Special Issue Future of Smart Cities

FUORI LUOGO

Rivista di Sociologia
del Territorio, Turismo, Tecnologia

Guest Editors
Monica Bernardi
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Alessandra Landi, Tommaso Rimondi [1]

Investigating urban inequalities in a climate crisis scenario: the contribution of Big Data to environmental justice studies[2]

Introduction

The foundation of this paper lies in the notion that cities serve as a pivotal "battlefield" in confronting contemporary environmental challenges. Climate change poses significative threats for urban landscapes and communities living in urban space. On the one hand, today's challenges have significant continuities with classical urban issues: cities have always been spaces of conflicts, contradictions, inequalities. Environmental issues represent one of the many stressors of urban dynamics; conflicts on the locations of polluting sites, for example, have developed over the last fifty years, intertwined with segregation and discrimination processes. On the other hand, environmental policies, framed as "sustainability policies", often contribute to reproducing or generating urban inequalities, shaping an unjust transitions.

In this paper, these two aspects are analysed within the environmental justice framework, favouring a socio-spatial perspective: risks associated with climate change are not "the same for everyone", in every place and time, contingent on a multitude of contextual factors. Moreover, the paper also explores how sustainability urban policies can yield secondary effects on the socio-spatial dimensions of climate and environmental justice.

Furthermore, research in the field of the so-called "new orthodoxy of green planning" (Connolly, 2019) highlights an unequal distribution of climate "goods" and "bads"; such orthodoxy is rooted in an entrepreneurial perspective, drawing on the contemporary narrative of ecological modernization which describes a vision of ecologically and socially responsible urban development and a technocratic and politically neutral approach to the resolution of environmental problems (Cucca, 2020). However, the "acritical" approach to sustainability and sustainable urban development is not able to recognize the contradiction implicit in its own premise: «that we can stimulate economic growth while mitigating the effects of climate change, without any sacrifice» (Checker, 2020). The spatial effects of urban strategies (e.g., urban greening, resilience planning) become evident in terms of exclusion, marginalization, or displacement of low-income residents. Such geographies of injustice often reflect the uneven distribution of population and social groups in urban spaces due to economic and social processes such as residential segregation and spatial concentration of poverty.

The investigation of the social and spatial structure of the city and the inequalities within it, from a climate justice perspective, has made wide use of the classic sociology toolbox, using both quantitative (census, official statistics, surveys) and qualitative (interviews, participant observation, newspapers, archival) data, at times integrated with GIS techniques of mapping and spatial analysis. As many scholars emphasized, Big Data should be seen as complementary to the "small data" produced by more traditional methodologies, creating new opportunities for empirical research on new and "old" issues. Despite the increasing utilization of big data in sociological research, its application to combat environmental injustices has been relatively limited. Nevertheless, big data holds considerable promise as a research tool in this endeavor.

The purpose of this article is to show how these new tools offer innovative possibilities for empirical research at the micro-urban scale, crucial in the field of environmental and climate justice, for example, in the analysis of social inequalities related to spatial patterns of individuals and community, vulnerability to natural hazards, and displacement processes related to the impacts of disasters or driven by urban sustainability policies.

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In order to show the contribution of big data - and their fruitful integration with data produced from traditional empirical methods - the case of the Boston Area Research Initiative (BARI, https://cssh.northeastern.edu/bari/) will be presented and discussed. The BARI's example, in our opinion, not only demonstrates how new methods and tools can enrich social and urban research, and the fruitfulness of research practices characterized by their multidisciplinarity and the ability to make many urban actors work together, involving the community.
The paper is structured as follows: in the first part of the work, a literature review on environmental and climate justice studies is presented (par. 1), focusing on its lasting interest in spatial inequalities and discrimination processes (par. 2). In a climate crisis scenario, such perspective proves to be still valuable, permitting to deepen our understandings of vulnerabilities and recovery processes in the aftermath of disasters and climate change hazards. Vulnerability, the political and social condition that affects a community's ability to prepare, respond, cope, and recover from a hazardous event, is socially and spatially unevenly distributed, intertwined with a system of inequalities structured on several axes (e.g., race, class, and gender) (par. 2.1). In recent years, climate mitigation and adaptation strategies, as well as the resilience framework shaping urban planning, have emerged bringing with them both benefits and costs that may prove to be "unjust" in several ways (par. 2.3).
For the most part, in this article, the concept of resilience is read critically, underlining how a resilient socio-ecological system could legitimize, reproduce, and reinforce the status quo, widening pre-existing inequalities at the social and spatial level. Secondly, the risk for climate policies, or -more broadly- "sustainability" policies, can become drivers for new forms of inequalities. In this regard, the selected literature on "environmental", "green" or "climate" gentrification highlights the spatial dimension of environmental justice: some segments of the population are directly or indirectly unable to take advantage of certain environmental resources, infrastructures and services (e.g., regenerated areas, urban green spaces). Research on ecological gentrification shows the environmental disadvantage emerging in socio-spatial processes of exclusion, marginalization, and displacement - as well as the environmental privilege in terms of accessibility to greening developments for more affluent social groups (the "green space paradox", Wolch *et al.,* 2014).
Building on the literature review developed in spatial-oriented perspectives, the last section of this work (par. 3) is aimed to a) show/address the methodological contribution that the use of big data can provide to environmental and climate justice studies, thereby, improving the sociological understanding of socio-spatial dynamics within urban systems; b) illustrate how new analytical tools, such as Big Data or ecometrics, can be used to inform local policies and strengthen cooperation between activists, citizen, administrators, and academics in tackling inequalities within the urban fabric. For this purpose, the experience of the Boston Area Research initiative is presented as a significant research itinerary integrating data produced from traditional empirical methods, "ecometrics", big data, and administrative data - tools that, when applied, affirm the need to design place-based policies able to recognize and enhance contextual characteristics, moving away from a 'one-size-fits-all' approach.

1. The battlefield of environmental justice

Environmental justice originated in the 1970s within the United States, sparked by grassroots movements that sought to combat racial segregation and discrimination targeting minorities in American cities. Environmental issues were framed as part of the civil rights movement claims: activists realized, before social science scholars, that environmental "bads" distribution was spatially and socially uneven, disproportionately situated in black and low-income neighborhoods. Inequalities related to living conditions, as concerns, for example, different exposure to industrial pollution or different urban sanitation conditions, are not a novelty of the Twentieth Cen-

tury: as some authors note, the entirety of human history can be read from an environmental (in)justice perspective (Pellow, 2000). Already in pre-modern times, urban waste tended to be concentrated in neighborhoods inhabited by marginalized populations (Melosi, 2005), with this condition assuming unprecedented dimensions with the Industrial Revolution and contemporary, fast urbanization processes, causing a «tremendous environmental change in the cities» (*ibidem,* p.6). Friedrich Engels, in his inquiry into *The Condition of the Working Class in England*, remarked how the upper class used to live «in free, wholesome country air, in fine, comfortable homes,» far -also visually- from «the filth, ruin, and uninhabitableness, the defiance of all considerations of cleanliness, ventilation, and health» of Manchester working-class districts:

> «the members of this money aristocracy can take the shortest road through the middle of all the labouring districts to their places of business, without ever seeing that they are in the midst of the grimy misery that lurks to the right and the left. For the thoroughfares leading from the Exchange in all directions out of the city are lined, on both sides, with an almost unbroken series of shops, and are so kept in the hands of the middle and lower bourgeoisie, which, out of self-interest, cares for a decent and cleanly external appearance and can care for it.» (Engels, 1987).

Proximity to polluting industries, waste storage sites, and contaminated land has always been a "privilege" of the marginalized. Nonetheless, a significant turning point in the history of environmental justice emerged in relatively recent times when the ecological sensitivity that inspired early environmental groups merged with the demands of the civil rights movement. This step enabled overcoming the "elitism" that characterized early environmental movements, which primarily focused on wildlife preservation, resource conservation, and pollution reduction and were driven largely by white middle and upper classes, with significant economic, cultural, and social capital (Bullard, 2000).

In literature, the emergence of the environmental justice movement is attributed to two central events. The first, exemplifying the Anti-Toxic Movement (Brulle & Pellow, 2006), involved the mobilization of Love Canal citizens (Niagara Falls, New York State), during the late 1970s. The construction of several houses and a school near a massive toxic chemical landfill caused significant health damages for hundreds of residents. This disaster led to the evacuation of more than 800 families thanks to the mobilization of numerous community organizations and had major repercussions on political and public opinion (Armiero, 2017; Fletcher, 2003; Schlosberg, 2007). The second event, which «put 'environmental racism' on the map» (Bullard, 2001, p. 151), is the 1982 Warren County (North Carolina) protests. A coalition of citizens, civil rights activists, and environmentalists mobilized against the siting of a PCB (polychlorinated biphenyls) landfill in one of the state's poorest counties, two-thirds of which was inhabited by African Americans (Goldman, 1996; McGurty, 1997). The Warren County protest led to the first critical report on environmental equity and hazardous waste. In 1983, a survey conducted by the United States General Accounting Office in eight Southern states revealed that three out of four hazardous waste landfills were situated in predominantly African-American communities, despite African Americans comprising only 20 percent of the population in that region (Bullard, 2001). The Warren County mobilization is cited in literature as a 'watershed' event for the environmental justice movement, as it represents one of the earliest instances of collaboration between civil rights activists and environmentalists working together on shared concerns (Schlosberg, 2007).

Inspired by these social movements and in close connection with them, a composite academic environmental justice field has emerged, dealing with environmental risks at different spatial and temporal scales. Different disciplinary lenses have been involved (historical, sociological, geographical, politological), and different theoretical and methodological perspectives have been developed (Maung & Pellow, 2021). Environmental justice studies have shown the uneven distribution of causes and effects of pollution and other environmental risks on different class and ethnic/racial groups, simultaneously making the environmental justice movement a subject

for research (Timmons Roberts *et al.,* 2018). Moreover, researchers are often personally involved in environmental social movements in various forms, ranging from militancy to consulting, aimed at providing scientific support for activists' claims.
However, we would like to emphasize how environmental justice, from its very beginning, adopted an explicitly spatial approach to environmental issues: waste disposal sites, polluting industrial installations, and other "problematic" facilities become a politically relevant issue precisely in relation to their top-down established localization, questioned by local communities. NIMBY (*not in my back yards*) opposition movements, whose ability to affect policy-makers' choices is limited and in any case unequal, perfectly fit in this framework: «whiter communities were more successful than people of color in campaigning against the toxic site» (Maung & Pellow, 2021, p. 38). Plus, the "victory" of a NIMBY claim may simply result in relocating the "contested" site to a different location, inhabited by communities less able to oppose it, for many reasons.

> «the hazardous wastes, garbage dumps, and polluting industries were likely to end up in somebody's backyard. But whose backyard? More often than not, these locally unwanted land uses (LULUs) ended up in poor, powerless, black communities rather than in affluent suburbs. This pattern has proven to be the rule, even though the benefits derived from industrial waste production are directly related to affluence. Public officials and private industry have, in many cases, responded to the NIMBY phenomenon using the "PIBBY" principle, "Place in Blacks' Back Yards"» (Bullard, 2019)

Black and low-income neighborhoods are on «the 'wrong side of the tracks', and subsequently receive different treatment when it comes to enforcement of environmental regulations» (Bullard & Wright, 1987, p. 25). The existence of a link between environmental inequality, socioeconomic status, and race/ethnicity has been discussed widely in literature since the 1980s, but race and income are still crucial factors in the location of hazardous waste facilities and unequal exposure to pollution (eg., Bullard *et al*., 2008; Sampson & Winter, 2016; Tessum *et al.*, 2019)
As Mohai and Saha summarize (2007), the "existence" of an unequal distribution of hazardous sites can be the outcome of three processes: a) *economic*, such as economic actors will to minimize costs by occupying lower-value land parcels, often coinciding with those occupied by minorities and the poor; the "getaway" of (white) wealthier residents, resulting from the location of polluting sites, is another example: the collapse of property values in the affected neighborhood makes room for the "arrival" of less affluent residents; b) *sociopolitical*: decision-makers and private investors location choices tend to penalize communities with weaker political voice, less social and economic capital, identified as less able to mobilize against these choices; c) *racial*, pertaining not so much to an explicit desire to locate polluting sites in ethnic minorities, out of an explicit racist choice, but rather to the long history of identifying black neighborhoods as less likely to resist government or industry choices (Bullard & Wright, 1987), less capable of lobbying. Moreover, residential segregation reduces poor and black people's ability to move "out" when environmentally harmful structures are placed near their homes.
However, it is essential to flesh out and elaborate on the contours and subcategories of *justice* (and its intrinsic relationship with inequality) and how it is defined in environmental justice literature. As several authors have made clear, three are the dimensions considered (for a summary, Schlosberg, 2007):

- *Distributive* justice: emphasizes how the causes and effects of environmental degradation affect social groups and places differently, with environmental policies tending to favor some populations and territories' interests, while others may be penalized;
- *Procedural justice*: refers to the "openness" and degree of transparency in decision-making processes, the possibility for different actors to "voice" in agenda-setting and decision-making processes, as well as the power effectively devolved to participatory processes (against the risk that they are simply asked to "validate" pre-made decisions).
- *Recognition* justice: concerns the failure to recognize individuals, territories, or cultures' specific

features; this is one of the leading causes of distributional and procedural inequality, as it leads to the exclusion of individuals and groups from decision-making processes and a failure to consider their aspirations and needs in policies.

During the 1990s 2000s, environmental justice spread horizontally -to include different areas of the planet – and vertically – to link global protests and local mobilizations (Walker, 2012). On the one hand, it prioritizes the distributional consequences of neoliberal politics of scaling and the new processes of "accumulation by dispossession" (Harvey, 2003) and on the other hand it focuses on patterns of socio-spatial and environmental inequality, and the processes through which these inequalities are produced (Cook & Swyngedouw, 2012; Pellizzoni, 2014).

2. Spatial patterns of environmental and climate justice. Vulnerability to climate change hazards

As the environmental justice movement expanded globally, climate change gained growing prominence in scientific discussions, public spheres, and policy agendas, emerging as the most pressing environmental issue of the 21st century. The environmental justice framework has proved highly fruitful for researchers and grassroots movements engaged in climate change "front".
Climate change thinking has led to the adoption of international perspectives and organization structures, more suitable for discussing globalized capitalism and its downsides, where global warming and climate change have their roots. Thus, for example, critical thinking developed about the "emissions quota market" established under the Kyoto Agreement, emphasizing how

> «dynamics of capital accumulation are creating a carbon space-economy based upon the enclosure (in 19th-century terms) of non-polluted air, oceanic carbon-absorption capacity, land, forests, social commons and indigenous knowledge [...] carbon trading represents at best a shifting of the deck chairs on both the climate and economic Titanics, and at worst -and most probably- will suffer from major new holes in the ships» (Bond, 2012, p. 689).

New environmental commodities create new opportunities for accumulation through dispossession, widening the global North-South gap and the inherent inequalities (Böhm *et al.,* 2012).
In this framework, climate justice's contribution focuses on the asymmetries implicated in climate change, concerning its causes, its consequences, and how public policies manage it, ranging from global to local scales. Risks associated with climate change are not *the same for everyone* in every place and time and are highly dependent on numerous contextual factors. Throughout the following pages, this work focuses on the "persistent relevance" of urban fractures, contradictions, and resources for cities' environmental challenges.
In the same way environmental justice's origin is often traced back to the Warren County protests, a pivotal turning point for the intersection of environmental justice and climate justice is generally recognized in Hurricane Katrina, which struck the U.S. Gulf Coast in August 2005: the collapse of levees and floodwalls installed to protect the city of New Orleans (Louisiana) caused the flooding of roughly 80 percent of its surface area and the deaths of approximately 700 people[3].
Literature has focused its theoretical and empirical efforts on "denaturalizing disasters" (Pelling,

3 Schlosberg and Collins (2014), however, specify that «there was a relationship emerging before that particular storm. The Environmental Justice and Climate Change Initiative was founded in 2001 [...] The initiative straddled this global focus and its US emphasis; its membership included a diverse group of "environmental justice, climate justice, religious, policy, and advocacy groups that represent hundreds of communities" that laid out 10 principles of climate justice in 2002. This is crucial: an environmental justice organization, before Katrina, defined key principles of climate justice based in the experience of environmental justice communities in the United States».

2001) against a reductionist view of "natural disasters" being limited to mere physical and material dimensions. By emphasizing the deeply intertwined nature of human and social factors in shaping disasters' consequences, it has been argued that «there is no such thing as a natural disaster [...] the contours of disaster and the difference between who lives and who dies is to a greater or lesser extent a social calculus» (Smith, 2006). Natural hazards, mediated by many individual, social, and contextual factors, can turn into socio-natural disasters.

Several studies have shown that «the unequal distribution of vulnerability to climate change is therefore exacerbated by pre-existing inequalities» (Adger, 2006, p. 274). Vulnerability, the political and social condition that affects a community's ability to prepare, respond, cope, and recover from a hazardous event, is socially and spatially unevenly distributed, intertwined with a system of inequalities structured on several axes (among which race, class, and gender represent some important examples) (Cutter *et al.,* 2003).

On the global scale, the awareness of disequilibrium between countries responsible for the majority of the emissions and countries that, nearly blameless, experience the most damaging effects was already established at the beginning of the 21st century (in IPCC reports too). Many factors were identified as shaping developing countries vulnerability, including wealth, technology, knowledge, infrastructure, institutional capabilities, preparedness, and access to resources (Kasperson & Kasperson, 2001).

On the urban scale, climate "goods" and "bads" distribution is unequal, reflecting the uneven distribution of population and social groups in urban space due to economic and social processes such as residential segregation and spatial concentration of poverty. Some segments of the population are directly or indirectly prevented from accessing environmental resources, infrastructure, and services, such as urban green spaces, clean air, urban biodiversity, and eco-efficient housing. The link between residential segregation and the quality of the urban environment, identified in the context of classical environmental justice studies, is a valuable key to understanding new environmental issues, particularly climate change, and vulnerability (Cucca, 2020).

With regards to Hurricane Katrina's social impact, a crucial role is attributed to New Orleans' dramatic inequalities of the early 2000s and its «deep and complex relations of racial and class division» (Elliott & Pais, 2006, p. 297), with high residential segregation and an acute concentration of poverty, often within the same area (The Brookings Institution, 2005). Scholars discovered that poor and black communities had been strongly affected by flooding: 58 percent of residents living in flooded neighborhoods were African Americans or members of other ethnic minorities, compared to an overall share of 45 percent in the regional population. In New Orleans, this share raised an impressive 80 percent. At the same time, the average household income of those living in the flooded areas was approximately 15 percent lower than the residents of the "dry" areas ($44,000 vs. $53,000); again, a wider range characterized New Orleans, where the difference was 30 percent ($38,000 vs. $55,000). Furthermore, 38 out of 49 extreme poverty census tracts in the metropolitan area flooded, all in New Orleans (The Brookings Institution, 2005).

Andy Horowitz notes that although «racism and poverty are necessary beacons for navigating Katrina's history, because they structure American inequality, often leading to inequities so stark they can be fatal» (Horowitz, 2020, p. 7), they may prove to be insufficient in explaining "what happened" when Katrina hit the Louisiana coast. «When the levees broke, the homes of tens of thousands of suburban, middle class white people flooded catastrophically, while the homes of New Orleans' poorest African American residents, who lived in public housing, largely did not. There are no straight lines that connect racism or poverty to flood depths» (*ibidem*). Similarly, James Elliott and Jeremy Pais (2006) point out that exposure to flood risk, despite its uneven geographical distribution across the region (due to different elevations and availability of protection systems), cannot be traced solely to race or class factors: Katrina had a strong impact on neighborhoods inhabited by affluent, middle-class whites, too. Instead, a complex interplay of

class and race helps to explain the response of individuals and communities at different stages of the disaster (from "pre" to "post").
The historical analysis of urbanization processes and transformations that affected the New Orleans metropolitan area during the twentieth century becomes necessary to understand the geographical location of different groups and the observed impacts of the disaster, avoiding tricky simplifications (Campanella, 2007). The racial bias implicit in federal housing policies (which included redlining, segregation, and loans disproportionately aimed at whites), indeed, allowed the white middle class, between the 1930s and the 1960s, to relocate to new, higher-quality housing, exposed to greater risk of flooding (Horowitz, 2020). During the 1960s and 1980s, the phenomenon of white "exit" (white flight) from the historical boundaries of New Orleans surged, driven by suburbanization facilitated by novel reclamation and physical landscape transformation processes.
This long-term perspective, thus, emphasizes the centrality of urban processes in shaping the vulnerability of individuals and groups to climate extremes. Moreover, it shows how vulnerability is socially constructed well before disasters take place.
Eric Klinenberg, renowned for his famous "social autopsy" of the 1995 Chicago heat wave (Klinenberg, 2002), advocates for a socio-ecological approach to understanding vulnerability. His study explores the environmental and social factors that influence residents' varying likelihood of survival. Demonstrating that «the patterns of mortality reflect the inequalities that divide Chicago» (*ibidem*, p. 18), Klinenberg rejects the idea that the city's residents are "all in the same boat" when facing the heat wave: deaths are predominantly among African American and elderly populations. In every age group, African Americans show a higher mortality rate than any other ethnic group in the city. Geographically, communities with the highest death rates were concentrated in the city's South Side and West Side, revealing a «clear clustering of deaths in Chicago's segregated black regions» (*ibidem*, p. 82). The presence of low-income and elderly populations, lack of vegetation, and high crime rates are all ecological characteristics associated with high death rates.
The ethnographic work aimed at analyzing what we might call a "neighborhood effect" (Sampson, 2012; Sampson *et al.,* 2002), how living in a specific neighborhood may have led to an increased vulnerability to the heat wave, suggests that residents of poor, segregated and dangerous neighborhoods are at greater risk of dying alone because the context "discourages" them from leaving the "safe" space of the home and, at the same time, creates obstacles for the opportunity of finding some protection in neighborhood social networks. African Americans are the only ethnic group in the city segregated and ghettoized in physically degraded areas with high rates of crime and violence, lacking commercial infrastructure and places for socialization (Klinenberg, 2002).
Post-disaster redevelopment, too, is influenced by inequality structures and their spatial patterns. This results, for example, in different access to resources available for recovery and different "resilience capacities" of people and communities. In New Orleans, «we can view the unevenness of the pace and trajectory of the post-Katrina redevelopment as a result of the interaction between preexisting racial, class, and neighborhood disparities and inequalities in access to post-disaster recovery resources» (Gotham & Greenberg, 2014, pp. 169–171). The return of displaced households, for example, is not so much ascribable to individual wills, values, or personal abilities but should instead be read in connection with factors such as the social vulnerability of affected communities in different neighborhoods and the severity of the "physical" harm suffered (Finch *et al.,* 2010). Low-income African-Americans were frequently displaced in cities far from New Orleans: far from being an ineffective spatial feature of their "post-disaster" experience, this resulted in a deterioration of pre-existing family and community networks and much higher travel costs to return (without -in many cases- the opportunity to use a private car). Middle-class whites, vice-versa, were in most cases able to rent apartments in the suburbs or, otherwise, to find temporary accommodations not far from it. In addition, the flooding insurance rate among

New Orleans' population was not the same: again, individuals living below the poverty line and black people were less insured, whether for economic reasons or because of insurance redlining processes (Gotham & Greenberg, 2014). Frequently, post-disaster redevelopment projects become battlefields for heated debates about the future, with different ideas, narratives, and political positions clashing. In New Orleans, some explicitly hoped that poor people would not return to the city and "find some other place to live", others promised that the city would not return "as black as it was before". This idea of disaster as a process of creative destruction assumed the gentrification of New Orleans (labelled as "green", in some measure) as a newfound tool for the accumulation of capital (Cossman, 2007; Davis, 2005; Gotham & Greenberg, 2014; Horowitz, 2020).

3. Resilience and spatial inequalities: secondary effects of climate policies

Environmental justice, as explained above, is evident in the distributive geographies of burdens and risks related to the impacts of extreme natural hazards. Moreover, environmental policies can have significant secondary effects on the socio-spatial dimensions of climate and environmental justice. Climate mitigation and adaptation strategies involve benefits and costs that may prove to be "unjust" in a myriad of ways. The French *gilets jaunes* protests of 2018-2019 provide an example of a reaction to the government's implementation of a carbon tax on diesel fuel. This event demonstrates how a green policy, deemed distributionally, procedurally, and recognitionally unfair, led to a conflict where territorial inequalities played a crucial role. Suburban and rural areas with a working-class population heavily reliant on cars perceived the "center" as neglecting their needs. The significance of the intersection between space and social structure underscores the need for place-based, more just policies (Carrosio, 2022).

The spatial dimension of climate justice, thus, is also implied in the issue of policies implemented for the construction of "resilient" societies – societies able to deploy an adaptive change that aims to preserve the activities, functions, and structures perceived as "useful" (because they are sustainable or generate human well-being) in the face of climate change threats. The resilience framework has emerged in recent decades from "hard" natural sciences literature to acquire a transdisciplinary diffusion. Despite its wide use, however, it has its own limitations. In particular, resilience adopted as a merely "technical" notion has been criticized, as it would tend to hide behind a "claim of neutrality" the eminently political dimensions of choices guiding the transformations required to cope with the climate crisis (Pellizzoni, 2017). The resilience frame «can also allow unsustainable or socially unjust practices to persist» (Pelling, 2010, p. 56). Thus, a resilient socio-ecological system can legitimize, reproduce, and reinforce the status quo, widening pre-existing inequalities (Jennings, 2011).

Therefore, the following section focuses on one issue in particular: the risk for climate policies (or, more broadly, "sustainability" policies) to become drivers for new forms of "environmental", "green", or "climate" gentrification. The purpose of this work, however, coherent with the aim of this paper, is not that of analyzing the pros and cons of the whole sampling of urban sustainability policies that local administrators can deploy in their cities. Instead, this work aims to emphasize how a perspective aware of urban inequalities can inform policies aimed at making cities more "resilient" to climate challenges, avoiding the distortive effects of "space blind" policies.

In post-disaster contexts, as illustrated in the case of New Orleans, low-income and black neighborhood gentrification may become a precise choice to make the city "more livable". Nevertheless, also in "peacetime", expulsion processes can be encouraged by environmental and redevelopment urban policies.

If the unequal distribution of environmental "bads" and "goods" was the main topic for the environmental justice framework, environmental gentrification allows to dynamically understand

how urban processes promoted in the context of sustainable development and urban resilience can produce processes of displacement and exclusion. The focus is on how urban greening policies can make neighborhoods unaffordable for low-income residents rather than on how gentrified neighborhoods demand parks and other green infrastructure (Gould & Lewis, 2017).
Supported by international policies and research and innovation programs (e.g., Goal 11 of the Sustainable Development Goals, the Horizon Europe program, or, in the North American context, the EPA's Green Infrastructure Program), urban greening projects insist on the economic, ecological, social, and health benefits they bring, assuming cascading effects that would benefit all (Anguelovski *et al.*, 2018; Wolch *et al.,* 2014). Rarely, however, these projects explicitly address equity, providing concrete and contextual measures to ensure that ecological solutions benefit all residents, particularly the most vulnerable. Instead, territorial contexts are often seen as homogeneous domains where "one-size-fits-all" policies can be dropped from above (Castrignanò & Landi, 2018).
Research in this field critically analyzes the so-called "new orthodoxy of green planning" (Connolly, 2019) – highlighting its spatial effects in terms of exclusion, marginalization, or displacement of low-income residents. This orthodoxy draws on a contemporary narrative of ecological modernization, which simultaneously describes a vision of ecologically and socially responsible urban development, a "green" lifestyle (attractive for affluent and eco-conscious residents), and a technocratic and politically neutral approach to the resolution of environmental problems (Cucca, 2020, p.193). Sustainability becomes a brand aimed at increasing urban appeal to attract investments, events, highly skilled workers, tourists, and students.
Many scholars associate the new sustainability consensus with the "entrepreneurial turn" in urban governance (Harvey, 1989), especially with "sustainability fixes"[4]. Urban management has a growing interest in incorporating environmental issues in governance and planning, «but as long as the efforts required promote economic and interurban competitiveness» (Scanu *et al.*, 2021, p. 1371), essential to reproduce the expansive dynamics proper to neoliberalism through a process of "greening of the growth machine".
The literature on environmental gentrification has developed at first in North America and later in the European context, highlighting some differences between the two contexts: first, the broader role usually played by European public policies in promoting or containing gentrification; second, the average size of European cities, smaller than American ones, makes large-scale urban transformations unusual and thus tends to "blur" the ability of an "isolated" urban greening project to produce displacement processes (Beretta & Cucca, 2019).
Many of these studies focus on the limitations of an "acritical" approach to sustainability and sustainable urban development, unable to recognize the contradiction implicit in its own premise: «that we can stimulate economic growth while mitigating the effects of climate change, without any sacrifice» (Checker, 2020, p. 7). Melissa Checker, for instance, identifies three mechanisms of environmental gentrification that run through the history of New York City: a) *green gentrification* turns parks, gardens, and other urban green spaces into commodities that contribute to raising property values and reorganizing urban space according to wealth and privilege, thereby denying minorities and low-income residents access to such resources. The emphasis on "sustainability" has been crucial in transforming New York City into a luxury, exclusive, and excluding city: private investments in urban green spaces attracted affluent populations and raised property values; (b) *industrial gentrification* concerns the spatial distribution of industrial sites, historically complementary to green spaces localization in order to protect property value; the history of NYC's industrial gentrification is intertwined with the city's economic and planning development, including zoning reforms, peripheralization of manufacturing zones to make room

4 The concept of sustainability fix is defined "as a sociospatial compromise between economic interests and environmental claims whose main function is to 'safeguard growth trajectories'" (Scanu *et al.*, 2021, p. 1371). There is a vast literature on sustainable fix that we do not address here, see e.g. Long, 2016; Scanu *et al.*, 2021; Temenos & McCann, 2012; While *et al.*, 2004.

in central areas for businesses, financial offices, and luxury housing, processes of displacement and segregation of low-income residents, shrinking of services following neoliberal austerity "mantra", development of small "eco-friendly" businesses better suited to meet the preferences of affluent green consumers; c) *brown gentrification*: reclamation programs of toxic properties and brownfields, based on private investment, mainly in neighborhoods where property values were set to rise. The apparent consistency of these programs with environmental justice movements' claims that call for intervention to reduce the environmental burdens faced by communities of color; the acknowledged role of the market and private investment, however, means that interventions are concentrated in neighborhoods where property values are rising, widening the gap with "depressed" neighborhoods lacking the tools for remediation.

Similar trends can also be found in the European case, although often less "violent". In Leipzig, Annegret Haase (2019) focuses on how greening can create exclusionary dynamics when embedded within capitalist logics of housing markets. A park established at the end of the 1990s, during a phase of strong urban shrinkage (Großmann *et al.*, 2013; Martinez-Fernandez *et al.*, 2012), to create a green space available to residents and "keep" them in the neighborhood, becomes – during the city's sudden regrowth after 2010 – a catalyst for regeneration processes, real estate investment and transformation of the demographic, social and residential structure of the neighborhood's population, with the risk for poorer residents to be displaced elsewhere.

Although not all urban greening initiatives create gentrification (Eckerd, 2011), gentrification can be a driver of the development of such projects, while in other cases, it is the green redevelopment interventions triggering gentrification processes (Carrosio & Landi, 2023). Research focuses primarily on this second dynamic, but the two processes often overlap. However, the outcome is the same: wealthier, better-educated people and more powerful groups tend to have greater access to greener and more valuable neighborhoods, while long-term residents of lower incomes face an increase in the value of ownership of such areas (which, depending on the context, translates into an increase in rental prices, property taxes or maintenance costs) (Anguelovski *et al.,* 2019; Cucca, 2020).

4. Investigating the urban fabric for a contextual design of urban policies: the case of the Boston Area Research Initiative

The theoretical focus on the social and spatial structure of the city and the inequalities within it needs adequate methodological tools. Research on environmental justice, vulnerability, and climate change has made wide use of the classic sociology toolbox, using both quantitative (census, official statistics, surveys) and qualitative (interviews, participant observation, newspapers, archives, etc.) data, sometimes integrated with GIS techniques of mapping and spatial analysis.

Recent technological development has led to the explosion in technological capacity for data production, collection, and processing, together with the diffusion of a large number of internet-connected devices equipped with sensors of various kinds collecting data on – for instance – environmental conditions (temperature, light, sound, ...), location (GPS coordinates, movement, ...), and individual health conditions (heartbeat detection sensors, ...) (Swan, 2012). The so-called Big Data challenges the «predominant authority of sociologists and social scientists more generally to define the nature of social knowledge», bringing «different modes of addressing the public, mobilizing expertise, conceptualizing the social, and research methodology» (Burrows & Savage, 2014, p. 5).

In environmental justice studies, the innovation of low-cost monitoring devices has opened new research possibilities. Already characterized, as previously demonstrated, by a certain contiguity between activists and researchers, the environmental justice movement has benefited and evolved around the possibility of having these devices. This technological advancement has fu-

eled a new impetus to citizen science, resulting in science-led or citizen-led projects that create new opportunities for cooperation between academics, activists, and citizens. From a scientific perspective, «citizen science is particularly effective at addressing ecological questions at large spatial and temporal scales that cannot be covered by a small team of investigators. By tracking ecosystems over time, citizen science can provide crucial baseline information on effects of global change and for identifying locations with both good and poor environmental health» (Adler *et al.,* 2020, p. 53). Voluntary modes of citizen participation in environmental justice citizen science research are, for example, citizen sensing, with citizens becoming "monitoring terminals" dispersed throughout the territory of interest (e.g., Johnston *et al.,* 2020; Racz & Rish, 2022), or participatory mapping, with digital mapping technologies used to collect, amplify and represent the needs of the most marginalized communities, developing a more egalitarian system of knowledge production, with equal dignity accorded to citizen knowledge and researchers' scientific expertise (e.g., Connors *et al.,* 2012; Haklay & Francis, 2017).

Big Data, unique in "holding together" features of *volume*, *velocity*, *variety*, *exhaustivity*, fine graining in *resolution*, *relationality,* and *flexibility* (Kitchin, 2013) with generally affordable costs, have seen a rapid increase in diffusion and use in social research. Moreover, because much of these data contains geographic attributes, they represent an extraordinary tool for spatial research, suitable for analysis conducted on different spatial levels (*ibidem*). From this article's perspective, it is worth emphasizing how these new tools offer new possibilities for empirical research at the micro-urban scale, crucial in the field of environmental and climate justice, for example, in the analysis of social inequalities related to spatial patterns of individuals and community vulnerability to natural hazards, and displacement processes related to the impacts of disasters or driven by urban sustainability policies.

As many have emphasized, Big Data should be seen as complementary to the "small data" produced by more traditional methodologies, creating new opportunities for empirical research on new and "old" issues (Gray *et al.,* 2015; Kitchin, 2013, 2014; Kitchin & Lauriault, 2015; Kontokosta & Malik, 2018; O'Brien, 2016). An innovative form of Big Data integration with "classical" ones can be seen in the "ecometrics" approach (O'Brien *et al.,* 2015; Raudenbush & Sampson, 1999). "Ecometrics" represents a systematic approach developed to measure the socio-ecological features of a neighborhood. The idea implicated is that neighborhood phenomena need specific measures, not based on individual or aggregated data (such as census data). From a methodological perspective, ecometrics can be combined with Smart City technological tools, contributing to a holistic environmental and social sustainability approach.

A brilliant example of integration between data produced from traditional empirical methods, "ecometrics", big data, and administrative data is the experience of the Boston Area Research Initiative (BARI). BARI is an inter-university research center developed by Northeastern University, Harvard University, and the City of Boston. Academics, policymakers, community members, foundations, and corporations work together on research projects addressing a variety of crucial urban issues such as custodianship in the urban commons (O'Brien *et al.,* 2015), segregation and mobility (Wang *et al.*, 2018), microspatial inequalities connected to heat and air pollution in the city, and the different geography of these two hazards (O'Brien & Mueller, 2023). Moreover, these issues are studied innovatively, integrating big data (data from 311 and 911 calls, data mining from social networking platforms, satellite data, mobile phone GPS data) and data produced by traditional methods or administrative data.

In particular, the opportunities big data can bring to understand better environmental and climate injustice and the fight against them are well documented in studies published in the last few years (O'Brien *et al.*, 2020; O'Brien & Mueller, 2023). Moving from the understanding that exposure to environmental hazard vary across neighborhoods and communities, the Authors focus on *microspatial inequalities*, specifically at the level of Boston streets, to evaluate extreme heat and air pollution distribution. This perspective is to overcome some limitations of neighborhood-level analyses, given that some crucial factors for environmental hazards (such as pave-

ment density, trees, reflective surfaces, and building heights) not only differentiate neighborhoods but also streets within neighborhoods and even street segments along the same street, with different outcomes on public health. Using remote sensing data on land surface temperature (from Landsat) and other associated factors such as surface reflectivity, canopy and impervious surface cover, scholars were able to map the spatial distribution of extreme heat hazard, identifying so-called "urban heat islets" (O'Brien *et al.*, 2020) crucial to explain health outcomes detected during heat advisory days.

In relation to air pollution, cellphone mobility data is utilized to estimate vehicle emissions at the road scale, and these estimates are combined with data on the urban canyon effect, describing local air flows that can trap vehicle emissions. This information is derived from data on the built environment, including the average height of buildings for each street and the street width, enabling a classification of each street's risk level for the city. This approach offers several benefits, providing an accurate understanding of environmental inequalities and spatial distribution, considering the diverse nature of urban areas that may vary significantly even at the neighborhood level. Furthermore, it has significant implications for urban adaptation and mitigation policies concerning climate change, as it helps guide investments and interventions towards areas with higher risk to mitigate exposure or prevent local effects during heatwaves.

Finally, BARI demonstrates both the importance of a "micro-scale" understanding of inequalities, especially in terms of distributive justice, made easier by Big Data, and the value of collaborative, interdisciplinary research for understanding and addressing complex urban problems. Its work serves as a model for other research centers seeking to engage with communities and policymakers to produce research with "real-world", public implications. In addition, the hope is that tools such as the one briefly described, focused on the issue of urban inequalities, will help affirm the need to design contextual policies able to capture the inequalities within a city and its neighborhoods in a "place-based" approach that recognizes and enhances the contextual distinctiveness in policies, departing from a one-size-fits-all, "unjust", approach.

Final remarks

To understand cities as spaces *where climate change happens* implies examining preexisting inequalities and other "classical" topics for urban sociologists. Environmental issues have always been part of this story, representing one of the many stressors of urban conflicts and segregation processes. However, in the climate change scenario, the urgency for research and interventions to focus on the distribution of hazards along race, class and gender axes and its spatial dimension is magnified.

The article focused on this last matter, with par. 1 exploring how environmental justice, from its very beginning, adopted an explicitly spatial approach to environmental issues. Facilities such as waste disposal sites and polluting industrial installations become politically "problematic" precisely because of their location and the top-down procedure determining it, opposed by local communities. Par. 2 focused explicitly on climate justice, driven by the idea that the risks associated with climate change are not experienced the same for everyone. Inequalities in exposure, sensitivity, and capacity to adapt to climate change underline how cities' environmental challenges in the coming climate-changing scenario are still spatially unevenly distributed. Par. 3 argues that big data (whether produced by citizens, sensors, or apps) can play an essential role in today's environmental and climate justice studies, expanding opportunities for scholars, activists, and policymakers' efforts: from a spatial perspective, for instance, by allowing a better understanding of micro-inequalities. We described the Boston Area Research Initiative experience as an exciting example of this opportunity, being at the same time a virtuous example of inter-institutional collaboration, able to engage with local communities and their needs.

The public's attention today on the impacts of climate change and the need for a just transition, the increasing relevance of environmental issues within urban policies, together with the increased availability of relatively cheap technologies make new room for climate justice scholars and activists. The opportunity to collect massive amounts of digestible data on the environmental features of our cities represents a crucial innovation for urban policies, informing policymakers' decisions and activists'. In this context we would like to stress the need for a robust spatial analysis rooted in environmental justice history- with its legacy not being overshadowed but vehemently reaffirmed.

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