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Cities of the future: an integration of climate resilience, urban ecology, and energy justice

Cidades do futuro: uma integração entre resiliência climática, ecologia urbana e justiça energética

Ciudades del futuro: una integración entre resiliencia climática, ecología urbana y justicia energética

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Abstract

Climate change and its negative effects on urban spaces (intense rainfall, floods, flash floods, heat islands and heat waves, landslides, prolonged droughts, among others) are among the greatest challenges cities already have to face, and the outlook indicates that these situations will become increasingly recurrent and intense. In this context, this article aims to propose an analysis of the process of building urban resilience, that is, it examines how cities are preparing to face and recover from the negative effects of climate change, through the processes of integrating Nature-based Solutions (NbS) into urban planning and the necessary just energy transition. The methodology used is deductive and was developed through a literature review. It is possible to conclude that, in order to make the resilience of present or future cities viable, their growth process must be planned (land-use regulation and urban planning), integrating and respecting natural flows (NbS), as well as changing the way energy is produced and distributed, so as to replace non-renewable energy sources with renewable ones.

Keywords: climate adaptation; nature-based solutions; urban resilience; climate justice; just energy transition.

Resumo

As mudanças climáticas e seus efeitos negativos nos espaços urbanos (chuvas intensas, enchentes, enxurradas, ilhas e ondas de calor, deslizamentos, estiagens prolongadas, entre outras) são um dos maiores desafios que as cidades já têm que enfrentar, e o prognóstico indica que essas situações serão cada vez mais recorrentes e intensas. Nesse contexto, o presente artigo tem como objetivo propor uma análise do processo de construção de resiliência urbana, ou seja, observa a preparação das cidades para enfrentar e se recuperar dos efeitos negativos das mudanças climáticas, por meio dos processos de integração no planejamento urbano das Soluções Baseadas na Natureza (SbN) e da necessária transição energética justa. A metodologia utilizada é dedutiva e foi desenvolvida por meio de revisão bibliográfica. É possível concluir que, para viabilizar a resiliência das cidades do presente ou do futuro, deve-se planejar o seu processo de crescimento (regulação do uso do solo e planejamento urbano), integrando e respeitando os fluxos naturais (SbNs), bem como mudando a forma de produção e distribuição de energia, de modo a substituir as fontes de energia não renováveis por fontes renováveis.

Palavras-chave: adaptação climática; soluções baseadas na natureza; resiliência urbana; justiça climática; transição energética justa.

Resumen

El cambio climático y sus efectos negativos en los espacios urbanos (lluvias intensas, inundaciones, crecidas repentinas, islas y olas de calor, deslizamientos de tierra, sequías prolongadas, entre otros) constituyen uno de los mayores desafíos que las ciudades ya tienen que afrontar, y las previsiones indican que estas situaciones serán cada vez más recurrentes e intensas. En este contexto, el presente artículo tiene como objetivo proponer un análisis del proceso de construcción de la resiliencia urbana, es decir, examina la preparación de las ciudades para afrontar y recuperarse de los efectos negativos del cambio climático mediante los procesos de integración, en la planificación urbana, de las Soluciones basadas en la Naturaleza (SbN) y de la necesaria transición energética justa. La metodología utilizada es deductiva y se desarrolló mediante una revisión bibliográfica. Es posible concluir que, para hacer viable la resiliencia de las ciudades del presente o del futuro, es necesario planificar su proceso de crecimiento (regulación del uso del suelo y planificación urbana), integrando y respetando los flujos naturales (SbN), así como modificando la forma de producción y distribución de la energía, de manera que se sustituyan las fuentes de energía no renovables por fuentes renovables.

Palabras clave: adaptación climática; soluciones basadas en la naturaleza; resiliencia urbana; justicia climática; transición energética justa.

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1 Introduction¹

Global warming, the main cause of the climate change that contemporary society is experiencing, has produced negative effects that profoundly impact people's lives in the urban environment. Floods, flooding, landslides, flash floods, heat islands and heat waves, and prolonged droughts, for example, are some of these effects, which tend to intensify if the pace of warming is not curbed.

In this scenario, urban areas face a dual challenge: at the same time as they suffer the adverse impacts that compromise essential infrastructure and human health, they act as active agents in the process of global warming, through the burning of fossil fuels and energy generation. It is in light of this reality that it becomes necessary to rethink the urban environment in order to make it resilient and climate-adapted.

The central problem of this research lies in the need to understand how the process of building urban resilience can be carried out through the integration of different strategies into urban planning. The aim is to demonstrate that urban climate adaptation, Nature-based Solutions (NbS), and just energy transition are not isolated elements; on the contrary, they act interdependently and mutually reinforce the construction of cities that are effectively sustainable, just, and climate-adapted.

The article proposes to demonstrate the existence of an international and domestic urban legal framework guiding climate adaptation through Nature-based Solutions (NbS). Moreover, it advances beyond studies already carried out, which focus only on the biological aspects of NbS or the economic aspect of just energy transition, by demonstrating that the regulation of urban land use is the legal-urbanistic instrument capable of giving concrete effect to the abstract legal norms that mandate adaptation to climate change.

This research used a deductive methodology, starting from global research and standards on the climate crisis in order to make it possible to understand the specificity of legal-urbanistic regulation within the national legal system. The research was developed based on two articulated dimensions: the literature review and the analysis of legal documents.

The literature review sought to identify works addressing the concepts of urban resilience, urban ecology, Nature-based Solutions (NbS), and energy justice. The selected articles were collected through searches carried out on *Google Scholar* and on the SciELO platform. It should be noted that the research keywords were: urban resilience, nature-based solutions, and just energy transition.

In addition to the search carried out in the aforementioned databases, the reports produced by the Intergovernmental Panel on Climate Change (IPCC) were analyzed, especially the AR5 and AR6 Assessment Reports, along with the international climate milestones, the New Urban Agenda/Habitat III and the Paris Agreement. At the domestic level, the legislation that implemented the National Policy on Climate Change was analyzed, namely Law No. 12,187/2009 and its recent amendments, the Resilient Green Cities Program, and the 2024-2035 Climate Plan.

As for its structure, the article is divided into three main parts: the first discusses urban climate resilience and adaptation, analyzing the scientific evidence on global warming and the role of cities within international frameworks for climate action. The second topic will address Nature-based Solutions (NbS), considering the focus on urban ecology and green infrastructure as pathways for reconnecting cities with natural flows.

Finally, the last topic will discuss the need to replace non-renewable energy sources with renewable energy sources, in light of socioeconomic inequalities and the role of urban land-use regulation in this process. Throughout the research, the aim is to demonstrate the need to transform the process of city-building, so that natural flows are respected while also contributing to the reduction of greenhouse gas emissions. In addition, it reflects on how this dynamic can be incorporated into the urban planning process.

The authors declare that they did not use generative Artificial Intelligence (AI) tools at any stage of the production of this manuscript.

2 Urban climate resilience and adaptation as key elements for the development of cities

Since 1988, the Intergovernmental Panel on Climate Change (IPCC) has been gathering global studies on the causes of climate change, synthesizing them into periodic reports on the subject. In its latest synthesis report

¹ This work was conducted with the support of Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

(IPCC, 2023), the body states, with scientific confidence, that “human activities, principally through emissions of greenhouse gases (GHG), have unequivocally caused global warming.”²

Global warming is characterized by an increase in the Earth’s temperature above pre-industrial levels. From this perspective, it has been identified that human activities have caused global temperature to rise by approximately 1.0°C above the levels prior to the First Industrial Revolution (1760). The projection is that this temperature rise will reach 1.5°C between 2030 and 2052, should the increase in GHG emissions follow current trends (IPCC, 2019). With the rapid growth of emissions since 1850 and, consequently, of temperature, contemporary society faces, increasingly often, the adverse impacts of climate change.

Studies show that the rise in the Earth’s average temperature causes “widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere” (IPCC, 2023, p. 21). This climate change, “caused by human activity, is already affecting many climate and weather extremes in every region across the globe” (IPCC, 2023, p. 21). As a result, there are widespread negative impacts, with losses and damage to nature and to people, especially to communities in situations of vulnerability.

Some of these impacts associated with climate change are: an increase in average temperature in most regions of the planet, including the oceans; extreme heat in most inhabited regions; an increase in the occurrence of extreme rainfall in different regions; and an increased probability of droughts and lack of rainfall in many regions (IPCC, 2019). Also worth noting are the rise in sea levels, which places small islands and coastal zones at risk, as well as acidification and the decrease in oxygen levels, which compromise marine life. On land, in general, one can point to “impacts on biodiversity and ecosystems, including species loss and extinction” (IPCC, 2019, p. 11).

Climate change negatively impacts “health, livelihoods, food security, water supply, human security, and economic growth” (IPCC, 2019, p. 12). Thus, the impacts of climate change on urban spaces impose challenges such as: heat islands, extreme events (intense rainfall and droughts, for example), degradation of air and water quality, in addition to impacts on public health and the economy.

In urban areas, climate change has caused adverse impacts on human health, livelihoods, and essential infrastructure. Notably, high temperatures have intensified in cities. Urban infrastructure, such as transportation, water, sanitation, and energy systems, has been compromised by extreme and slow-onset events, resulting in economic losses, service disruptions, and negative impacts on well-being. Adverse impacts are concentrated among economically and socially marginalized urban residents (IPCC, 2023).

Cities, in this scenario, face a dual challenge in relation to climate change. On the one hand, they must confront the adversities caused by climate change, as shown above; on the other, they must constitute themselves as active “agents” in this process. The human actions responsible for the increase in greenhouse gas emissions, the main cause of global warming and systemic changes in the climate, are carried out especially in cities: “extraction and burning of fossil fuels, such as coal, oil and natural gas; power generation; transportation of people and goods; the production of food and goods; heating” (Itaipu, 2024, p. 12).

It is in this context that the need for adaptation and resilience strategies emerges, as means of confronting and minimizing the negative impacts of these changes. Thus, the climate issue requires that the urban environment be climate-adapted, developing urban resilience, which consists in the capacity to withstand extreme events; “this resilience should not be limited to recovery after disasters (intense rainfall or flooding, for example), but should also involve the ‘capacity to avoid or minimize the need for recovery and the capacity to resist unexpected and unpredictable changes’” (Field, 2014, p. 548).

In March 2014, the IPCC published its Fifth Assessment Report (AR5) and, among the topics discussed, Chapter 8 is devoted to urban areas, pointing to conclusions that were reaffirmed in later reports. In the urban environment, climate change fosters scenarios that may include an increase in the occurrence of hot days and periods of intense heat that will intensify the effects of urban heat islands, causing heat-related health problems. In addition, there is a possible increase in air pollution and in energy consumption, due to the demand for cooling during periods of heat (Field, 2014, p. 554).

The conclusions presented within the scope of the IPCC were observed in the process of drafting the New Urban Agenda, prepared under the United Nations Conference on Housing and Sustainable Urban Development (Habitat III), held in Quito, Ecuador, in 2016. The process of drafting the New Urban Agenda (NUA) reflects a process

² For the purposes of this article, all direct quotations from the original sources have been translated into English.

of consolidation of the Right to the City at the international level and, although the text cites the concept only once, it is possible to conclude that it constitutes the central core of the document (Alfonsin *et al.*, 2017).

However, despite the centrality of this unequal process of space production and the commodification of urban land, the climate issue already appears in the document's initial considerations, particularly in the recognition of the advances achieved under the Paris Agreement (2017). Moreover, the document presents, as one of its commitments, international climate action, which encompasses local and subnational mitigation and adaptation actions, with a guideline to "support resilience-building and greenhouse gas emission reduction in all relevant sectors" (UN, 2016, p. 79).

The vision of the city of the future built into the document shows concern for urban climate risks, particularly for disasters and urban vulnerability. In this sense, the text recognizes the need to develop resilience and the capacity to respond both to risks arising from nature and to those arising from human actions, through the mitigation of greenhouse gas emissions and the adaptation of cities to the climate change already underway (UN, 2016).

Mitigation and adaptation constitute foundational dimensions of the New Urban Agenda. They result from the need to ensure urban environmental sustainability, as well as the promotion of the use of clean energy and the sustainable use of resources, the protection of biodiversity, and the promotion of "sustainable consumption and production patterns" (UN, 2016, p. 8).

Thus, it is possible to see that, in addition to the construction of a city designed around the concept of the Right to the City, the mitigation of greenhouse gas emissions and adaptation to the changes already underway were points already recognized as important since 2016, with the approval of the New Urban Agenda. The process of concern with the climate issue in the urban environment, therefore, appears in these documents as the result of a discussion process that was underway in different international bodies.

Climate change and its consequences, especially the negative ones, have been the object of international attention since 1988, with the creation of the IPCC. With the deepening of research and the establishment of the link between greenhouse gas emissions, global warming, and climate change, as well as the intensification of extreme climate events, the need emerges to confront the prevailing pattern and logic of urban development.

At the domestic level, since 2009, Brazil has had specific legislation on the subject, Law No. 12,187, of December 29, 2009, which establishes the so-called National Policy on Climate Change. This law sets out the main concepts of adaptation³, mitigation⁴, adverse effects of climate change⁵, among others, in addition to the State's responsibility to reduce the impacts of human actions on the climate system, as well as to adopt measures "to foresee, avoid, or minimize the identified anthropogenic causes of climate change within the national territory" (Brasil, 2009, p. 1).

In line with the increasingly evident need for climate adaptation, in June 2024 the aforementioned legislation was updated through Law No. 14,904, which establishes guidelines for the preparation of climate change adaptation plans, which must integrate different levels of administration: local, municipal, state, regional, and national (Brasil, 2024b). Concern for the urban environment appears explicitly in the legislation, specifically when it defines that climate adaptation plans must provide for strategies primarily in the areas of "urban infrastructure and the right to the city" (Brasil, 2024b, p. 2).

Two points deserve to be highlighted in this legislation. The first relates to the inclusion of Nature-based Solutions (NbS) in its guidelines. Thus, article 2, item VII, provides for the "adoption of nature-based solutions as part of adaptation strategies, considering their additional benefits and their capacity to simultaneously integrate adaptation and mitigation outcomes" (Brasil, 2024b, p. 1).

The second point consists in the dialogue between Nature-based Solutions (NbS) and nature-based infrastructure:

[...] which uses elements of nature to provide services relevant to adapting to the consequences of climate change, with a view to creating resilience and protecting the population, property, and an ecologically balanced environment, in a sustainable manner, with the possibility of simultaneously integrating climate change adaptation and mitigation actions (Brasil, 2024b, p. 2).

³ Art. 2 [...] I - adaptation: initiatives and measures to reduce the vulnerability of natural and human systems to the current and expected effects of climate change (Brasil, 2009, p. 1);

⁴ Art. 2 [...] VII - mitigation: technological changes and substitutions that reduce the use of resources and emissions per unit of output, as well as the implementation of measures that reduce greenhouse gas emissions and increase sinks (Brasil, 2009, p. 1);

⁵ Art. 2 [...] - adverse effects of climate change: changes in the physical environment or biota resulting from climate change that have significant deleterious effects on the composition, resilience, or productivity of natural and managed ecosystems, on the functioning of socioeconomic systems, or on human health and well-being (Brasil, 2009, p. 1).

From the analysis of the legislation and its aforementioned update, the Brazilian legal system clearly incorporates Nature-based Solutions (NbS) as strategies that must be used for the mitigation of, and adaptation to, the adverse effects of climate change. This incorporation becomes even more evident when one analyzes the 2024-2035 Climate Plan, as well as the Resilient Green Cities Program, which will be analyzed more specifically below.

On the international scene, the discussions and advances achieved within the Conference of the Parties – COP 30, held in Belém, Brazil, in 2025²⁰, stand out. COP 30 moves forward in bringing instruments that concretely materialize the abstract promise of adaptation, such as the Global Implementation Accelerator. The accelerator is a collaborative and voluntary initiative, “to support countries in implementing their Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs), prioritizing actions with the greatest potential for rapid, large-scale impact” (Brasil, 2026b, p. 66).

In addition to the accelerator, COP 30 approved other important mechanisms in the field of urban climate adaptation: the Belém Adaptation Indicators. These constitute a set of indicators that will make it possible to “monitor progress on all GGA targets and will give policymakers better tools to guide adaptation actions” (Brasil, 2026b, p. 64).

In general, domestic and international legislation establishes instruments, mechanisms, and indicators that set abstract adaptation and mitigation objectives in the face of climate change and the evolution of the Brazilian legal system, imposing the challenge of converting abstract normative provisions into concrete territorial interventions. In this context, master plans and local urban legislation face provisions that bind them to the climate issue and to the need to break with the way cities are built, so that the climate variable is taken into account in how urban land is used.

As will be observed, this shift can be materialized through overcoming the paradigm of contemporary cities, founded on a traditional model of commodifying and impermeabilizing infrastructure, toward a model of the city that combines urbanization with the flows of nature. It is at this intersection between climate adaptation norms and concrete intervention in urban land that Nature-based Solutions (NbS) emerge, a concept that brings together the elements needed to rethink urban space.

3 Nature-based Solutions (NbS) and the rethinking of urban space

In the context of the need to adapt to climate change and in the pursuit of promoting urban sustainability, Nature-based Solutions (NbS) gained traction in Europe at the end of the 2000s, as they were disseminated by the International Union for Conservation of Nature (IUCN) and by the World Bank (Fraga; Sayago, 2020).

It is important to mention that Nature-based Solutions (NbS) constitute strategies that “in some way, were inspired by, copied, or based on natural processes to generate social, environmental, and economic benefits for society” (Fraga; Sayago, 2020, p. 68). The concept has several meanings, but functions as an umbrella idea, since it represents:

actions to protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges (such as climate change, food and water security, or natural disasters) effectively and adaptively, simultaneously providing benefits for human well-being and biodiversity (Cohen-Shacham *et al.*, 2016, p. xii, our translation).

Although the concept gained ground at the end of the 2000s, Cecília Herzog (2013) shows that reflection on the construction of urban spaces coordinated by ecological dynamics is older. The author points out that, in 1969, the book “*Design with Nature*” brought visibility to the technique of ecological planning, which integrates different layers (geological, hydrological, and topographic maps, as well as land use and occupation), so as to make it possible to understand “the natural processes and flows that occur in the landscape of each place and the forms of occupation in harmony with nature” (Herzog, 2013, p. 107).

In this sense, the author states that urban ecology functions as a mechanism that enables a better understanding of the relationship between nature and people; thus, “cities came to be understood as complex socio-ecological systems in which nature exists in the places we least imagine, but influences us all the time” (Herzog, 2013, p. 109). From this perspective, the concept of Nature-based Solutions (NbS) is not yet present in the text, but the author already points to another interrelated concept: that of green infrastructure.

Green infrastructure, also called ecological infrastructure:

consists in planning, designing, and managing new and existing buildings and infrastructure so as to transform them into multifunctional spaces - which are part of an interconnected network of vegetated or

permeable fragments, connected by green and blue corridors, in which biodiversity protects and improves water quality, aiming to restructure the landscape mosaic across multiple scales (Herzog, 2013, p. 111).

It is at this point that the concepts converge, since today green corridors are classified as Nature-based Solutions (NbS), among other strategies inspired by nature to promote ecosystem benefits (ecosystem services), such as: “urban green areas, rain gardens, constructed wetlands, green roofs, and urban agriculture” (Fraga; Sayago, 2020, p. 68). These benefits, when implemented in cities, allow for the reduction of urban vulnerability to the negative impacts of climate change.

In general, the benefits can be divided into four groups: (1) provisioning services, which encompass food (marine and terrestrial agrosystems provide food), raw materials (timber, biofuels, and derivatives), and water (flow control, storage, and purification); (2) regulating services, which cover climate and air quality (tree cover, parks, and green areas help reduce heat in cities and influence rainfall dynamics and air purification), carbon sequestration (green areas capture and store carbon dioxide from the atmosphere), and moderation of extreme weather events (urban vegetation helps cushion natural disasters); (3) cultural services, which encompass recreation and health (green areas, such as parks and constructed wetlands, function, during dry periods, as leisure and sports environments); tourism (restoration of ecosystems and biodiversity, which can be a source of economic benefits) and spiritual experience (nature constitutes a spiritual element in various communities and traditional practices); and (4) supporting services, which encompass *habitats* for species (green areas constitute *habitat* for various species, enabling the life cycle of many species), and maintenance of genetic diversity (contributes to the base of diverse crops with genetic variability) (Evers *et al.*, 2022).

Each of these mechanisms must be shaped locally, according to the specificities of each situation, integrated into long-term urban planning. Many of these strategies take natural hydrological cycles into account and contribute, distinctly and/or in combination, to confronting the main challenges posed by global warming.

Historically, one observes the need for transformation, so that the human gaze turns toward nature:

Among the Greeks, Nature was a concept used to construct, expose, and justify political-social realities [...]. Humanity, in search of new paths, turns to the observation of the natural world to draw from it conclusions that justify its aspirations for change and social transformation (Antunes, 2002, p. 27).

But it is in Henry David Thoreau, considered the father of modern ecological thought, that one finds one of the greatest inspirations for environmental defense movements (modern environmentalism) and for this return of the gaze toward nature and its flows (Antunes, 2002).

Thoreau's main reference work is the book “Walden; or, Life in the Woods.” Originally published in 1854, the book “is a watershed, since long before ecological movements began to emerge, Thoreau was already preaching a life in harmony with the earth, affirming the need to change the relationship that the people of his time had with nature” (Rocha, 2018, p. 69).

Contrary to the argument that Thoreau rejected urban life by taking refuge near Walden Pond, in the rural area of the town of Concord, “Thoreau and his works serve to place him in the position that rightfully belongs to him, that of an urban thinker who seeks to reflect on nature with a view to drawing consequences applicable to his own world” (Antunes, 2002, p. 40).

Thoreau's work should be read as a whole and represents a critique of the frenetic pace of the society of his time: “artificial worries, superficially harsh tasks, which cannot reap the tastiest fruits of life, and the fact that individuals scorn leisure in the schizophrenic pursuit of work and the accumulation of capital and property” (Rocha, 2018, p. 70). Thus, for the author, there was a disregard for biological, natural, and environmental aspects.

According to Thoreau, it is in nature that human beings can most fully observe “difference, multiplicity, the diversity of forms” (Antunes, 2002, p. 40) and perceive freedom as the guiding thread of his thought. Thus, it is possible to observe, in the author, the same dynamic proposed when one speaks of Nature-based Solutions (NbS) as mechanisms for confronting climate change, since Thoreau, like the Greeks, “used nature as a paradigm for the transformations he wished to see implemented in pursuit of his utopia” (Antunes, 2002, p. 41).

Thus, Thoreau's work inspires an urbanism that integrates nature, a “return to the simple [...] back to nature,” into community life, not merely as a service, but as an element intrinsic to quality of life and well-being (Rocha, 2018, p. 73). This highlights the importance of cultivating environmental awareness among citizens for the effective implementation and appreciation of NbS.

In line with the needs of climate adaptation, Brazilian legislation, in June 2024, established, through Law No. 12,041, the Resilient Green Cities Program, which has the objective of:

increasing the environmental quality and resilience of Brazilian cities in the face of impacts caused by climate change, through the integration of urban, environmental, and climate policies, the promotion of sustainable practices, and the appreciation of the ecosystem services of urban greenery (Brasil, 2024a, p. 1).

The program focuses on the urban environment and the enhancement of ecosystem services in cities, the proposal of guiding parameters for sustainable and resilient urban-environmental planning and management, as well as the strengthening of federative entities in adopting climate change mitigation and adaptation measures in urban areas (Brasil, 2024a).

Ordinance GM/MMA No. 1,256, of December 26, 2024, establishes the initiative to support the preparation of Municipal Climate Change Adaptation Plans - Adapta Cidades, "with the aim of supporting states and municipalities in developing local or regional climate change adaptation strategies and plans, within the scope of the Resilient Green Cities Program" (Brasil, 2024c, p. 1). In this way, it evidences the deep connection between urban climate resilience and urban planning.

As can be seen, 2024 was a very significant year with regard to the enactment of laws aimed at regulating the preparation of climate change adaptation plans, as well as the development of programs aimed at building resilient cities. Following this process of drafting national guidelines for climate adaptation, in 2026 the Ministry of the Environment and Climate Change published the 2024-2035 Climate Plan (Brasil, 2026a).

The Climate Plan was approved by the Interministerial Committee on Climate Change (CIM), established in 2023, and the plan's updating process began in 2023, constituting it as an instrument of the National Policy on Climate Change, "to consolidate strategies, plans, and targets of the Federal Executive Branch, contributing to the Policy's objectives and to the achievement of the targets set out in the Nationally Determined Contribution (NDC), under the Paris Agreement" (Brasil, 2026a, p. 17).

The development of the Climate Plan involved broad social participation, engaging ministerial bodies, states, municipalities, civil society organizations, academic sectors, the private sector, and popular participation, and unfolded over approximately two years of work (Brasil, 2026a, p. 17). It is structured around three main pillars: 1) Greenhouse Gas Mitigation, made up of the national strategy and sectoral mitigation plans; 2) Climate Change Adaptation, also made up of a national strategy and sectoral and thematic adaptation plans; and 3) Cross-Cutting Strategies for Climate Action (Brasil, 2026a, p. 17).

One of the main aspects, for the purposes of this study, for developing environmental awareness and for respecting the natural flows proposed by NbS, is confronting the current energy matrix. For harmony with the Earth, as proposed by Thoreau, to be possible in the urban context, society must confront one of the roots of the climate crisis: dependence on fossil fuels for energy production. The energy issue and the need for a transition process that is just and inclusive appear in the Climate Plan, specifically in the "mitigation" pillar, in the "adaptation" pillar, and also in the "Cross-Cutting Measures for Climate Action" pillar, as will be further explored below.

4 Just and sustainable energy transition: the interaction between renewable sources and urban planning

The contemporary climate crisis does not result from a process that began in recent decades; on the contrary, it is the sum of years of greenhouse gas emissions, and, moreover, is rooted in the emergence of industrial society, which brought about a continuous and pronounced process of "alienation from the natural world" (Rocha, 2018, p. 75). Thoreau's critique of the social dynamics he experienced remains current, since society, throughout the 19th and 20th centuries and the beginning of the 21st century, became even more predatory, which is embodied in the climate-environmental crisis we are living through today (Rocha, 2018).

Therefore, the First Industrial Revolution marks an important analytical turning point on a global scale, since it represents the beginning of the use of combustion (the burning of coal) as the driving force of English industrial development, replacing the energy matrix that had depended on the climatic and biological cycles of ecosystems (Cardoso; Oliveira, 2023). The burning of coal predominated for approximately two centuries, until, in the mid-20th century, it was overtaken by the burning of oil (Ferreira; Furtado, 2024).

Today, science makes it possible to identify, through chemical analysis, that “the increase in CO² observed in the atmosphere is that resulting from the burning of fossil fuels, from the burning of forests. It is not that released when a volcano erupts” (Nobre; Reid; Veiga, 2012, p. 11). Thus, once it is established that the CO² accumulated in the atmosphere is the CO² produced by the burning of fossil fuels carried out through human activities, it is worth noting that the center of the debate lies in the way energy is produced, both for discussing the reduction of gas emissions (mitigation) and the transition to less polluting ways of producing energy:

The drastic reduction of greenhouse gas emissions and the energy transition are the main challenges of our time. This means a transition to a low-carbon economy, using renewable, clean, and efficient energy sources, such as solar, wind, hydroelectric, and biomass energy (Itaipu, 2024, p. 12).

Just as there was a profound shift in the energy matrix during the First Industrial Revolution, the emergence of climate issues and the advance of global warming have demanded an energy transition toward less polluting forms, in order to ensure long-term sustainability in cities. The beginning of the 2000s, the period in which Nature-based Solutions (NbS) emerged, also marks the exploration of new renewable energy sources (Ferreira; Furtado, 2024).

However, despite this exploration and the existence of a wide variety of renewable energy sources, “what is observed is that fossil fuels continue to play a prominent role in the world’s energy matrix” (Ferreira; Furtado, 2024, p. 7). This is because, given their formation dynamics, fossil fuels are classified as non-renewable sources, since their formation requires thousands or millions of years for accumulated organic material to transform into oil, natural gas, or coal (Ferreira; Furtado, 2024).

Thus, the contemporary dilemma is “ensuring the supply of human needs, present and future, while avoiding a global catastrophe” (Ferreira; Furtado, 2024, p. 13), whether due to the possible eventual depletion of fossil fuels, or due to the increase in global warming and the cascading negative effects of climate change.

In this sense, confronting these issues involves the need for: 1) reducing the consumption of non-renewable energy sources; 2) the gradual, constant, and broad replacement of non-renewable sources with renewable ones, such as: wind, hydro, solar, and biofuel (Ferreira; Furtado, 2024, p. 14). This process is called energy transition.

However, the discussion cannot be limited to changing the energy matrix. This change must take into account the inequalities, especially the economic ones, that permeate capitalist society. Energy transition alone is not enough; it must be just and sustainable, “understood in a multifaceted way, taking into account political and social factors, in addition to technological components” (Brumatti; Chaves; Siman, 2024, p. 232).

Thus, for this process to actually be based on environmental, financial, and social sustainability, certain paradigms must be incorporated and associated with the process of developing public policies aimed at energy transition. Based on a literature review of research that attempts to outline what the guiding principles of a just energy transition would be, Brumatti, Chaves, Siman (2024) synthesize the research found into 10 (ten) key principles, which should guide actions aimed at implementing a just energy transition.

The ten principles are: 1) Accessibility; 2) Investments, lines of credit, and tax incentives; 3) Environmental sustainability; 4) Financial sustainability; 5) Employability, labor relations, and workforce training; 6) Policies; 7) International coordination; 8) Reliability and diversified energy supply; 9) Civil society; and 10) Successful interventions (Brumatti; Chaves; Siman, 2024).

The first principle, accessibility, translates into the need for States to focus efforts on promoting universal access to energy. The second principle relates to investments made by the State itself; thus, these investments should promote broad action, encompassing the energy sector, the opening of lines of credit, tax incentives for research, subsidy policies, among others. The third principle, environmental sustainability, should be a priority in all countries, especially those that emit the most greenhouse gases (GHG), promoting a transition to renewable energy. In addition to environmental sustainability, financial sustainability (fourth principle) consists in the necessary planning of the transition, with an assessment of economic impacts, costs, risks, and benefits (Brumatti; Chaves; Siman, 2024).

Considering the centrality that fossil energy sources still occupy in the energy production process, the employability, allocation, and training of workers in these sectors must be part of the process (fifth principle). In addition, public policies must be directed toward the sector and must consider the needs of economic development and societal well-being (sixth principle). Internationally, the role of the United Nations (UN) should be to guide and lead countries in working together toward zero carbon emissions (seventh principle). Countries must be able to meet their energy needs without seasonal climate disruptions and, accordingly, must develop a reliable structure, with a diversified energy supply (eighth principle) (Brumatti; Chaves; Siman, 2024).

Civil society (ninth principle) must be guaranteed democratic participation, including indigenous communities and others in situations of vulnerability, in the process of planning and implementing the energy transition. Finally, successful actions by other states (tenth principle) should serve as examples, with due adjustments made to local needs (Brumatti; Chaves; Siman, 2024). Building on these fundamental principles of the transition process, it is also essential to understand that the dichotomy between city *versus* and nature does not exist, given that “cities are, in fact, processed nature” (Scarpacci, 2023, p. 35).

From this perspective, energy transition can be understood as one of the central pillars of the process of building a sustainable city. The Climate Plan itself declares that its general objective is:

To guide, promote, implement, and monitor coordinated actions aimed at the transition to an economy with net-zero greenhouse gas emissions by 2050 and at the adaptation of human and natural systems to climate change, through short, medium, and long-term strategies, in light of sustainable development and climate justice (Brasil, 2026a, p. 75).

Thus, the energy transition process, to be truly just, must understand urban space as an important space for the realization of a just energy transition. Service infrastructures, whatever they may be (transportation, drinking water, energy, waste, internet etc.), have the capacity to democratize social space and, therefore, to produce a dignified contemporary life for those who can access the services they offer” (Scarpacci, 2023, p. 36).

The centrality of urban space in the just transition process becomes evident when the Climate Plan, in addition to establishing a national strategy for both mitigation and adaptation, unfolds into sectoral and thematic plans: agriculture, family farming, biodiversity, cities, energy, racial equality and combating racism, industry and mining, ocean and coastal zones, traditional peoples and communities, indigenous peoples, water resources, health, food and nutritional security, transportation, and tourism (Brasil, 2026a). Although there is a specific sectoral plan for cities, the other themes and sectors can, and should, be considered in a cross-cutting way within the urban environment.

Therefore, the entire process of urbanization and regulation of urban land use must be rethought and directed toward respecting natural flows. This depends on a just energy transition process, as well as on the implementation of planning, drawn up on the basis of the general guidelines set out in the Climate Plan, and on the use of legal-urbanistic instruments regulating urban land use, such as the land use and occupation law.

An important example of integration between the city and energy transition is the use and dissemination of photovoltaic energy. Given the country’s energy potential (incidence of sunlight), Bastian (2024) researched the master plans of eight state capitals (Fortaleza, Natal, Salvador, Cuiabá, Rio de Janeiro, São Paulo, Curitiba, and Florianópolis) and of Brasília, seeking to identify how urban planning regulations are incorporating photovoltaic solar energy (Bastian, 2024).

The author also presents international experiences of how photovoltaic energy has been incorporated into urban planning in cities such as San Francisco, in the United States, Copenhagen, in Denmark, and Berlin and Munich, in Germany. In addition, she highlights how the incorporation of these initiatives demonstrates “a growing trend of sustainable urbanism, in which the integration of photovoltaic solar technology plays a crucial role in reducing the carbon footprint and promoting more resilient and self-sufficient communities” (Bastian, 2024, p. 144).

Taking these experiences as a guiding thread, the author seeks, based on article 1 of the City Statute (Law No. 10,257/2001), which deals with guaranteeing the right to sustainable cities, to identify, in the master plans of the state capitals - the basic instruments of municipal urban planning - how they are integrating the use of renewable energy (Bastian, 2024).

The analysis of the legislation demonstrates an important point when it comes to planning cities and implementing urban sustainability strategies, whether Nature-based Solutions (NbS) or policies for implementing sustainable energy. It is not only the master plan that matters, but also the entire body of urban planning legislation (the master plan’s general law and the laws that complement it). Land-use regulation must be directed toward the same purpose. In this context, Salvador’s urban planning legislation stands out.

Salvador’s Master Plan, Law No. 9,069/2016, provides, as a general guideline, for the use of renewable energy. The Law on Land-Use and Occupation Planning (Law No. 9,148/2016), in addition, determines that “certain types of developments with more than 50 housing units must include measures aimed at environmental sustainability, especially through the use of solar energy with the installation of their own generation unit” (Bastian, 2024, p. 146). Other municipalities analyzed use tax incentive mechanisms to promote the use and/or production of renewable

energy, for example, the Green IPTU and the Yellow IPTU (Salvador), the Sustainable IPTU (Cuiabá), and BH Sustentável no IPTU (Belo Horizonte) (Bastian, 2024).

The conclusions indicate that, even in the face of a notable effort to incorporate the promotion and use of sustainable energy into the urban planning and development process, there is “a significant gap regarding the definition of specific urban parameters that would facilitate the effective implementation of photovoltaic energy generation technologies in buildings” (Bastian, 2024, p. 149).

Thus, just energy transition necessarily incorporates strategies that allow for the replacement of energy produced from non-renewable sources with energy produced from renewable sources (photovoltaic solar, wind, biomass, among others). However, the issue is not limited to energy replacement, consumption, and production, but also to the model of production and distribution adopted, which must consider the social and economic inequalities that mark capitalist society.

5 Concluding Remarks

This study has demonstrated that the use of Nature-based Solutions (NbS) should be understood as one of the pillars for achieving a just energy transition. These strategies are indispensable for building cities that are not only adapted to climate change (resilient), but that also thrive socially and economically. By mitigating economic inequalities and creating new opportunities, the integration of NbS reduces dependence on non-renewable energy sources, allowing urban resilience to be achieved more equitably.

For these objectives to be fully achieved, urban planning, at the local, regional, and national levels, must integrate climate adaptation and its instruments (NbS and just energy transition) systemically, avoiding the fragmentation of these dimensions. In this context, the city must indeed be understood as “processed nature” shaped by human labor and an integral part of a social ecosystem in which land-use regulation plays a decisive role in protecting natural flows.

The analysis of the urban planning regulations of some cities indicates that urban planning legislation, in regulating how the city will develop and in determining the construction standards for buildings, must incorporate building parameters aligned with addressing the negative effects of climate change. This thus evidences the overcoming of the fragmented view separating climate resilience, urban ecology, and energy justice, and the merging of these concepts under the umbrella of urban law.

The example of photovoltaic energy can be extended to other renewable sources and NbS. However, for this to be possible, just energy transition and the implementation of NbS must stand as the guiding pillars of the urban planning process and of the construction of sustainable, resilient, and climate-adapted cities.

Ultimately, the discussion carried out made it possible to understand that the sustainable and resilient city of the future requires a development model that replaces the predatory capitalist logic with respect for natural limits and flows. Urban law, through the regulation of urban land use, is the legal instrument that enables the operationalization and materialization of the climate variable in urban development.

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