level perspective of changes in the urban food system related to sustainable economy in cities.



Source: Adapted from Geels (2011).

BIODIVERCITIES AS SPACES FOR TRANSFORMATIVE INNOVATION SYSTEMS

Advances in biological knowledge and technological development are essential for developing sustainable economies based on biodiversity, making it possible to achieve levels of competitiveness and productivity within ecological limits that ensure sustainability at different scales. This purpose implies that research and development are a pathway for generating value, wealth, and social equity and therefore frame these types of sustainable economies also in knowledge economies. In this way, the configuration of the territorial system of science, technology, and innovation is fundamental in determining the type of impulse that these types of economies will have in a BiodiverCity.

Three frameworks have been described to determine science, technology, and innovation policies. The first seeks to institutionalize government support for R&D to contribute to economic growth, prioritizing the competitiveness of the productive sector. The second also emphasizes competitiveness and focuses on creating linkages, clusters, and networks that stimulate learning and facilitate entrepreneurship. Finally, the third framework calls for transformative change, proposing that innovation should be directed to respond to social and environmental challenges (Schot and Steinmueller, 2018). This last framework highlights that research efforts should focus on the production of academic knowledge and incorporate bottom-up strategies to generate transformations in line with the different regional contexts (Schot et al., 2020). This indicates a scope beyond increases in competitiveness and productivity of the economic apparatus and points to higher purposes such as social justice and equity, poverty reduction, combating climate change, and generating returns to conservation and well-being.

Therefore, urban-rural territorial systems of innovation that consider the principles of transformative innovation make it possible to reconfigure socio-technical systems to perform essential functions for society. To this extent, it is necessary to consider the distinctive features of the territory and efficiently manage biodiversity as an opportunity to achieve goals associated with socio-ecological sustainability.

Figure 3 proposes an example of how this transformative innovation approach could influence changes in socio-technical systems to move towards sustainable economies in a BiodiverCity. In a multi-level analysis of urban food systems, it is identified that, given the pressures of the environment, networks of actors begin to generate innovations related to the provision of products and associated services (e.g., through the development of gastro-botanical prototypes). This is linked to the creation of urban gardens and the circular use of waste to generate value-added products through bioprospecting, which provide economic opportunities to different sectors under sustainability principles and end up guiding changes in this socio-technical system and the associated socio-ecological system.

KEY MESSAGES

➔ **Cities must be spaces for innovation.** Urban-rural environments are conducive to developing innovations of all kinds, taking into account all their relationships and interdependencies, in order to move towards sustainable economies based on biodiversity knowledge. Examples of these developments are the circular bioeconomy, nature-based economies, and biomimicry, as they are transversal to all economic and industrial activities.

➔ **Sustainable urban economies must be based on R&D&I processes.** The transition of cities towards sustainability will imply intensifying efforts in these three dimensions within a framework in which not only competitiveness is sought but also the consideration that these processes must provide answers to significant urban social and environmental challenges (transformative changes and transformative innovation).

➔ **Indicators of the state of biodiversity are required as key variables for measuring the sustainable development of cities.** Indicators make it possible to monitor and analyze the stock and flow of natural capital and its benefits to integrated urban management, facilitating the creation of more adaptive and evidence-based policies.

➔ **Sustainable economies based on knowledge of biodiversity must be promoted.** Policies that consider the spatial relationships of cities with their socio-economic and socio-ecological dynamics, promoting models of multi-level governance, market regulation, biointensification and environmental accounting, with principles of social justice and equity are required.

➔ **Socio-economic developments in cities must abandon the source-sink and degradation of nature model.** Cities should not only respond to a logic of source of resources for their development and subsequent waste sink but should also generate positive returns to nature conservation, climate change mitigation and adaptation, and human well-being.