Understanding the 'green resilience paradox': How climate adaptation planning (re) configures urban social and racial inequities and insecurities

Galia Shokry

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Ph.D. Dissertation

Galia Shokry

Directors:
Prof. Isabelle Anguelovski
and
Dr. James J. T. Connolly

Academic tutor: Prof. Isabelle Anguelovski

Institute for Environmental Sciences and Technologies (ICTA)
Universitat Autònoma de Barcelona (UAB)

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Galia Shokry [galia.shokry@uab.cat], Universitat Autònoma de Barcelona, 2021
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Affiliations of Ph.D. supervisors and academic tutor:

Prof. Isabelle Anguelovski: Institute of Environmental Science and Technology (ICTA), Univesitat Autònoma de Barcelona (UAB), Barcelona, Spain IMIM (Hospital del Mar Medical Research Institute), Barcelona, Spain ICREA (Institució Catalana de Recerca i Estudis Avançats), Barcelona, Spain

Prof. James J.T. Connolly: School of Community and Regional Planning, University of British Columbia, Vancouver, Canada Institute of Environmental Science and Technology (ICTA), Univesitat Autònoma de Barcelona (UAB), Barcelona, Spain IMIM (Hospital del Mar Medical Research Institute), Barcelona, Spain

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To Athen,
may your resilient spirit soar
while I rapidly tinker to make the world a better place

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Abstract

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Chapter 1 - Introduction and research objectives

Background and motivation

The year of publication for this thesis, 2021, marks the 15th anniversary of Hurricane Katrina, perceived as the first major climate disaster on American territory and the first glaring example of inequality – especially racial inequality – in impact and response. Katrina was indeed one of the most catastrophic hurricanes in the history of the United States resulting in over 1400 deaths and 100,000 displaced residents. Failure to provide immediate evacuation and long-term relief left tens of thousands indefinitely homeless, separated from family and friends, and grief- and trauma-stricken. With a mortality rate two to four times higher for Black residents in Orleans Parish, Katrina also highlighted the historically racialized American geography of vulnerability to climate risks and impacts and the ongoing failure to equally protect and secure the welfare of all citizens from harm.

The increased perception and experience of climate impacts through subtle everyday changes as well as highly visible disasters, such as Hurricane Katrina, in addition to a better understanding of climate risks (Nay et al., 2014; Pielke et al.) has helped garner support for planning measures to strengthen cities' adaptive capacities to climate impacts (Nordgren et al., 2016). Climate adaptation took off in 2007 at the 13th Conference of Parties (COP-13) of the United Nations Framework Convention on Climate Change (UNFCCC): "adaptation was recognized alongside mitigation, technology cooperation and finance as one of the four 'building blocks' required to respond to climate change (Ayers & Huq, 2009; cited in Dodman and Mitlin, 2013)". In the same year the Intergovernmental Panel on Climate Change (IPCC) issued an Assessment Report (AR4) (Parry and IPCC, 2007), the first high level report to include a focus on urban areas, giving attention to the particular vulnerability of cities to climate hazards and the role of urban governance in driving successful adaptation.

Yet, already back then, adaptation planning was much more than a technical matter and had deep social ramifications. Back to New Orleans, when early in 2006, city planners unveiled a proposal to increase the resiliency of some of the hardest hit neighborhoods to future storms through new urban green spaces, the plan was met with public uproar. What became known as the New Orleans Green Dot Map and the Great Footprint Debate seemed to illuminate the emerging social and racial dynamics of climate resilience planning. Where city planners perceived and attempted to sell an innovative solution to absorb excess stormwater and reduce the urban footprint to its more elevated urban core, communities of color did not see a move toward protective urbanism, but rather another attempt to displace and dispossess Black residents from their lands and livelihoods. Residents' fears of losing their homes and lands to opportunistic developers in the storm's aftermath, transformed into fear of municipal-led erasure by resilience. A reduced urban footprint seemed to signify replacing their neighborhoods with green resilient buffers to save *other* more privileged, white parts of the city from future climate impacts, in this way perpetuating an historical and ongoing experience of environmental racism and injustice.

With the increasing frequency of extreme weather events and intense damage most visibly experienced in large and dense population centers, cities throughout the world have been, like New Orleans after Hurricane Katrina, increasingly seeking to be less vulnerable to climate risks through adaptation (IPCC,

2007; 2014). Hurricane Sandy in October of 2012 provided a brutal awakening to New York City's vulnerability to storm surges and sea level rise, killing 44 people and causing $19 billion in damages.[1] A flood of new adaptation proposals emerged in response including one to extend lower Manhattan by 500 feet into the East River and another to construct a Multi-Use Elevated Promenade and seawall around Staten Island's eastern shoreline. The East River Coastal Resiliency Project was met with particular outrage when residents learned that existing parks and recreational amenities would be demolished to integrate floodwalls into the coastline.[2] Cities like Dallas, Boston, Barcelona, Medellin and Durban have all proposed adaptation and resiliency plans with some already being implemented.

Despite being a relatively new area of action, almost fifteen years after its emergence as a policy and planning field, climate change adaptation is now an important public policy and investment domain, which in turn has fueled interest among scholars and practitioners in the broader question of how urban systems become resilient (Meerow et al., 2016; Stumpp, 2013). This resilience question especially resonates in the planning and development spheres (Davoudi et al., 2012; Vale and Campanella, 2005) where the broad aim is to reduce cities' level of risk and increase preparedness to withstand and respond to extreme weather events and other chronic disturbances (Chelleri et al). While resilience and adaptation are often used interchangeably, the former tends to be understood as a pathway to a more flexible, multi-scalar response to climate change adaptation and more strongly associated with the capacity to bounce back to an operational state after a disturbance (Chelleri, et al).

The New Orleans example illustrates how an urban resilience framework encompasses a great deal of complexity much more than linearly adjusting the parameters of urbanization relative to the conditions of climate change. Given the complex social-ecological interactions, there is no generic model for adaptation and resilience and the potential pitfalls are rooted in historic land use patterns. Once this point was made clear by the blowback to the Green Dot Map in New Orleans, city planners responded to residents' outcry with a new offer: any community wishing to stay, could propose its own resiliency plan demonstrating its community's adaptive and placemaking capacity. In short, planners capitulated to the complexity of the circumstance.

However, simply offloading the complexity onto smaller and more localized, resident-led or -centered organizations does not make the path toward adaptation and resilience any easier and more just. Residents of the long-disinvested, geographically isolated Lower Ninth Ward in New Orleans – a 98% African American neighborhood - perceived themselves once again as victims of municipal abandonment, left to rebuild on their own. Of the neighborhoods that took on the city's challenge, the previously more privileged, more racially diverse Broadmoor, became a hallmark of success[3]. These differing outcomes of testing the resilience of communities underscore the racialization of structural inequalities and the effects of longstanding neglect by public institutions which have established stark inequities in resources and in sensitivity to "disturbance". As a result of these circumstances, a simple turn toward so-called bottom-up planning did not resolve the challenge of unequal urban resilience.

Given the need for nuanced approaches to building urban resilience that responds to complex social-ecological conditions, much of the scholarship on building resilience through climate adaptation has focused on the early stages of assessing risk and vulnerability to climate impacts and the mainstreaming

[1] A Livable Climate - OneNYC 2050 - (cityofnewyork.us)
[2] Inside the controversial plan to remake the East River waterfront - Curbed NY
[3] https://www.usgbc.org/articles/tale-two-neighborhoods

of adaptation across city sectors. Critical adaptation research bolsters this effort by asking how processes to build resilience and provide environmental protection might become more inclusive and participatory to ensure that citizens have a real voice in adaptation (Chu et al., 2016; Dodman and Mitlin, 2013). However, these scholars are careful to recognize that community-based adaptation is not intended to become a "do-it-yourself" solution that replaces city services. Despite much recent discussion about the potential promises and pitfalls of mobilizing the resilience concept in cities, including its equity prospects, few empirical studies have examined the social and racial impacts of the broad-based cross-agency push toward urban resilience planning, nor the lived experience of a general shift toward resilience urbanism at the neighborhood scale.

Among many adaptation responses, an increasingly popular pathway toward creation of a broadly resilient form of urbanism involves building new climate adaptive green infrastructure – climate-proofed parks, rain gardens, berms, trees and green roofs, for example (Haase et al., 2017; Jim et al., 2015; Lennon and Scott, 2014; Meerow and Newell, 2017; Pauleit et al., 2017). Research focused on green infrastructural approaches to climate resilient urbanism continues to demonstrate the benefits of greening but also the social, racial and environmental inequities associated with green space development. These inequities arise through uneven direct access to the benefits of green infrastructure and through more indirect processes, wherein green infrastructure sparks socio-spatial change in cities (Anguelovski et al., 2017; Checker, 2011; Cole et al., 2017; Dooling, 2009).

Scholars are therefore calling for similar scrutiny of climate resilience planning rooted in green infrastructural interventions, asking how benefits from these interventions can be expanded beyond the privileged few (Davoudi et al., 2012; Fainstein, 2015; Shi et al., 2016). At its core, this emerging line of critical urban resilience thinking seeks to understand how cities might adopt more transformative and just planning frameworks as an adaptation pathway (Pelling, 2011). From this perspective, research is needed to understand how climate change adaptation and resiliency planning, constructed on centuries of environmental racism and uneven development, can avoid perpetuating already entrenched inequalities. This need for understanding how the link is formed or hindered between broad societal transformation and green infrastructure planning rooted in resilience urbanism is the starting point for my research.

Theoretical Approach/Conceptual framework

There are three core issues shaping the way that critical scholarship views the link between urban green infrastructure and climate resilience planning that pushes toward societal transformation. First, the recent emergence of an urban resilience paradigm with origins in the social-ecological systems approach raises questions about which mode of governance and planning generates a pathway toward climate adaptation in cities (Part A). Second, the motivations and constraints for urban climate adaptation among various actors is an essential concern for what types of outcomes are possible. The material drivers behind city decision-making related to climate action, and in particular green climate adaptation, are a key factor in shaping perverse outcomes within climate resilient urbanism (Part B). Lastly, there are questions about the specific dimensions of community-based adaptation approaches in relation to

other sociocultural and placemaking dimensions that hinder or support a transformative model of urban resilience planning (Part C).

Part A. Towards broader transformation and justice in urban resilience pathways?

Urban research advocating for the mainstreaming of climate adaptation in city planning, has closely tracked the trends pertaining to how these policies and programs have taken root, different forms of policy innovation and processes of institutionalization, as well as access to resources from best practices to funding, partnerships and technical capacity-building (Anguelovski et al., 2014; Anguelovski and Carmin, 2011; Carmin et al., 2012; Hughes, 2015; Leichenko, 2011; Nordgren et al., 2016; Rauken et al., 2015; Runhaar et al., 2012). This scholarship has tended to evaluate urban climate governance by examining both the motivations to prepare for climate impacts, and the barriers to implementation and further advancement in the process. In the next section, I review this scholarship which laid the foundations for more recent critical scholarship on climate adaptation and resilience through insights into the factors influencing cities' decision-making about how to address ecological risks which in turn influences existing systemic dynamics that shape social and racial inequities.

A.i. Motivations/Incentives

Early empirical research on climate adaptation focused on the early stages of cities' adoption of climate adaptation strategies. This was due in part to the newness of adaptation on the scene of climate change prevention and long-term planning, as well as the importance of governance to the process of uptake and implementation (Anguelovski and Carmin, 2011). As such, empirical work examined the endogenous and exogenous factors implicit in the taking root of climate adaptation in cities, demonstrating that for early urban adapters, local concerns about climate change impacts on citizen well-being, internal leadership and support from diverse city stakeholders and willingness to innovate were more important than external incentives, pressures or frameworks from supranational and national bodies (Carmin et al., 2012; Chu et al., 2016). In some cases, the desire to showcase leadership in this realm, change a city's image, and become a model for other cities, were strong drivers for change. Studies of US cities reveal that asset protection, such as infrastructure, is especially high on decision-makers' lists of motivations for climate adaptation planning (Berrang-Ford et al., 2011; Carmin et al., 2012; Hughes, 2015).

Over time, transnational and non-governmental organizations made available an increasing number of resources including financial instruments, knowledge sharing and exchange platforms, and risk assessment tools (Nordgren et al., 2016). However, the experience itself of a disaster remains one of the strongest catalysts for a change in approach (Anguelovski and Carmin, 2011; Woodruff and Stults, 2016). This is the case, whether by engendering local support and attracting funding or spurring leadership and decision-making that takes risk preparedness more seriously. Even as more cities become aware of the importance of climate action, research suggests that few have progressed past the stages of vulnerability analysis and planning, and even fewer have begun implementing their programs (Hughes, 2015; Olazabal et al., 2019; Shi et al., 2015; Woodruff and Stults, 2016). Therefore little is known about

the actual effectiveness of adaptation and resilience initiatives (Olazabal and Ruiz De Gopegui, 2021). In assessing the state of climate adaptation planning, urban research therefore focuses on adaptation processes and understanding the barriers to progress.

A.ii. Constraints/Barriers

Local decision-making takes place in a climate of uncertainty especially about the nature, timing and magnitude of climate changes to come (Bierbaum et al., 2013), and how best to prepare (Huq et al., 2007; Nordgren et al., 2016). The extent of change that might be endured, for how long, of what type and precisely where, are all future scenarios that cities wish to predict and manage; however, even with this knowledge, other important variables and their interaction effects remain unknown and difficult to assess (De Sherbinin et al., 2007; Olazabal and Ruiz De Gopegui, 2021). In particular, uncertainty about future population growth and settlement patterns, socioeconomic and political conditions, and ever-changing technologies has meant a preference for incremental rather than transformational change, as well as a proclivity for the most cost-effective, iterative, no- and low-regrets adaptive solutions (Bierbaum et al., 2013; Hughes, 2015). This makes long-term decision making especially challenging. Measures with the most immediate and visible results in the short-term (e.g., tree planting) are thus preferred (Bassett and Shandas, 2010; De Sherbinin et al., 2007; Huq et al., 2007). However, "failing to address uncertainty may cause adaptation plans to be ineffective or maladaptive" (Woodruff and Stults, 2016).

Hurdles to progress in climate action can also be explained by challenges in accessing resources, including knowledge, expertise, staffing capacity, and finances which therefore affects adaptation choices. With the sparsity of available resources and uncertainty about how to sustainably adapt to climate vulnerabilities, comes a tendency to focus on climate management tools that are simplest to understand, the best developed and flexible. Most abundant are those pertaining to reducing greenhouse gas emissions (Woodruff and Stults, 2016) and to managing stormwater retention and flooding, while information about the impacts of climate change on public health and the health of vulnerable populations is less plentiful (Nordgren et al., 2016). Risk and vulnerability assessments require a high level of expertise and resources but are essential to understanding the impacts of past, present and future climate scenarios and formulating contextually appropriate adaptation needs. A comprehensive vulnerability assessment can help to identify internal factors that make a system more sensitive to climate risks and resilient to impacts, while a risk assessment helps pinpoint the risks or threats themselves. Who or what is at risk or vulnerable to what may differ depending on whether a top-down or bottom-up community-based approach is used and therefore integrated approaches are recommended (Conway et al., 2019), but in many coastal cities, vulnerability assessments are missing, especially from resilience plans, and climate action is unaligned with the outcomes of risk assessments (Olazabal et al., 2019).

Because of the emphasis on mainstreaming an adaptation mindset across all government sectors, information tends to be generic and therefore difficult to apply (Nordgren et al., 2016); at the same time, research has shown that the collaboration required for mainstreaming adaptation is stymied by fragmentation across sectors (Hughes, 2015). This has led to making climate adaption more like a solo program directed by the Mayor's Office in order to overcome interdepartmental communication hurdles. On the other hand, sectors in which technical knowledge is better developed, such as in engineering and water management, there has been more advancement in regard to implementing

adaptive technologies. This also points to local contextualization issues: different climates have different adaptive needs and therefore needs for different kinds of knowledge and expertise, hence the challenges of knowledge-sharing in relation to best climate adaptation practices. Indeed, in addition to grappling with the technicalities of climate science, Woodruff and Stults (2016) found that many "practitioners still do not have a clear idea of what adaptation looks like or how it can be measured: an uncertainty that is mirrored in the academic literature".

Financing adaptation has also been a major issue. As the shift from a strictly climate mitigation approach to an adaptation approach is relatively new, much financial support for climate adaptation has been geared toward the early planning stages of risk assessment and knowledge acquisition for city leaders (Anguelovski and Carmin, 2011; Carmin et al., 2012). Resources assisting in the development of financial tools for adaptation projects are especially thin (Nordgren et al., 2016), leaving cities to innovate in this realm. Here they face constraints in leveraging already existing funds for climate adaptation, let alone acquiring new financing for the implementation of new resilience projects. Decision makers' perception of a lack of resources for urban adaptation planning may influence the selection of sites and approaches used (Hughes, 2015) leading to centralizing protection in wealthier neighborhoods and/or using less effective means in poorer areas, among other issues such as relying on private partnerships. "Given the limited resources available to city governments, it is inevitable that they look to the private sector for financing resilience efforts, but this requires that the programs developed be acceptable to funders" (Fainstein, 2018). Such tradeoffs may further entrench the inequitable distribution of climate protection and further encourage exclusionary methods.

In the meantime, given the many uncertainties, lack of finances and constituent support, many cities are waiting until disaster hits to claim resources for climate adaptation, creating a moral hazard (De Sherbinin et al., 2007). This means that in a strange twist the availability of post-disaster relief creates a lack of incentive to protect populations against climate risks before they occur. This is due in part to the relative lack of focus in funding and partnerships on disaster planning as compared with disaster relief (Harman et al., 2015). However, waiting may also mean constrained rebuilding choices due to public resources being used up by post-disaster relief. In this way, cities may become reliant on development choices, partnerships and private investments that may neglect socially vulnerable populations or even generate harm.

A.iii. Participation and Inclusivity: Moving beyond Constraints?

Adaptation through participatory and community-based adaptation (CBA) approaches, it is argued, helps ensure that marginalized voices are included in the design and selection of adaptation strategies. CBA also builds a sense of citizenship, strengthening local networks (Nay et al., 2014) and social cohesion, and tends to "lead to greater recognition of equity and justice criteria, which are particularly important for the urban poor" (Chu et al., 2016). It is a way to bring together many different actors – municipal and academic institutions of different sectors and disciplines, indigenous groups, youth, donor organizations, etc. – and improve the sustainability of adaptation programs. (Chu et al., 2016) It can result in increased local awareness about climate change, broader impacts, risks and vulnerabilities, while also improving capacities.

Inclusionary processes also provide an opportunity for decision-makers to tap into local knowledge and learn from communities about the impacts they are facing, the ways they are already adapting and how they remain vulnerable (Chu et al., 2016; Forsyth, 2013). Scholars argue that incorporating civil society

groups and local residents to design and select adaptation strategies not only increases the likelihood of achieving effective, locally appropriate outcomes and bolsters the legitimacy of decisions (Pringle & Conway, 2012; cited in Nay et al., 2014), but also helps ensure that they are just and equitable (Ebi, 2009). Community-based approaches are argued to present an important opportunity to develop neighborhoods that have been historically neglected and/or those especially vulnerable to climate change due to high levels of poverty (Huq and Reid, 2007; cited in Dodman and Mitlin, 2013; Harman et al., 2015).

Scholars, however, also question the extent to which participatory planning strategies can achieve the outcomes that enthusiasts would suggest, especially in urban areas. Dodman and Mitlin (2013) argue that "although low-income residents can take many risk-reducing measures, much of the exposure to risk and many of the vulnerabilities faced by these groups come from deficiencies in the provision of infrastructure that cannot be addressed independently (Satterthwaite et al., 2007). This may explain why CBA has been slower to take off in urban areas, although there is a growing interest in its applicability." In this sense, where there is trenchant poverty and inequalities, as well as strong private sector influence and partial democratic representation, inclusivity in adaptation processes will not be enough to achieve just and equitable development outcomes (Chu et al., 2016). Furthermore, little evidence in the way of bottom-up action or pressure for climate adaptation from residents has been found due to a general lack of awareness about climate adaptive options (FEW et al., 2007; Hughes, 2015). In connection with the constraints of achieving adaptation goals, donor agencies and market actors, show little interest in the broader socially transformative goals of a participatory approach, let alone citizen empowerment.

A.iv Critical views on current green practices in urban climate adaptation

Today, as part of urban climate adaptation planning, cities are increasingly turning to green infrastructure, especially existing green stormwater management tools to address climate change associated socio-environmental risks, vulnerabilities and impacts. Green resilient infrastructure (GRI), such as climate-proofed parks, green roofs, rain gardens, trees, wetlands and bioswales, reduce stormwater runoff by increasing permeability, mitigate water pollution and help reduce urban heat island effect. Cities like Boston, Minneapolis, Manchester, Lyon, Medellin and Durban, have already made important strides in this regard by implementing GRI. Green infrastructure solutions to urban climate adaptation are even promoted by supranational organizations and national governments in both the Global North and South. Greening is the most well-established soft mode in cities. The eco-systems services approach which is often operationalized at the local level by planning departments through green infrastructural interventions (Meerow and Newell, 2017) is the most well-known and diffused approach to managing land and water for the benefit of people and the natural environment. Other newer approaches, such as nature-based solutions and eco-system based adaptation are also promoted, branded, and reformulated/repackaged urban greening practices; however, it is yet unclear the extent to which cities are adopting them in discourse or practice (Pauleit et al., 2017).

Their popularity as a no-regrets solution (Mees and Driessen, 2011) and a "win-win" with the lowest tradeoffs is based on several attributes. As a more flexible, multifunctional and cost-efficient means of

addressing climate risks and impacts, green resilient infrastructure are increasingly preferred over repairing traditional grey infrastructure (e.g., storm-water drainage and retention systems, dams and levies) (Pauleit, Zölch, Hansen, Randrup, & Konijnendijk van den Bosch, 2017). Research has also demonstrated the myriad co-benefits of having nearby green spaces such as for residents' health and wellbeing (Tzoulas et al., 2007), through improved cardiovascular, respiratory and immunity-related health, better birth outcomes and overall self-perceived health – especially for women (Markevych et al., 2017). Along these lines, they also provide space for more active transport (such as walking and cycling) and may benefit the quality of life of people with intellectual disabilities or mental health disorders (Triguero-Mas et al., 2020). Greening may also generate a greater sense of belonging and benefit social cohesion in diverse communities, especially through environmental stewardship, community gardening and children's play spaces (Connolly et al., 2013; Haase et al., 2017; Pérez del Pulgar et al., 2020). Studies have also suggested that green stormwater infrastructure may reduce crime and improve sense of safety (Kondo et al., 2015).

Not surprisingly, however, lower-income and minority neighborhoods tend to be those less endowed with green amenities (in terms of quantity and quality). In Los Angeles, for instance, in the early 2000s, areas with a 75% or more Latino population had access to 0.6 park acres per 1,000 residents, against 31.8 park acres for largely white areas (Wolch et al., 2005). Studies also find that in working-class and lower-income neighborhoods, green amenities are typically of lower quality, fewer in number, less well-maintained and smaller than those found in wealthier neighborhoods (Rigolon, 2016; Rigolon et al., 2018). Cities such as San Francisco, CA, like others with high ParkScores (80) – the Trust for Public Land's measure of park quality, – are those associated with high median incomes ($103,801), and low percentages of Latinos (15%) and Blacks (5%). Such trends were often linked with communities heavily hit by deindustrialization, suburbanization, and disinvestment, whereas, wealthier and whiter communities, with higher homeownership rates, are historically environmentally privileged (Park and Pellow, 2011) with nearby parks, waterfronts, and other open spaces. Green inequalities deprive minorities and working-class residents of the numerous co-benefits described above, and neighborhoods deprived of green spaces tend to have worse outcomes for all those factors.

Therefore, the relative cost-effectiveness and multifunctionality of green infrastructure makes it an attractive way to address climate risks and impacts while possibly tackling inequalities associated with green spaces, including climate inequities, and other effects of long-term disinvestment from socially vulnerable neighborhoods. Planting trees, improving existing parks, cleaning vacant lots enhancing street facades, all of these contribute to neighborhood revitalization and to improving residents' quality of life and climate protection. Meanwhile, urban investment in green adaptive measures is also believed to enhance economic development, and improve property values in greened neighborhoods (Heckert and Mennis, 2012), thereby increasing city revenues. In these ways, GRI are also touted for their good economic sense, which has helped to create buy-in for their implementation. For example, the Philadelphia Water Department argued that an expanded approach to green stormwater infrastructure as described in the Green City, Clean Waters plan would generate economic, social and environmental benefits for the city valued at nearly $1.4 billion ($500 million, $1.3 billion, and $400 million, respectively) (Heckert and Rosan, 2016). However, despite so much potential benefit, few cities have actually implemented a greening agenda that would even approach closing the gap in environmental inequalities.

Among the most critical voices, urban environmental justice (EJ) studies and activism highlights and denounces inequalities according to race and class in access to environmental goods and amenities, which together with greater exposure to environmental contamination perpetuate a lower quality of life for historically marginalized groups. The EJ movement arose in response to the dumping of highly toxic waste in a majority African-American community of Warren, North Carolina in 1982 and quickly became a national movement. Those events further spurred extensive and groundbreaking research shedding light on widespread distributional inequities in exposure to contamination and health risks. These studies laid bare that minorities and low-income residents lived closest to polluting facilities (Holifield, Porter, and Walker 2009) traditionally known as locally unwanted land uses (LULUs) and were more likely to experience environmental harms. In addition, scholars found that environmental inequities were exacerbated by the fact that unlike privileged groups, residents of low-income neighborhoods and communities of color routinely received less environmental protection, stemming in part from unequal and neglectful enforcement of environmental protection laws and weak governmental regulatory capacity and oversight of contaminating industries. Environmental racism is a concept which emphasizes that even minority residents with a higher socioeconomic status tend to face disproportionate exposure to contaminating facilities because they are targeted by industries which take advantage of this lesser political power and exclusion from decision-making, in addition to the lower costs associated with siting in their communities. Environmental injustice is therefore rooted in institutions of the state and private industry which both perpetuate exposure to risks and deny protection from harm for communities of color.

The EJ movement contends that every person regardless of race, ethnicity, income, age, and gender has the right to a decent and safe quality of life (Gauna 2008). Defining the environment as any place that people "live, work and play", and not as a "wilderness", a place devoid of people in the way that mainstream environmental organizations tend to portray it (Schlosberg and Collins, 2014). This linked socio-ecological understanding portrays nonhuman nature on the one hand as exacerbating the vulnerability of communities of color and on the other hand as providing healing and health, and a haven in which to overcome trauma and fear of erasure and to remake place (Anguelovski 2013b).

However, an urban green space paradox (Wolch et al., 2014) – described in the literature as green, environmental or ecological gentrification – suggests that the greening of disinvested neighborhoods may actually exacerbate green inequalities through the displacement of socially vulnerable residents (Anguelovski et al., 2017; Gould and Lewis, 2017). As cities pursue an expanded greening agenda, urban research uncovers a green growth machine wherein environmental cleanup and restoration, investment in new green spaces or their rehabilitation, drive changes in demographic trends and increases in neighborhood property values (Gould and Lewis, 2017). As a part of this process, green city branding is used to attract capital investment and economic development especially to central disinvested neighborhoods to stimulate economic growth (Garcia-Lamarca et al 2019). In Atlanta, Georgia, the mere announcement of the future construction of the new green BeltLine to revitalize a mostly abandoned and underused rail corridor led to housing values within 400m of green infrastructure spiking by 30 percent in comparison with similar properties 1.6km away (Immergluck, 2009). A few years later, follow-up research found that housing values increased by 18% and 27% between 2011 and 2015 for properties within 0.8 of the Green Belt (Immergluck and Balan 2018). As this occurs, low-income residents and communities of color may be marginalized and displaced due to increasing unaffordability, exclusion, and the erasure of local commerce and services. Greening may increasingly be perceived as a LULU

(locally unwanted land use) (Anguelovski, 2016). Therefore, in the green space paradox, socially vulnerable residents who could most benefit from environmental amenities become those most excluded from their long-term enjoyment.

Extending this literature on green gentrification, several scholars have very recently begun theorizing a similar trend in relation to climate change risks and adaptation, calling it climate gentrification. Jesse Keenan and colleagues (Keenan et al., 2018) defined the broader parameters of this emerging theory based on the proposition that "climate change impacts arguably make some property more or less valuable by virtue of its capacity to accommodate a certain density of human settlement and its associated infrastructure." Based on the idea that urban development patterns influenced by "price volatility" may lead to gentrification and displacement, the authors hypothesize three climate gentrification pathways. The first stipulates that high-income groups will move away from high-risk areas, where for example there can be devastating loss due to sea-level rise; moving instead to lower climate risk, lower to middle-income areas (e.g., Little Haiti, Miami, Florida). A second pathway hypothesizes cases in which only the wealthy can afford to live in high-risk areas. In such places (e.g., Mestre, Venice, Italy), those with the means to afford rebuilding privately in the aftermath of climate impacts or better adapting to climate risks while less affluent residents will be forced to retreat. A third proposed pathway has to do with public investment in climate resilience (e.g., Norrebro, Copenhagen, Denmark). This suggests that new climate resilient infrastructure may indirectly increase local property values, and thus price out working class and middle-class residents. This pathway extends green gentrification scholarship, which investigates how investments in green amenities are unevenly distributed and may result in the displacement of socially vulnerable groups via gentrification.

Other climate gentrification scholarship corroborates, refines or presents new pathways to the above model. In a study of the equity impacts of climate adaptation in 8 cities, Anguelovski and colleagues (2016) find that in several cities adaptation actions through grey and green resilient infrastructure directly displace low-income residents both immediately or over time. Aune and colleagues (2020) find that in New Orleans higher ground neighborhoods were more likely to have gentrified after Hurricane Katrina, having attracted whiter, wealthier and more educated residents. These results support the first climate gentrification hypothesis. On the other hand, Gould and Lewis (2018) argue that the higher elevation hypothesis may be less visible in New York City's hot urban real estate markets where the attraction of waterfront properties still overcomes concerns over climate change effects such as sea level rise and coastal flooding. They find that climate risk mitigation by resilient infrastructure – which bears similarity to the third hypothesis – is more likely to explain climate gentrification in NYC which would be driven by the "sustainability class" elite who can afford increased building costs associated with structural mitigation. They call this effect, resilience gentrification. Other studies investigate a form of climate gentrification also referred to as "low-carbon gentrification" that also resembles the third hypothesis and the concept of resilience gentrification. Bouzarovski and colleagues (2018) find that gentrification in Gdansk is the result of a state-led and EU effort to improve housing through energy efficiency retrofits, rather than market driven as Keenan and colleagues posit in their paper. Rice and colleagues (2020) describe a case in which the gentrification of a Seattle neighborhood may paradoxically generate increased carbon emissions through new wealthier residents' higher-consumption lifestyles despite city investments in the new low-carbon infrastructure that has attracted them. These findings may contribute to the second and third climate gentrification hypotheses by

suggesting that only the wealthy can continue to live in a retrofitted neighborhood despite its worsening climate conditions. It goes a further step by implicating the sustainability class in the actual process of climate change. These studies, overall, take a more critical stance toward climate gentrification than the Keenan et al study, by linking the concept with racialized residential displacement, the green growth machine, the politics of housing improvements and urban regeneration and contradictions in climate benefits despite the implementation of resilient infrastructure.

While the scholarly research on climate adaptation has long been engaged in questions of equity and vulnerability of low-income populations (Carmin et al., 2012; De Sherbinin et al., 2007; Huq et al., 2007), most of this attention has been focused at the global or national scale, with the idea of a double inequity or double injustice: the poorest groups or nations, least responsible for climate change are those made most vulnerable to its impacts (Füssel, 2010; Gough, 2011). Climate adaptive interventions aim to begin repairing that gap by examining possible solutions to provide greater security against climate risks and vulnerabilities for lower-income nations. However, Roberts and Parks (2007) have raised the issue of "triple inequality" in which the poor are also the least likely to benefit from climate adaptation and mitigation efforts and are having to pay disproportionately for them. Missing from this discussion are the inequalities in climate impacts and protection as experienced at the local level, taking into consideration the uneven social and racialized landscape of cities.

Stemming from a grassroots and community-based perspective, climate justice is conceptualized by the EJ movement as a recognition of the disproportionate climate risk and vulnerability borne by minorities and built on preexisting injustices and vulnerabilities, and therefore the need for more equitable distribution of climate protection and disaster response as well as the inclusion of communities of color in decision-making processes about climate mitigation and the adaptation of their neighborhoods. This view has been missing from other climate justice conceptualizations by NGOs, governments and academia which tend to focus on influencing elite policy circles at the international level. Traditional climate activists have also tended to hold an uncritical view of global capital and market-led approaches to climate mitigation and adaptation. EJ has therefore brought the issue of the unevenly felt impacts of climate change on communities of color to the climate justice discussion and questioned the dominant growth based-model from which many adaptation choices tend to emerge (Schlosberg and Collins, 2014).

From the EJ perspective on climate justice, addressing climate change is seen as an opportunity to also address other EJ issues by for example reducing climate vulnerability through weatherizing and improving the energy efficiency of homes while also mitigating lead poisoning through the replacement of doors and windows. These adaptation tactics provide immediate protection against everyday climate risks and other environmental hazards long known in EJ neighborhoods. However, they may only achieve incremental change for communities of color. The kind of deep transformational change – redressing the actual drivers of social vulnerability and dominant structures of oppression and inequality – that the EJ movement hopes for may take very long to achieve via this linear, incremental approach, if ever, for it raises the question asked by some scholars of whether incremental adaptation can lead to transformation. Can adjustments to urban neighborhoods via the popularly espoused green resilient interventions lead to transformation that actually eliminates unsustainable and equitable development pathways or do they only strengthen adaptive capacity and build resilience at best? Furthermore, through an analysis of the green and emergent climate gentrification scholarship, it may also ask what kind of transformation can be expected via climate resilience action and who ultimately benefits if a

transformed neighborhood is one that has displaced socially vulnerable residents? A *just* transformation may need to consider the longer-term consequences of adaptation and resilience initiatives for historically marginalized groups.

At the city-scale the link is revealed between social and spatial injustices: how vulnerable populations are subjected to locally unwanted land uses, but also denied protection and remediation. This uneven terrain of adaptive, protective infrastructure seems to unfold at the sub-municipal scale; however, its nuances remain relatively under-examined for resilient and climate adaptive infrastructure. Rather, there has been an under-problematized promotion of green and resilient solutions as inherently good and beneficial for all (Anguelovski et al., 2016; Fainstein, 2015). Recently, however, critical scholars are questioning the greenwashing of resilience and the supposed "win-win" value of these strategies, suggesting that "urban economic actors may be employing the rhetoric of climate resilience to entrench speculative, exclusionary, or unsustainable practices, thus exacerbating historic injustices associated with infrastructure and land use development (Sovacool, Linnér, and Goodsite 2015, cited in Anguelovski et al., 2016)". From this perspective, research is needed to understand how exclusionary development via climate resilience may be implicated in the gentrification and displacement of , a more In the next section, I outline the questions that these scholars are raising and the current state of the research in this arena, with some suggestions for how I could advance it through my research.

Part B.

B.i Early research linking the social with ecological systems and resilience

In 1973, a new publication entitled Resilience and Stability of Ecological Systems by C.S. Holling (1973), an ecologist at the University of Florida, set the stage for a wide-ranging area of study that over the next 40 years shaped a number of disciplines, including urban planning and city governance. Holling argued that ecological systems were characterized more by their populations' ability to *persist* through high variability, rather than their capacity to *stabilize*. He termed this characteristic property of systems, 'resilience', defining it as "the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973, p. 14). His reframing of the traditional ecological stability model evoked a new approach to uncertainty, surprise and unpredictability in ecosystems, rather than the conventional idea of their controllability (Davoudi, 2016; Walker and Cooper, 2011; Watts, 2015). Over time, through interactive workshops with scientists and policy-makers in the 1970s and 1980s, Holling and his colleagues at the Resilience Alliance[4] and later the Stockholm Resilience Center, developed new explanatory models and policy recommendations promoting an adaptive ecosystem management process emphasizing the need to "learn to manage by change" (Folke, 2006) which became a precursor for expanding the resilience perspective well beyond the environmental sciences (Walker and Cooper, 2011) and to the development of a social-ecological systems (SES) research area .

[4] "a research organization that focuses on resilience in social-ecological systems as a basis for sustainability"

The emergence in the mid-1990s of SES scholarship came in part through the claim that, while on the one hand ecologists have long ignored the relevance of human intervention on nearly all dimensions of the environment, as well as environmental impacts on humans, social scientists have likewise failed to incorporate environmental concerns and a deeper understanding of ecological relations of a substantive nature in research on social issues (Berkes et al., 1998). An integrated social-ecological systems perspective therefore conceptualizes human and non-human natural systems as interlinked and interdependent, a key shift in thinking about changes in climate patterns and warming, which supports placing anthropogenic causes at the center of explanations for so-called natural disasters (Berkes et al., 2003).

In ensuing years, Holling and colleagues from the Resilience Alliance developed what they called the 'panarchy model' of adaptive renewal (Gunderson and Holling, 2002). Differing from the engineering model of resilience in which systems bounce back to a pre-crisis state, this *evolutionary* model of resilience (Davoudi, 2016) describes a "bouncing forward" (Shaw, 2012) to a new state: "when systems collapse, 'a window of opportunity' (Olsson et al., 2006) opens up for alternative systems configuration", innovation and the possibility for transformation (Davoudi et al., 2012). The panarchy model (fig. 1) assumes that uncertainty, unpredictability, and crisis is inherent to the social-ecological system and that adaptation is ultimately necessary (Watts, 2015, p. 37).

Critics, however, argue that despite the language of transformation, a conservative view of social change underlies the panarchy perspective, due in part to its insistence on constant adaptation to crisis. Furthermore, as some have observed, that both humans and ecosystems adapt and might be managed in much the same way (Walker and Cooper, 2011) is a proposition that is so distant from issues of politics, power, and equity (Cote and Nightingale, 2012; Meerow et al., 2016) and abstracted from human vulnerability that it could lead to a kind of social Darwinism (Turner, 2014). In this sense, overall system resilience – including its structural inequalities – may be prioritized over the reduction of human vulnerabilities which occur in diverse forms and unevenly across urban areas and social groups. These human vulnerabilities are not due to "natural" causes but rather to human-induced conditions (e.g., anthropogenic climate change and institutional racial inequities).

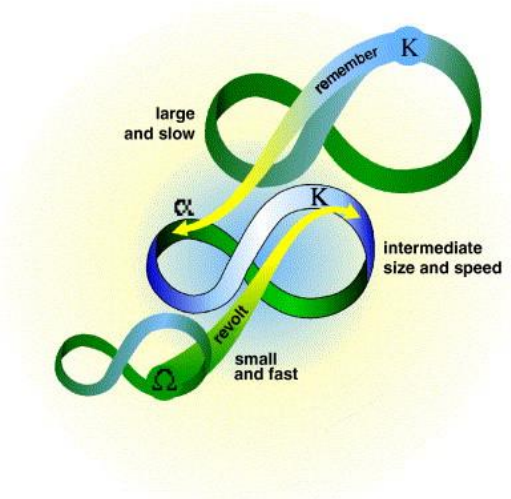

Figure 1: Panarchy Model

SES and resilience theory was not initially rooted in social scientific thought and theory. Even when social scientists engaged with it, they tended to be examining it from a non-urban context. As a result, the application of SES and resilience thinking to urban contexts in a way that appreciates the full complexity of urban social systems is new. There is room to further explore the impact of integrating a social-ecological systems management approach on racialized geographies, social relations and everyday life, particularly in the urban realm where these socio-spatial relations are dynamic, contentious and inequitable, and where the resilience concept has become an increasingly popular paradigm in planning theory and practice.

A.ii A New Urban Resilience Paradigm

In recent years, the resilience perspective has increasingly been applied to describe city systems in response to a disaster (Meerow et al., 2016; Stumpp, 2013; Vale, 2014) and as an all-encompassing solution (Fainstein, 2015) to a slew of concerns from rapid urbanization, urban unrest, greenhouse gas emissions, and vulnerability to climate change impacts such as heat waves and severe flooding. Urban resilience has become an increasingly favored concept (Carmin, Nadkarni, & Rhie, 2012; Leichenko, 2011) (Meerow et al., 2016) superseding sustainability as the new urban orthodoxy (Long and Rice, 2019). This has occurred, however, within the context of an incomplete and often narrow effort to reconcile the lack of a social scientific and urban lens within the SES approach that spawned the resilience framework.

Moving away from Holling's original descriptive use, the social-ecological systems perspective has been commonly mobilized within urban planning to promote resilience as a heuristic approach, "a way of thinking that presents a perspective for guiding and organizing thought (Folke et al., 2002; Folke 2006)." Just as adaptability and adaptive cycles are a key aspect of the complex adaptive systems model that shapes thinking in other realms (Wilkinson, 2011), the concept of resilience has also proven to be a 'boundary object': "a term that facilitates communication across disciplinary borders by creating shared vocabulary although the understanding of the parties would differ regarding the precise meaning (Star and Griesemer 1989)" (Brand and Jax, 2007). The conceptual malleability of resilience facilitates its uptake across academic disciplines, a useful tool for translating between science and policy (Eser 2002, Cash et al. 2003; cited in (Brand and Jax, 2007) and may even engender cross-sector collaboration among practitioners. Further, it may benefit urban planning processes which have tended to ignore environmental issues while increasing awareness among environmental practitioners of social needs and impacts (Wilkinson, 2012).

However, resilience does not translate directly from the environmental systems that it was developed to describe into city systems, and efforts to do such a direct translation garner critics from those who are focused on cities and the social construction of nature. These scholars caution against the pitfalls of "traveling ideas" when they are assumed to have similar application in vastly different contexts. The conceptual vagueness of boundary objects is precisely what makes resilience a concept with wide currency, but it is also what makes it problematic for analytical and normative use (Brand and Jax, 2007; Fainstein, 2015; Pizzo, 2015; Wilkinson, 2012). The array of objectives to which the resilience concept is applied expands the scope of plans with the potential consequence of sacrificing important details. Chief among what is often sacrificed is a view on how tradeoffs between objectives lead to inevitable unequal distribution of costs and benefits (Fainstein, 2018).

With the dangers of an overly facile application of resilience to cities in mind, many researchers warn that it has become a buzzword in danger of having all of its substantive meaning hollowed out (Davoudi et al., 2012; Meerow et al., 2016; Stumpp, 2013; Vale, 2014). Its "potential to transform the framing of planning problems and interventions" and justify many ends deserves greater scrutiny (Davoudi et al., 2012, p. xxx). The *100 Resilient Cities* program of the Rockefeller Foundation (2013-2019), for example, popularized urban resilience to guide action across a breadth of urban issues. "The largest coordinated

effort at implementing resilience thinking into city planning processes internationally" (Fitzgibbons and Mitchell, 2019, p. 648), the competitive program awarded funding and logistical guidance to cities that hired a chief resilience officer, whose role it was to connect disparate departments, developing and implementing "a holistic resilience strategy that reflects each city's distinct needs"[5]. Although the program is now obsolete, it helped define how a variety of "shocks" from severe weather events to urban unrest and terrorist attacks, as well as, slower transformations such as urban poverty, racial inequity, and food desertification might be managed through a city resilience strategy. However, without an explicit goal to address structural inequality, few cities have made it a priority and may even have adopted resilience strategies that threaten progress toward equity and justice (Fitzgibbons and Mitchell, 2019).

Scholars have illustrated parallels between the genealogy of resilience and the emergence of neoliberalism (Walker and Cooper, 2011), and therefore the inscription of neoliberal principles into resilience planning and policy making (Fainstein, 2018). Walker and Cooper argue that "the success of this ecological concept in colonizing multiple arenas of governance is due to its intuitive ideological fit with a neoliberal philosophy of complex adaptive systems" (2011, p. 144) in the sense that it reflects the classical economic notion of an "invisible hand", comprised in this case of an unknowable metaphysical process, guiding individuals' decision-making. Walker and Cooper also point to the growing integration of the governance of ecological risk with security practices and a 'culture of preparedness'. Environmental security and security from human threat saw the merging of competencies between environmental protection and national/homeland security agencies, first in the US, but also globally. Such confluences suggest that the tools of 'resilience thinking' are adaptable to securitizing the system no matter who or what precisely constitutes the system or the disaster. This reemphasizes the critique that transformation -- radical change to correct structural inequities -- would be beyond its reach (Fainstein, 2015; Friend and Moench, 2013; Meerow and Newell, 2016; Pelling, 2011; Vale, 2014), even if the act of consolidating so many city systems and institutions under one mode of thought may be radical in and of itself.

In recent years, scholarly attention to these matters has led to calls for examining how resilience is being operationalized at the city scale and the impacts of resiliency frameworks on power, conflict and culture in cities (Fainstein, 2015; Matyas and Pelling, 2015; Wilkinson, 2012). These approaches to resilience draw attention to the need to think about the who, what, where, when, why and how of resilience; particularly, they ask resilience for whom and for what, and who benefits? (Meerow and Newell, 2016; Vale, 2014; Wilkinson, 2012). Critical climate adaptation scholars (Anguelovski et al., 2016; Hardy et al., 2017; Ranganathan and Bratman, 2019; Ziervogel et al., 2017) are recently beginning to investigate the equity impacts of urban resiliency planning and tie these issues to questions of justice and rights. Thus, research on resilience is tied into larger efforts to examine how urban development, security and complexity governs and shapes urban social-ecological relations and everyday life.

A deeper reckoning with social thought and theory is underway with regard for urban resilience. Increasingly social, cultural and political critiques of social-ecological resilience raise questions about the possibility for a true system transformation when certain elements are resistant to change.

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[5] https://resilientcitiesnetwork.org/downloadable_resources/UR/Resilient-Cities-Resilient-Lives-Learning-from-the-100RC-Network.pdf

Part C. Culture, cities and justice: is a critical resilience possible?

Various sudden and unexpected disasters including hurricanes and terrorist attacks motivated some of the early scholarly works on urban resilience. This early turn toward the urban perspective examined social and institutional responses to the devastation, but also to attempts to recover and rebuild the city and the process of rehabilitating the social fabric by bringing residents back after a disaster (Vale & Campanella, 2005; Campanella, 2006). This emergent urban resilience frame emphasized rebuilding social networks and relations and the identity of the place. Citizen involvement and community self-organization, supported by institutions, were key to moving toward a full recovery (Graham et al., 2016) that included emotional and psychological healing. At the heart of this work was the question of "*who* counts as 'the city'?" (And *who* decides who counts as 'the city'?) (Vale, 2014).

Cote and Nightingale (2012, p. 481) picked up on the importance of the social construction of resilience in the urban setting. In their words, "much would be gained from investigating the kinds of cultural commitments and political relations that underlie the persistence of certain policy framings that are locked into equilibrium views and individualistic logics of many environmental and development policies." This signaled a stark and important break from the ecological theories that spawned the SES framework for resilience. SES scholars have long left of the politics of social and cultural relations in a vague and seemingly neutral category to the side of their observations. SES was not concerned with justice or rights, power or exclusion. More recently, urban resilience and SES urban planning scholars have combined thinking in a way that draws attention to account for who, what, where, when, why and how resilience occurs: the questions of resilience for whom and for what and who benefits? (Meerow and Newell, 2016; Vale, 2014; Wilkinson, 2012). Still, conflict, culture and politics are deeply undertheorized in the resilience paradigm relative to wider urban and planning theory (Wilkinson, 2012).

In the United States, critical scholars recently have been demonstrating one example of why a deeper connection with social processes is needed in order to arrive at a robust understanding of urban resilience. These scholars have shown the persistence of White Supremacist and settler colonial logics in urban and environmental planning (Connolly and Anguelovski, 2021; Pulido, 2015; Safransky, 2017). Such logics derive from underlying dynamics that shape land use in the city. If urban resilience is developed in a manner that is divorced from a recognition of these underlying dynamics, it too will reify those same white supremacist notions and, scholarship in this area argues, only reduce the resilience and adaptive capacity of certain racialized and systemically marginalized people (Hardy et al., 2017; Ranganathan and Bratman, 2019).

On the other hand, preserving local cultural ties, practices, and traditions can be seen as key community resilience traits in the context of disturbances. These cultural bonds and socially cohesive factors attest to the existing strength of social networks and place attachments. Among communities faced with displacement, those that manage to oppose the construction of exclusionary "ecological enclaves", may even see their resilience bolstered (Pearsall, 2012; Pearsall and Anguelovski, 2016). Such experiences might transform identities, structures and functions in these communities into cultures that identify more closely with place-based struggle for emancipation.

The extent of change embedded in community processes relates to the question of whether resilience initiatives are associated with incremental or transformational goals. Mark Pelling (2011) identifies three adaptation pathways, one leading to resilience which entails preserving or protecting existing conditions, a second to transition or adjustment via incremental change and a third to transformation via radical change. In practice resilience initiatives may preserve and protect aspects of the status quo while also supporting transition or transformation. Robert Kates and colleagues (2012, p. 7156) suggest that "the differences between incremental and transformational adaptations may not always be clear-cut". The extent of a particular adjustment may be more telling than the type of adjustment, such as a massive seawall that fundamentally changes coastal land uses. Likewise, the cumulative effect of smaller adjustments may prove to be transformative depending on the scale of analysis, intensity, newness, locational shift, and length of time over which the change is sustained (Kates et al., 2012). Ultimately, whose interests are served by change is for Pelling a key question, with its answer, he contends, rooted in the social relations of power between agency (of social capital) and structure (or institutions) (Pelling, 2011; Pelling and Manuel-Navarrete, 2011). To attempt to guide the outcome of these dynamics, Karen O'Brien (2012) argues for deliberate transformation as a key response to climate change, that is, transformation that is directional or purposive, and which may involve questioning values, beliefs, identities and assumptions underlying the systems and structures driving environmental degradation and social vulnerability. Thus, Pelling and O'Brien argue for a normative interpretation of transformation that distinguishes itself from incremental change, as one in which change via adaptation is directed at shifting the existing social-ecological system onto an alternative development pathway:

> *This positioning of transformation pushes decision-makers and those assessing adaptive capacity and action to extend their concerns from the proximate causes of risk (e.g., dwelling quality, livelihood structure or demographic characteristics) to its structural or root causes (e.g., social, cultural and economic relationships, power hierarchies) (Wisner et al. 2004), and to justify choices made between incremental and transformative agendas of change."*

Often the type of change that accompanies community-based resilience processes relates to how disturbances are perceived. Disturbance in community stability is perhaps too easily characterized sometimes in terms that either set social and ethnic groups against one another or construct nature as an indiscriminate force. However, disturbance in a community's wellbeing can also be attributed to underlying historical-geographic processes guided by racialized, gendered and elitist ideologies, constructed at higher structural and institutional scales and maintained through ongoing discourses, processes and practices. This is the approach taken by a field of critical urban theorists informed by the political ecology framework, which "more explicitly recognizes that material conditions that comprise urban environments are controlled, manipulated and serve the interests of the elite at the expense of marginalized populations (Swyngedouw 2004a). These conditions, in turn, are not independent from social, political and economic processes and from cultural constructions of what constitutes the "urban" or the "natural" (Kaika and Swyngedouw 1999; Kaika 2005)." (Heynen et al., 2006a, p#).

For urban political ecologists, these socio-spatial and socio-ecological questions about the dynamics between identities, disturbances, change and stability have to do with questions related to how social systems direct urban outcomes according to a logic of extraction of value from nature. While urban

political ecologists do not necessarily frame these matters as questions of justice, the inequitable social and ecological outcomes of such extractive logics, raises the issue. Climate adaptive urbanism that favors those in power, points toward a model of resilience that does so as well, with direct implications for distributive and procedural forms of justice, as well as recognition of social groups in matters of resilience. On the one hand there are the material questions of justice – the fair distribution of environmental protections and amenities, and a voice in decision-making. And on the other, there are the cultural, symbolic and affective aspects of justice. Who is valued, which relations are produced? Who shapes and how are these hierarchies and priorities, inter-relations and interactions shaped? All of these questions can and have been leveled at urban resilience.

While these are in part questions related to a classic understanding of social justice, going one step further, Setha Low (2013) draws on the work of Fincher and Iveson (2008) calling for a more relational understanding of diversity as it informs just outcomes in the green climate resilient city. Based on an ethnographic study of two parks, she argues for the need to address a particular kind of injustice having to do with everyday life experiences in public spaces. "The concept of *interactional justice* is about the quality of interpersonal interaction in a specific situation or place" (Low, 2013), an experience that is not lived equally by all. Indeed, recent work on mis-recognition (Hopkins et al., 2017) shows how recognition is not always in a linear relationship with justice, nor are all minorities perceived equally. Other work on multi-ethnic encounters in public spaces (Amin, 2002; Valentine, 2008) illustrates how, despite hopes for the intercultural, cosmopolitan "good city" (Amin, 2006; Sandercock, 2009; Thrift, 2005), living with difference does not necessarily mean that one becomes or acts in a more civil, open-minded or compassionate way toward 'strangers'. This work suggests that it is not enough to live side-by-side; rather, that change must be cultivated consciously and conscientiously, in safe spaces and organized encounters, through what Leonie Sandercock (2003) refers to as a process of "cultural destabilization and transformation" (cited in Valentine, 2008)).

In all, to see urban resilience as a conscious engagement with the forces of destabilization and a conscientious effort to shape the push toward stabilization behooves us to seek a model for critical urban resilience, and three key areas of thinking will shape this model. First, as outlined in the previous section, the concept of resilience, and of urban resilience in particular, has largely developed out of an interest in managing social and societal responses to shocks and catastrophes of all kinds (Godschalk, 2003; Tidball and Krasny, 2014; Vale and Campanella, 2005; Walker and Cooper, 2011). Resilience today is being promoted more from the natural hazards' perspective, calling for an interweaving of anti-terrorism resilience and climate resilience, seen for example in the activities of 100 Resilient Cities, but also in the merging of national security and environmental protection agencies. Despite calls for social and ecological linking, resilience, from this top-down perspective, tends to maintain a dualistic view of human-nature relations, but also human to human relations. On the one hand, it sees humans as victims of natural catastrophes, in need of protection: Nature is out there, unpredictable, out of control. On the other hand, it depicts some humans as threats to others humans, who are respectively in need of control/discipline and protection. In this way, the resilience rhetoric has coupled a fear of Nature with a fear of the Other, and further implied an urgency to act. A politics of fear underlies the discourse about resilience and human vulnerability to environmental disasters, financial crises, and terrorism.

The coupled politics of fear of nature and the Other that, in some ways, forms the parallel track for the politics of resilience has deep implications for how we do or do not support sociability in urban space within the green resilient city. Low (2011) attempts to go beyond sociological explanations for

sociability, and connects personal narratives with media coverage of geopolitical events and issues. She demonstrates the degree to which ideologies, behaviors and interactions are socially and politically constructed and mediated and draws our thinking on local resilience initiatives toward global dynamics. What Low uncovers through discourse analysis and that she points to in others' work (Røyrvik, 2010) is "the securitization of the social and the sociality of securitization that create distrust and distancing, cultures of fear, militarism, and deep patterns of global inequality" (p. 398). She connects this global experience with what arises from interviews conducted in the homes of residents of gated communities: "It is this interweaving of space, governance, and financial and legal institutions that is so politically and socially powerful, especially when evoked by residents' fear or anxiety about Others and the desire to live with 'people like us' (p. 402)."

To the extent that resilience is about increasing community securitization, it generates urban spaces of distrust and norms for cities wherein those deemed other are only increasingly marginalized. The production of space is shaped by precisely the types of normative codes of behavior that Low highlights, and Gill Valentine uncovers in encounters: "Encounters in public space therefore always carry with them a set of contextual expectations about appropriate ways of behaving which regulate our coexistence" (2008, p. 329). Valentine argues for "the need for geographers to pay more attention to sociospatial inequalities and the insecurities they breed, and to unpack the complex and intersecting ways in which power operates" (p. 335). With the corresponding changes in public space due to neoliberalism and a climate of fear, it is necessary that social scientists, managers, planners and designers develop clearer arguments about the substantive basis by which these changes can be considered unjust (Low, 2013), but Low (2013) also argues that it is "essential to address the multiple kinds of *perceived* injustice" in the distributive, procedural and interactional dimensions. In all, the push toward urban resilience has to be considered relative to these deeper threads of urbanism because it shapes and is shaped by these threads.

The second area of emerging thinking on critical urban resilience relates to the implications for cities of integrating resilience in planning and governance. This move has significant implications for the equity of socio-spatial outcomes and uneven contours of socio-environmental control and discipline (Low, 2013). A growing number of academics point to "the governmentalization of 'nature' and the 'environment'" which they claim has given rise to an "urban eco-geopolitics of environmental protection and securitization" (Lopes de Souza, 2016). In other words, underneath discourses of environmental protection and security, we can likely find practices of socio-spatial control and state-led (or industry-led) disciplining of people's movements and practices. Using the example of Rio de Janiero, Lopes de Souza (2016), shows how the 'environmental risk' that a favela neighborhood was designated to allegedly present eventually became a pretext for creating a buffer zone and justifying evictions. To this was added what he calls an argument of "'environmental risk' that certain spaces (read: the people living in these spaces) supposedly represent." What he observes in Rio, is more than land seizure, however, and rather an explicit 'gentrifying conservationism', a political strategy using the guise of environmental protection to accumulate land in such spaces for eventual elite residential projects. Land is taken materially and changed symbolically. The governmentalization of nature, employs urban planning and branding tools, allows for the stigmatization and seizure of environmentally at-risk areas to make way for gentrification and new locally unwanted land uses.

Lopes de Souza's thesis presents a case of fear of Nature/fear of the Other shaped by the political strategies and structural tactics used by a state government apparatus, but probably also private

industry actors. Drawing on ethnographic research on urban geopolitics, other scholars (Feldman, 2014) have also shown that the local plays more than a theoretical role in the production of security policies in the name of governing risk for the purpose of generating a more resilient city. Anguelovski and colleagues (2019) argue that this logic determines land grabbing practices in Medellin, where a massive new greenbelt is displacing longstanding informal communities in the name of reducing ecological risk, but also of making the city more appealing to global elites. Meanwhile, Tulumello (2017) argues that in some cases there is pushback at the urban level, for in the end it is the civil servants and local leadership that must see through the implementation of these projects imagined elsewhere. Furthermore, community groups do not always sit idly by, especially when faced with gentrification, landgrabbing and evictions. More research is needed to understand how the resilience of culture in place interacts with urban, top-down resilience discourses and practices.

Finally, a third emerging area of thought relative to critical urban resilience relates to the politics of emotion and encounters shaped by the geopolitics of fear. The emotions, "embodied, affective responses to change" (Butcher, 2016) generated by a biopolitics of fear and the "securitization fix" proposed by urban resilience are under-assessed and undervalued in political economy discussions about power, agency, and change. Adaptation and resilience have roots in the psychological, social-psychological and anthropological disciplines as well as ecology (Watts, 2015), meaning that emotion, affect and culture are deeply engrained in the discourses and practices of resilience and adaptation. However, the social science discussion and critique of urban resilience and climate adaptation tends to focus on institutional conflicts and resource constraints, and where "relational social space" is broached, this analysis tends to be limited to "the outer world of interactions between individuals, groups and institutions" (Pelling, 2011).

Social vulnerabilities generated from past and ongoing environmental racism, securitization and disinvestment of capital from minoritized neighborhoods (Brownlow, 2006), in addition to disproportionate climate impacts, are aspects of the lived experience of communities of color which shape residents' perceptions of risk and adaptive capacity (Grothmann and Patt, 2005). Choosing adaptive pathways that also help overcome these historical entrenchments, calls for attention to the "inner worlds of emotion and affect – value, identity, desire, fear – that give shape or meaning to, as well as being drivers for, public actions including adaptation choices (Pelling, 2011)". These inner worlds also define how people perceive and experience the urban as a relational social space, their neighborhood way of life, and sense of belonging. If the aim is more transformative change, then these motivations behind resilience-seeking initiatives by people at risk need not be ignored.

A key question here is the extent to which ecological risk creates a "security moment" (Goldstein 2010) and a politics and culture of fear, to which many scholars refer (Brownlow, 2006; Lopes de Souza, 2016; Low, 2001). It then needs to be asked whether this security moment generates interactional injustices through everyday practices and how they are experienced and responded to. Fear embeds in cognition and behaviors but also in the production of urban environments. What types of social and cultural transformations are responding, contesting, and submitting to these environmental and institutional changes? It is necessary to understand the extent to which these discourses transform attitudes, emotions and bodies, and their connections with and between health and social cohesion. To explore these connections, what is needed, first, is a clearer understanding of how urban resilience is operationalized in the city by way of adaptive structures that not only protect vulnerable people from environmental risks, but which have cultural meaning and with which citizens interact in ordinary ways.

These adaptive structures, then are a lens into the major emerging areas of thought related to a model of critical urban resilience.

Part. D. Research Gaps, and Objectives, and Overarching Research Design

D.i. A Move toward Critical and Just Urban Adaptation and Resilience

Three key research gaps emerge from my review of the scholarly literature. First, although differential climate impacts, unequal protections and adaptive capacities are well identified in recent climate adaptation scholarship, the role of green resilience planning in relation to changing patterns of uneven urban development and racialized landscapes, remains underexplored. Chapter Two contributes to addressing this gap through a study of climate gentrification and an analysis of the new patterns of urban change that emerge from the siting of green resilient infrastructure, in particular whether they may render historically marginalized populations more vulnerable and less secure, while benefiting more privileged new residents.

Second, Shi and colleagues (Shi et al., 2016) contend that "few studies have documented the barriers to redressing the drivers of social vulnerability as part of urban climate change adaptation efforts, or evaluated how emerging adaptation plans impact marginalized groups." Vulnerability studies tend to lack a long view because they fail to acknowledge neighborhood change through gentrification and displacement. Chapter Three goes beyond studies of vulnerability to climate impacts or ecological risk forecasting to examine the structural and contextual drivers of social vulnerability embedded in growth-driven neighborhood (re)development strategies in order to predict future outcomes of green resilience planning and infrastructure for communities of color.

Third, while scholarship on adaptation has examined power asymmetries in the planning process, the socio-cultural dimensions of the lived experience of the new planning orthodoxy of urban resilience remains underexplored. This is the last gap my dissertation studies. Chapter Four investigates therefore the impacts for sense of belonging and placemaking of an urbanism centered on a conservative understanding of risk and resilience through neoliberal and neo-settler strategies.

The end result of this work is an ability to speak to some of the emerging areas of thought around critical urban resilience. In particular my literature review has identified three issues, with the first related to a politics of fear that may underlie the popularization of the urban resilience paradigm and therefore find its way into the logics of many resilience planning initiatives and interventions. The second has to do with the increasing tendency of urban resilience to be operationalized not as a description of grassroots responses in the aftermath of a disaster, but as a normative, top-down process of organizing communities and planning for disaster that operates as a mode of governance and perhaps, governmentality. And lastly, a third issue emerges from the scholarship having to do with how the growing urban resilience orthodoxy shapes emotion and encounter in everyday life but also how affect drives adaptation choices and adaptive capacity.

D.ii Research Strategy and Design (Methods, site selection, research limitations)

Research Question	Study Focus	Methods	Data Collection	Output
To extent to do green and resilient interventions protect vulnerable groups, or, on the contrary, result in new inequities and insecurities?		Spatial and quantitative analysis of GRI and gentrification		Chapter Two article published in *Urban Climate (2020)*
To what extent will planned green resilience infrastructure intensify inequities and vulnerability to gentrification or, in contrast, are social support services and anti-displacement infrastructure sufficient for adaptive capacity?		Spatial and quantitative cluster analysis of individual vulnerability to gentrification indicators, plus in-depth case study of neighborhood sensitivity and adaptive capacity to future climate gentrification	Collected open-source data to create more than 20 indicators, 16 semi-structured interviews, and a review of relevant policy, non-profit and planning documents	Chapter Three article published in *Housing Policy Debate* (2021), special edition on Housing Policy and Climate Change
How are collective senses of belonging shaped and (re)configured through green climate resilient infrastructure? What do those pathways of belonging mean for urban climate justice?		In-depth case study	15 semi-structured interviews, plus 17 more for case background;	Chapter Four article submitted to *XXXXXX*

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Chapter 2 - Understanding climate gentrification and shifting landscapes of protection and vulnerability in green resilient Philadelphia

Abstract

As resilience strategies become a prominent orthodoxy in city planning, green infrastructure is increasingly deployed to enhance protection from climate risks and impacts. Yet, little is known about the social and racial impacts of such interventions citywide. In response, our study uses a quantitative and spatial analytical approach to assess whether interventions we call "green resilient infrastructure" (GRI) protect social groups traditionally most at risk and/or least able to adapt to climate impacts – or conversely, if the aggregate effect is maladaptive and inequitable outcomes (i.e. shifting vulnerability or climate gentrification). First, we performed a pre-post test of GRI siting distribution relative to socio-ecological vulnerability in Philadelphia neighborhoods. Second, we examined gentrification trends in relation to GRI siting and whether these interventions contribute to increasing the socio-ecological vulnerability of historically marginalized populations. Our findings point to a strong negative association between GRI siting and increased minority population, and a strong positive association between GRI siting, gentrification, and reduced minority population. The paper contributes to a better understanding of siting inequities in climate protective land-use measures and offers a new conceptual frame for critical urban adaptation research and practice of the pathways that shape uneven and unjust outcomes.

Keywords: Adaptation planning; Urban resilience; Green infrastructure; Vulnerability; Climate gentrification; Climate justice

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1. Introduction

As strategies to "build resilience" gain urgency and prominence in city planning, green infrastructure – rain gardens, green roofs, bioswales and climate-proof parks – are much heralded as a win-win solution for enhanced urban climate protection and security. These green climate adaptations are often highlighted for their economic and neighborhood attractiveness co-benefits in order to boost political salience and financial feasibility. Yet, as social-ecological resilience is frequently framed in the context of reducing vulnerability to "natural" disasters and extreme events, it is thus decoupled from the political-economic landscape of cities' historic and ongoing patterns of uneven and unsustainable growth. In this sense, urban adaptation may be repackaging "business as usual" land use planning practices that deprioritize the protection and security of vulnerable and minority residents and reproducing uneven landscapes of social-ecological vulnerability.

In this paper we bring the critical adaptation planning and social-ecological resilience literature together with recent scholarship on urban green inequities and climate gentrification in order to analyze the extent to which green and resilient interventions protect vulnerable groups, or, on the contrary, result in new inequities and insecurities. Using data from Philadelphia, we examine how neighborhoods' social, racial, and real estate characteristics change over time in relation to the siting of green and resilient infrastructure, with a focus on processes of gentrification and increased vulnerability. Here, we seek to test whether social-ecological vulnerability is addressed by green and resilient infrastructure siting or if uneven conditions are reproduced, paradoxically rendering historically marginalized populations more vulnerable and less secure, while benefiting more privileged new residents. This paper contributes new understandings on urban climate justice and injustice dynamics.

2. Theoretical Foundations

2.1. From climate adaptation to urban resilience

With cities increasingly dedicating planning and funding efforts to climate adaptation (Aylett, 2015; Carmin et al., 2012; Hughes, 2015; Woodruff and Stults, 2016), their attention on reducing vulnerability to and preparing for ongoing (e.g., global warming) and sudden (e.g., flash flooding) environmental risks and impacts (Dodman, 2009; Hughes, 2015; Huq et al., 2007) is has grown more nuanced. In some cases, these efforts are also geared toward addressing differential climate impacts vis-à-vis social vulnerabilities, unequal rights and entitlements (Bulkeley et al., 2014; Eriksen et al., 2015; Hughes, 2015; Ziervogel et al., 2017). As such, climate adaptation is being folded into a larger umbrella of resilience planning and broad-scale governance of urban capacities to cope with an array of social, economic and environmental risks (Woodruff et al., 2018).

"Resilience thinking" for governance and planning has come to be seen as a comprehensive and multi-scalar way of reducing vulnerability and improving the capacity of systems to cope with multiple and diverse shocks and chronic disturbances (Coaffee and Clarke, 2015; Friend and Moench, 2013; Wilkinson, 2012). This is accomplished through risk-diffusing self-organization and decentralization combined with redundancy and flexibility, and through multi-functional and diverse interventions that might prevent entire system failures resulting from one component or single point failure (Folke, 2016,

2006). Thus, some scholars and practitioners view resilience as a necessary critical step along the way to a deeper, more structural and systemic transformation of social-ecological relations (Pelling, 2011).

2.2. The shift from grey to green to green resilience

Many adaptation programs start out as or are even conceived as non-adaptation programs and then reframed and remarketed to gain buy in and support (Bassett and Shandas, 2010; Carmin et al., 2012). Today, as part of urban climate adaptation planning, cities in the global North are increasingly deploying green infrastructure (Meerow and Newell, 2017), especially existing green stormwater management tools (Liu and Jensen, 2018) toward a new goal of building climate resilience. These more flexible and socially-oriented means of addressing climate change impacts and urban environmental risks are increasingly preferred (Ahern, 2013) to repairing traditional grey infrastructure (e.g., underground sewer systems, seawalls or levies), in particular for their lower-cost.

Widely defined as an "interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations" (Benedict and McMahon, 2001, p. 5), green infrastructure (GI), such as parks, gardens, greenways or green roofs, is meant to achieve strong ecological *multifunctionality* while making cities more livable (Kabisch et al., 2016; Pauleit et al., 2011; Young et al., 2014). Among the manifold *co-benefits* of exposure to green spaces are those to health and wellbeing (Douglas et al., 2017; Triguero-Mas et al., 2015; Tzoulas et al., 2007) and to greater inclusiveness and social cohesion, especially through participatory and community-based greening (Connolly, Svendsen, Fisher, & Campbell, 2013; Haase et al., 2017). Meanwhile, urban investment in green adaptive measures is touted as good economic sense based on demonstrated rises in real estate values (Heckert and Mennis, 2012; Immergluck, 2009) around greened spaces and to green job creation. In other words, urban green infrastructure is perceived as a *cost-effective* (Ahern, 2007), *pragmatic* approach for resilience planning (Lennon and Scott, 2014; Palmer et al., 2015) making it more politically feasible to implement.

Despite claims that green infrastructure provides city decision-makers with a "no-regrets solution" to climate adaptation (Mees and Driessen, 2011), a "win-win" with the lowest tradeoffs, the jury is still out as to who benefits (Anguelovski et al., 2016; Gould and Lewis, 2018; Haase et al., 2017). Indeed, there is growing evidence that the benefits of adaptation flow primarily to entrenched political and economic interests (Sovacool et al., 2015) and that "competitive resilience" strategies may generate concentrated protection zones (Teicher, 2018). Even though mapping and modeling tools help identify hotspots for GI investment (Kremer et al., 2016; Meerow and Newell, 2017), GI siting-decisions may lead to perverse outcomes for vulnerable residents despite efforts to ensure equal distributions (Heckert and Rosan, 2018; Mabon and Shih, 2018). Displacement and gentrification are especially virulent social impacts that undermine calls for socially and ecologically transformative aims (Chu et al., 2017).

2.3. From critical climate adaptation to climate and resilience gentrification

Research on green and environmental gentrification has shown that new green amenities and environmentally revitalized brownfields can create conditions favorable to the exclusion and displacement of the most vulnerable residents (Dooling, 2009; Essoka, 2010; Pearsall, 2010). This work draws away the neutralizing veneer of technocratic and economic valuation approaches to

infrastructural siting decisions (Finewood et al., 2019) and exposes how urban sustainability planning can contribute to gentrification and displacement via redevelopment strategies that revalorize stigmatized neighborhoods (Checker, 2011; Gould and Lewis, 2017). Green beautification tactics may even be perceived by socially vulnerable groups as "green locally unwanted land uses (green LULUs)" (Anguelovski, 2016).

While scholarly research on climate adaptation and climate justice has engaged with questions of equity and vulnerability of low-income populations (Carmin et al., 2012; De Sherbinin et al., 2007; Huq et al., 2007), most of this attention has been focused at the global or national scale (Bulkeley et al., 2014), with the idea of a double inequity or double injustice: the poorest groups or nations, least responsible for climate change are those made most vulnerable to its impacts (Füssel, 2010; Gough, 2011). The poor are also often faced with a third injustice in which they are the least likely to benefit from climate adaptation and mitigation efforts while paying disproportionately for them (Anguelovski et al., 2016; Roberts and Parks, 2007).

At the city-scale, the uneven terrain of urban adaptive and protective infrastructure remains relatively under-examined (Shi et al., 2016). There is an under-problematized and depoliticized promotion of green and resilient solutions as inherently good and beneficial for all (Anguelovski et al., 2018a; Brown, 2014; Fainstein, 2015; Ziervogel et al., 2017), often overlooking historic and ongoing racial inequalities (Hardy et al., 2017). However, GI, such as trees, may even face the resistance of low-income and minority residents when histories of urban development and disinvestment give rise to the perception that they will be burdened with its maintenance (Carmichael and McDonough, 2019; Lyytimäki et al., 2008). Emerging studies on GI adoption by residents, even less costly ones, find that income is a significant barrier to uptake and implementation (Baptiste et al., 2015; Newburn and Alberini, 2016) contributing to uneven results. Indeed, GI siting may simultaneously have adaptive and maladaptive effects – protection in one urban area can generate more risk in another and disproportionately burden the most vulnerable residents (Barnett and O'Neill, 2010; Juhola et al., 2016). Recently, critical scholars are pointing out how these asymmetric outcomes compound deeply rooted environmental inequalities (Garrison, 2017) and generate green landscapes of pleasure and privilege for a few and new riskscapes for others (Anguelovski et al., 2018a; Connolly, 2018).

New empirical studies also link a high risk of sea-level rise with "climate gentrification" in elevated urban areas, and suggest that resilience investments may drive gentrification in more socially vulnerable neighborhoods (Keenan et al., 2018). Resilience gentrification might therefore represent a "dual process of urban greening and structural mitigation of climate change threats, [with] resilience [being] equated with wealth, and the sustainability class emerg[ing] as the new urban elite" (Gould and Lewis, 2018, p. 13). Gould and Lewis' argument suggests extending the existing research focus on increased property values to the actual displacement of (historically) marginalized peoples (Anguelovski et al., 2018a), and to the analysis of how the greening of cities paired with climate resilience actions may ignore and even undermine the long-term security and livelihoods of the most vulnerable residents (Ranganathan and Bratman, 2019; Zografos et al., 2014).

While recent scholarship on urban greening and climate adaptation problematizes security in terms of differential climate impacts or unequal protections or adaptive capacities, new studies have yet to (a) operationalize the impacts of climate protective land-use measures on human security at the city level in the context of green resilience gentrification, and to (b) investigate the specific forms and patterns of

urban change that emerge. This paper is focused on addressing these gaps. In the next section, before delving into our research design, we present Philadelphia's green resilience efforts, as a critical case to examine green resilience planning, and possible resulting inequities and gentrification.

3. Philadelphia's green resilience turn

By the late 1990s, Philadelphia began considering new green landscaping measures to tackle chronic watershed issues in response to dramatic changes to U.S. Federal environmental regulations including cuts to grey infrastructure grants and fines for the breaching of stormwater limits (Environmental Protection Agency, 1994; EPA Office of Research & Development, n/a; Pollock, 1991; Tibbetts, 2005). Despite once having an avant-garde XIXth century combined sewer overflow system (CSS) (US Environmental Protection Agency, 2004), currently, during major storms experienced at least annually, the CSS allows pollution from storm-water runoff and wastewater overflow into the same streams from which drinking water is sourced. Coupled with the presence of vast non-porous surfaces, Philadelphia has also experienced frequent and costly flooding and expects a mid-century sea level rise of between one and three feet and an end-of-century sea level rise of between one and six feet (Phil. Office of Sustainability & ICF, 2015). Along with chronic subsidence due to sewer line breaks and the swelling of buried streams, Philadelphia's CSS has given rise to health and safety concerns for nearly the whole XXth century.

The Philadelphia Water Department (PWD), renamed Philadelphia Water (PW), has since the early 2000s embarked on a mission to tackle flooding, stormwater runoff, drinking water pollution, and wastewater overflow with green interventions that by the early 2010s became a major milestone in watershed planning in the United States (Liu and Jensen, 2018). The city's program created a broad scope of data collection methods, green stormwater practices, and citywide public-private partnerships to dramatically reduce 85% of the contamination in combined sewer areas (PWD, 2009), as well as to mitigate urban heat island effects and air pollution. In 2006, a major flood episode prompted a citywide sense of urgency to better control overflows (Madden, 2010). Their cost-effectiveness and multi-functionality in the context of reductions to federal grey infrastructure funding made GI especially appealing to the cash-strapped city.

Indeed, following decades of deindustrialization, suburbanization, population decline, and widespread land pollution and abandonment (Adams, 1991; Cooke, 2003), there was an effort in the early 2000s to promote green stormwater interventions for both beautification and better water management. When in 2009, Philadelphia's mayor released the *Greenworks* sustainability plan, he declared that Philadelphia would become the greenest city in America and outlined a broad array of urban greening projects with particular emphasis on economic benefits to boost the city's revival. Two years later in 2011, Philadelphia adopted the signature *Green City, Clear Waters* (GCCW) plan (PWD, 2009),[6] setting in motion a 25-year citywide landscape-based approach to stormwater management, also claiming a host of economic advantages, at a lower cost to the city. Back then, Philadelphia was still a city in recovery, with 40, 000 vacant lots, an ailing economy (Heckert and Mennis, 2012) and in some areas violent crime

[6] Also the Combined Sewer Overflow Long-Term Control Plan Update

was rapidly rising (Brownlow, 2006); meanwhile, other areas that were faring better had started to gentrify (Hwang, 2016).

In this vein, the PW program claimed to provide co-benefits by: addressing a lack of attractive green spaces in schoolyards, improving residential and commercial streetscapes, revitalizing parks, and contributing to cleaning up its vacant lands which have been associated with crime and property value decreases (Heckert and Mennis, 2012). It also emphasized the benefits of reducing climate risks and impacts such as warmer and wetter weather and diminished air quality. Now, green infrastructure (GI) in Philadelphia has been associated with health and safety co-benefits, including lower rates of narcotics possession (Kondo et al., 2015), and increases to property values in moderately-distressed neighborhoods (Heckert and Mennis, 2012). Nevertheless, with real estate prices soaring in many central neighborhoods, advantages may not be experienced evenly or equitably by Philadelphia residents.

3.1. Philadelphia's green infrastructure programs for stormwater management

Many PW interventions prioritize high visibility projects and, wherever possible, complement ongoing greening programs, but are also selected based on individual leadership or community petitioning (Dalrymple, 2018; Heckert and Rosan, 2018; Madden, 2010). Specific green stormwater management practices include green roofs, rain gardens, bioswales, and tree trenches in combination with other non-vegetated "green" measures including pervious pavements and sub-surface infiltration tanks[7]. With this suite of tools, engineers may overcome most localized environmental and technical constraints (Christman et al., 2018; Philadelphia Water, 2015), in contrast to single GI intervention programs such as MillionTreesNYC and MillionTreesLA (Garrison, 2018), and facilitate their installation throughout the Combined Sewer System on both public and private lands.

The showcase Big Green Block project[8] completed in 2013 in West Kensington and Fishtown – 20 acres (approximately 8 ha.) of vacant land converted to include a LEED Platinum certified high school facility, dog park, athletic field, and new paths to local public transit – is one recent example of maximizing partnerships and visibility while capturing 95% of stormwater runoff from the area. It is also an example of the PW's partnership with groups like the Pennsylvania Horticultural Society to identify vacant lands[9]

[7] For comprehensive descriptions of the city's various GI tools, see: Philadelphia Water, "Green Stormwater Infrastructure Design Requirements and Guidelines Packet," Philly Watersheds. Philadelphia Water Department, May, 15, 2015, http://phillywatersheds.org/doc/GSI/GSI_Design_Requirements_&_Guidelines_Packet_5-15-2015.pdf. (accessed on July 26, 2019)

[8] For information about this particular Big Green Block, see: New Kensington Community Development Corporation, "About us: Big Green Block," http://www.sustainable19125and19134.org/about-us/big-green-block. (accessed on July 30, 2019)

[9] See: Philly Watersheds (PW), *Green Vacant Land,* http://www.phillywatersheds.org/green-vacant-land. (accessed on July 30, 2019).

for new or improved green spaces. Similarly, the Green Parks[10] and Green Schools[11] programs partner with Philadelphia Parks & Recreation, local schools and others to utilize public green spaces, playgrounds, recreation centers and schoolyards to reduce overflows and climate risks.

Furthermore, as part of the Philadelphia Rain Check program[12], small-scale products are offered to homeowners for purchase, such as rain garden kits and downspout planters, engaging private individuals in improving neighborhood aesthetics and property values while cost-sharing in reducing urban environmental risks. Lastly, stormwater management regulations for new development and major retrofits, as well as parcel-based stormwater fees and grants incentivize both residential and nonresidential properties to install green stormwater infrastructure (Mandarano and Meenar, 2017) and reduce impervious surface areas. In these ways, the GCCW program leverages private investment, which also raises the issues of income, land rights and capital as key constraints in the uptake of green resilience-building interventions (Baptiste et al., 2015; Newburn and Alberini, 2016), ones that will be reproduced as these programs continue unfolding.

3.2. A new climate adaptation plan with the same green tools

Growing Stronger: Toward a Climate Ready Philadelphia – released in 2015, became the first report on the city's climate change adaptation planning process which began in 2012 (Phil. Office of Sustainability & ICF, 2015). The Mayor's Office of Sustainability (MOS) in partnership with the city's Climate Adaptation Working Group (CAWG), other city departments and external consultants created the report to identify climate risks and impacts and existing climate resilient strategies. The plan deploys many of the same green stormwater interventions in existence since the early 2000s as low-barrier adaptation options intended to reduce vulnerabilities and protect vulnerable populations.

In sum, Philadelphia has gained nationwide status as a model for wide-scale urban green stormwater infrastructure (Liu and Jensen, 2018) and seems to be successfully layering a new green and resilient identity over one of the most racially and economically segregated cities in the US. What has received little or no focus, however, is how the distribution of the nearly 1,200 green stormwater interventions relates to shifts in Philadelphia's uneven landscape and who benefits from these ecological protections and amenities in the long run. We therefore argue that because identical green stormwater management tools were incorporated into Philadelphia's later adopted Growing Stronger climate adaptation program, a study like ours can provide key missing insights into how climate resilience programs using the same long-standing GI tools may encounter uneven and inequitable outcomes.

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[10] See: Philly Watersheds (PW), *Green Infrastructure Programs: Green Parks*, http://www.phillywatersheds.org/what_were_doing/green_infrastructure/programs/green-parks. (accessed on July 30, 2019).

[11] See also: Philly Watersheds (PW), *Green Infrastructure Programs: Green Schools*, http://www.phillywatersheds.org/what_were_doing/green_infrastructure/programs/greenschools. (accessed on July 30, 2019).

[12] For more about the Rain Check program, see: Philadelphia Water Department, *What is Rain Check?,* https://www.pwdraincheck.org/en/what-is-rain-check#whatisraincheck (accessed on July 30, 2019).

4. Research Design

We designed this study as a spatial quantitative analysis of the effects of GRI on populations vulnerable to climate exposure and gentrification. We conducted, on the one hand, a cross-sectional analysis that studied social-ecological conditions before and after green resilient interventions to evaluate the equity of siting decisions; and, on the other hand, a longitudinal analysis that tracked socio-economic changes over time in relation to GRI siting to examine gentrification trends. Our goal was to understand the extent to which green and resilient interventions protect vulnerable groups, or result in new inequities and insecurities.

4.1. Green Resilient Infrastructure

Our principal explanatory variable is what we call "green resilient infrastructure" (GRI). Drawing on PW's preferred stormwater management practices, we defined GRI as all *surface-level*, *vegetated* interventions, installed to mitigate environmental risk or impact, and improve adaptive capacity in the context of climate change, while enhancing neighborhood attractiveness. In Philadelphia these included green roofs, rain gardens, wetlands, and tree trenches, among others[13] We, therefore, excluded sub-surface, or non-vegetated (grey) projects – those which are generally not visible and not green – such as permeable pavements, sub-surface infiltration trenches and rain barrels. Because our study is focused on the combination and intersection of green and resilient – where the goal was improved protection – we have not included all forms of existing green space. However, utilizing this definition, it became clear that GRI were sometimes implemented in *vacant lands, parks,* and *schoolyards.* To deal with this circumstance, we identified vacant lands, parks, or schoolyards where isolated GRI installations constituted upwards of 10% of the surface area. In such cases, we considered the entire green space to have been ostensibly transformed into GRI. Given the generally small size of GRI installations, this was a fairly conservative threshold. Out of 1172 GRI data points included in the study, only a few green spaces – 6 parks, 1 schoolyard and 72 vacant lots – met the 10% requirement. Overall, 26% of the total surface area of GRI is under public ownership; the remainder is privately-owned—although private GRI is largely implemented due to public mandate or assistance programs.

Our green spatial data collection extended between 2000 and 2016 – that is the period during which the PWD recorded new installations of green stormwater infrastructure. We selected polygon features meeting our "green" criteria from PWD Stormwater Management Practice (SMP) and *Rain Check* points to create a combined shapefile of all active stormwater GRI (up to 2016). These databases provided a detailed geographic inventory of every intervention, its subtype, installation date, ownership typology,

[13] For comprehensive descriptions of the city's various GI tools, see: Philadelphia Water, "Green Stormwater Infrastructure Design Requirements and Guidelines Packet," Philly Watersheds. Philadelphia Water Department, May, 15, 2015, http://phillywatersheds.org/doc/GSI/GSI_Design_Requirements_&_Guidelines_Packet_5-15-2015.pdf. (accessed on July 26, 2019).

and lifecycle status. Where only point data without surface area was available, – such as for planters and rain gardens of the Rain Check program – we used either exact dimensions to create a polygon or estimated areas of the GRI, both based on city data and descriptions of the infrastructure. This allowed us to preserve the count and the surface area per tract of 'greened acres'. Next, we joined the city's vacant lands shapefile with the combined SMP and *Rain Check* file to identify and incorporate lots which received green stormwater features. Lastly, we selected parks from among the Philadelphia Parks & Recreation assets data, which included schoolyards, and followed a similar procedure.

4.2. Identifying Sites of Omission (SO) and Sites of Commission (SC)

To investigate how issues of equity and security pan out across green and resilient urban landscapes, we constructed two dependent variables: Sites of Omission (SO) and Sites of Commission (SC) – building upon and refining Anguelovski, et al's (2016) classification of *acts of omission* that result in uneven and inequitable climate protection because the urban poor are "omitted" from interventions, and *acts of commission* that may worsen baseline social vulnerabilities over time, much of it because of gentrification or displacement of the urban poor.

Through our analysis, we identify tracts as SO when (a) tracts are highly vulnerable and do not receive GRI or/and when (b) tracts with wealthier, privileged populations (or where other economically valorized areas of cities, such as waterfronts, central business and historic districts exist) receive GRI without necessarily being most vulnerable to climate threats. In other words, Sites of Omission identify where higher social and ecological vulnerability neighborhoods have been neglected or deprioritized in relation to economically valorized areas. On the other hand, Sites of Commission include socially-underprivileged areas that received protection and subsequently gentrified or where GRI seemed to have contributed to a certain extent to the displacement of low-income and minority groups. Hence, SC may also refer to areas that gained low-income and minority groups over time but received little or no GRI while other areas received GRI and gentrified. They indicate new insecurities in the long-time place of residence, livelihoods, social ties and climate resilience of socially vulnerable populations. Therefore, the SO and SC variables are socio-ecological and politico-economic indicators of who benefits from or is disadvantaged by GRI – are they the socially and ecologically more, or less, vulnerable populations and areas?

4.2.1. Data Selection for SO and SC

All census variables required for SO/SC analysis for 2000, and 2010 5-year estimates, were downloaded at the census tract level from the Geolytics database, and 2016 5-year estimates, from the American Community Survey (ACS). All data was normalized to 2010 census tract boundaries[14] to enable demographic comparison across three time periods (2000, 2010, and 2016) at the finest spatial resolution possible (Maantay, 2002). We decided to exclude 13 tracts out of 384 for having zero or low

[14] In cases where the normalization process appeared to have created large discrepancies across years in a tract's population, we reapportioned the tracts to allocate population counts more evenly.

population and/or housing, and population loss due to unique factors such as Navy yard closure and airport expansion.

Our first outcome variable, Sites of Omission, requires identifying areas with high *social-ecological vulnerability* (SEV), which we define as the interlinked socioeconomic and biophysical factors (Bennett et al., 2016) relating to a local capacity to respond to stress or change. Vulnerability studies have recently paid much attention to the multiplicity, relationality and diversity of exposures and sensitivities in a more integrative and dynamic way (Adger, 2006; Bennett et al., 2016; Cinner et al., 2011; O'Brien et al., 2007; Pearsall, 2010; Taylor, 2015; Turner et al., 2003; Turner, 2016). Following this trend, we conceptualize SEV by considering the disparities in exposure to climate hazards across the urban landscape in relation to disparities in the susceptibility of Philadelphia residents to those shocks and stresses.

We selected census variables for Sites of Omission guided by empirical research on social vulnerability to environmental hazards, including the Social Vulnerability Index (SoVI) (Cutter et al., 2003), Climate Resilience Screening Index (CRSI) (Summers et al., 2017), and Social Vulnerability Index (SVI) (Flanagan et al., 2011) of the US Centers for Disease Control (CDC). We calculated population percentages at the tract-level for each of the following categories of demographic indicators: residents living in poverty, unemployed, non-Bachelor's degree holders, aged over 65, single-parents, of minority background (Black and Hispanic), and with limited English language proficiency. We call this combined variable "social vulnerability" (SV).

Next, using Philadelphia's open data portal,[15] we collected spatial data and calculated percent surface area per census tract on several bio-physical environmental variables –Combined Sewer System (CSS) area, FEMA 100-year floodplain and impervious surfaces data updated in 2004. While location in CSS area was the main criteria in municipal GRI siting decisions, this, together with flood plain and impervious surface data[16], captures urban biophysical/bioenvironmental aspects that were important to GRI siting and therefore to identifying and locating "ecological vulnerability" (EV) throughout Philadelphia.

Our second outcome variable, Sites of Commission pertains to pathways of *green resilience gentrification* which we define as a change in population such that an area gains in wealthy and/or less vulnerable populations (while losing more vulnerable populations), and in which private rental real estate values rise in conjunction with actions taken to mitigate climate and environmental risks. The definition and operationalization of gentrification varies across studies and landscapes (Freeman and Braconi, 2004; Newman and Wyly, 2006; Owens, 2012; Phillips and Smith, 2018). In Philadelphia, income (PEW Charitable Trusts, 2016), and education and property value-based (Ding et al., 2016) variables have been applied to identify gentrification.

[15] The open data portal can be found at: OpenDataPhilly, https://www.opendataphilly.org/ (accessed on July 30, 2019).

[16] Areas that have higher impermeability have less green and are more likely to be ecologically vulnerable.

For this study, we operationalized gentrification in Philadelphia tracts as combined tract increases[17] in median gross rent, residents earning above the citywide median income, White residents, and residents with a college degree (or higher) and a parallel decrease in Black and Hispanic residents. This meant that our analysis captured more change than other local gentrification studies and therefore more neighborhoods were found to be gentrifying. Because of the historical significance of "race" and racism behind practices of segregation, redlining and suburbanization underlying Philadelphia's uneven development patterns (Beauregard, 1990; Brownlow, 2006), the racial dimension of gentrification is particularly important to understanding in a novel and more fine-grained manner the distribution and impact of new development patterns of green and protective infrastructure.

4.3. Analytical Strategy

Overall, we aimed at spatially analyzing the impacts of reducing climate risks through urban GRI on social-ecological vulnerabilities (SEV) and in relation to gentrification trends at different periods of time. To achieve this aim, we examine, first, the distribution of new green and resilient infrastructure at different points in time relative to social and ecological vulnerabilities; and second, the relationship between this distribution and the processes that render historically marginalized populations more vulnerable and less secure, while benefiting more privileged populations.

While the precise causal role of GRI relative to other potential drivers of gentrification is an important consideration, it is not an explicit or direct part of this analysis. Rather, we highlight the extent to which GRI, despite intentions otherwise, become enmeshed in deeper processes of urban change and the creation of environmental insecurity through uneven resilience. In doing so, we illuminate the interplay between social and ecological riskscapes in a way that challenges technocratic site selection and spatial planning approaches to account for a more complex set of considerations. It is we argue, less a question of causality, and more one of how, when, and where urban greening becomes inexorably linked with social change such that interventions like GRI are both cause and consequence.

4.3.1. GRI and Sites of Omission

First, we used a quantitative spatial approach to identify *sites of omission* (SO) in GRI plans and interventions. Here, we address the first sub-study question: Which areas receive GRI by 2010 and 2016, relative to social-ecological vulnerabilities? Because GRI data is tracked annually, whereas census data provides a snapshot in time at larger intervals, we performed a pre-post study to describe tracts before and after GRI went in. We assessed SEV in 2000 and 2010, as pre-GRI starting points, and in 2010 and 2016, as post-GRI endpoints. We then looked for associations between spatial accumulation/clustering of GRI and changes in SEV over time.

To do so, we built 5 social-ecological type indicators representing varying combinations of high (scores >4) and/or low (scores <3) social and ecological vulnerabilities in census tracts. For example, if a tract

[17] For demographic variables, percent change is given as the increase or decrease in percentage points for a specific variable during a given period

scored < 3 for social vulnerability, but > 4 for ecological vulnerability, it was classified as a Low SV-High EV tract, abbreviated as LH. Table 1 below explains how the scores were calculated for each SEV type and their abbreviations (LL, LH, HL and HH) which are later referenced in our maps. We included a fifth indicator for tracts with moderate levels of social or ecological vulnerability (M): if either score, but not necessarily both, was in the middle range (3-4), then the tract was classified as moderate. Two types of tracts were classified as Sites of Omission: tracts that received little or no GRI but had high SEV (HH) and tracts with low levels of social and ecological vulnerability (LL) that gained in GRI.

Social Vulnerability (SV) score \ Ecological Vulnerability (EV) score	< 3	3 - 4	> 4
< 3	**LL**		**LH**
3 – 4		**M***	
> 4	**HL**		**HH**

L=Low; H=High; M=Moderate; SV precedes EV (i.e. LH = Low SV, High EV)

*in this case only one of either SV or EV needed to equal 3 or 4. The other variable could have been equally moderate or of low or high value.

Table 1: Social-Ecological Vulnerability (SEV) matrix according to SEV score

4.3.2. GRI and Sites of Commission

In order to analyze the extent to which the implementation of GRI is associated with green resilience gentrification, we identified tract level changes over time in socioeconomic indicators of gentrification and compared them with concentrations of GRI in the same tracts.

First, we identified which tracts could be gentrified, or were "gentrifiable" tracts at the start of each study period (2000 and 2010). Gentrifiable tracts had to have a median household income below the citywide median in 2000 and 2010. In a second step, gentrifiable tracts were examined for gentrification trends during the following time periods: 2000-2010, 2010-2016 and the overall 2000-2016 period. We chose the overall city-level rate of gentrification to provide a comparison point from which to interpret degree of gentrification at the tract-level. Indicators that changed according to our criteria received one point and were subsequently added together to obtain a composite score, with a maximum of six demographic or real estate changes possible (Anguelovski et al., 2018b). For example, if median rent grew faster than the citywide median change, a gentrifiable tract received one point toward its composite gentrification score.

Five tract typologies emerged from this analysis: non-gentrifiable, gentrifiable-non-gentrifying and three sub-types for gentrifiable-gentrifying tracts. These were highly gentrifying (scoring 5 or 6), moderately gentrifying (scoring 3 or 4) and low gentrifying (scoring 1 or 2). We then summarized the average GRI

counts and average GRI percent area for each typology to examine which tracts had the highest concentrations and numbers of GRI.

5. Results

5.1. Sites of Omission: Who received GRI and who did not?

5.1.1 SEV in 2000 and GRI investment from 2000 to 2010

First, our analysis from 2000 to 2010 reveals that areas that tended to receive the highest average number (0.95 per tract – note that the average is below one because many years in this time period tended to have zero GRI) and average percent area (0.029%) of GRI in the same period were those that were simultaneously the least socially and ecologically vulnerable (LL) at the beginning of the time period (see Figure 1 and Table 2a). The second highest average number of GRI (0.48 per tract) (with a similar average surface area of 0.029%) was located in areas with the highest social and ecological vulnerability (HH), but these sites tended to cluster exclusively around the city center (downtown) in the neighborhoods of Center City, Rittenhouse, University City, Powelton, West Kensington and Fishtown. Generally, less vulnerable populations received the most GRI and more vulnerable populations received GRI only if they were close to the business district and downtown.

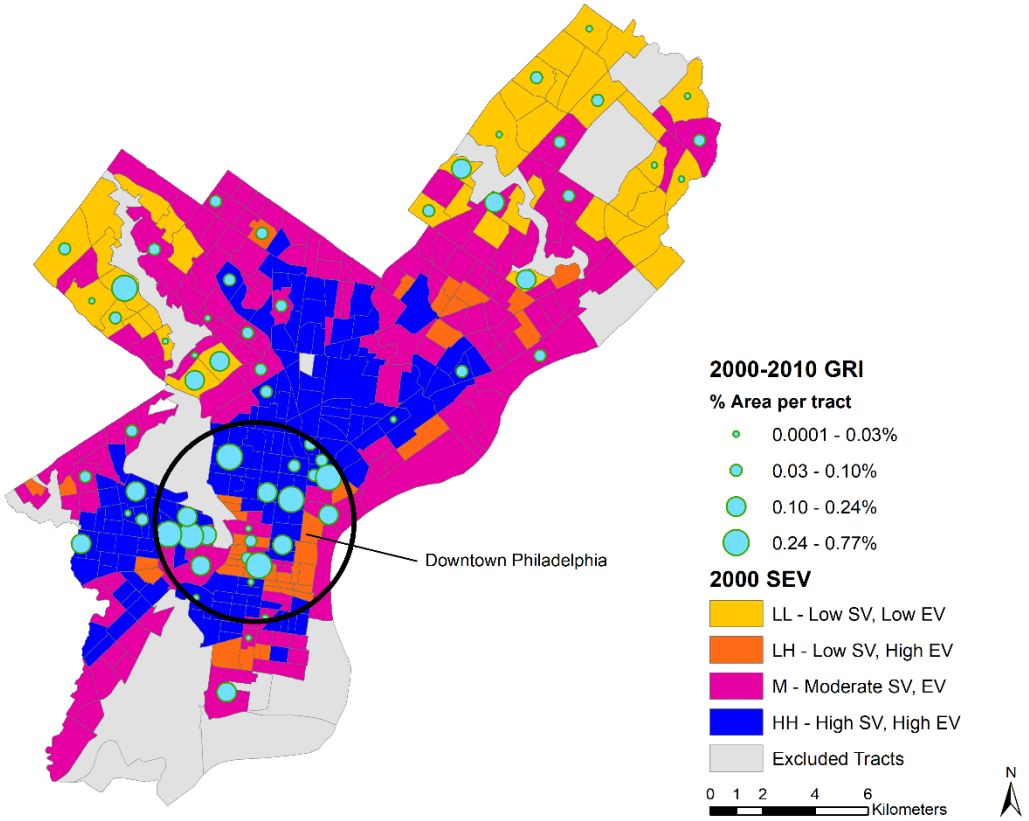

Figure 2: Sites of Omission, SEV in 2000 and GRI from 2000 to 2010, in the City of Philadelphia

5.1.2 SEV in 2010 and GRI investment from 2011 to 2016

Second, from 2011-2016, areas that tended to receive the greatest average number of GRI (2.91 per tract) were those that had moderate (M) social and ecological vulnerability at the beginning of the time period (see Figure 2, Table 2b). This may be explained by the downspout planters, offered by the Rain Check program which began in 2012. They are small in area (estimated at roughly 0.5 m^2) but could quickly impact the total count of interventions in a tract. However, in terms of percent area of GRI, tracts with a combined low social vulnerability and high ecological vulnerability (LH) tended to receive the most protection (0.113% area on average). Conversely, the highest overall vulnerability tracts – high social and high ecological vulnerability (HH) – had the lowest percent area of GRI (0.070%), fewer numbers of interventions (1.86) and overall less protection. Ecological vulnerability gained increasing focus for GRI in later years, but social vulnerability remained a low priority.

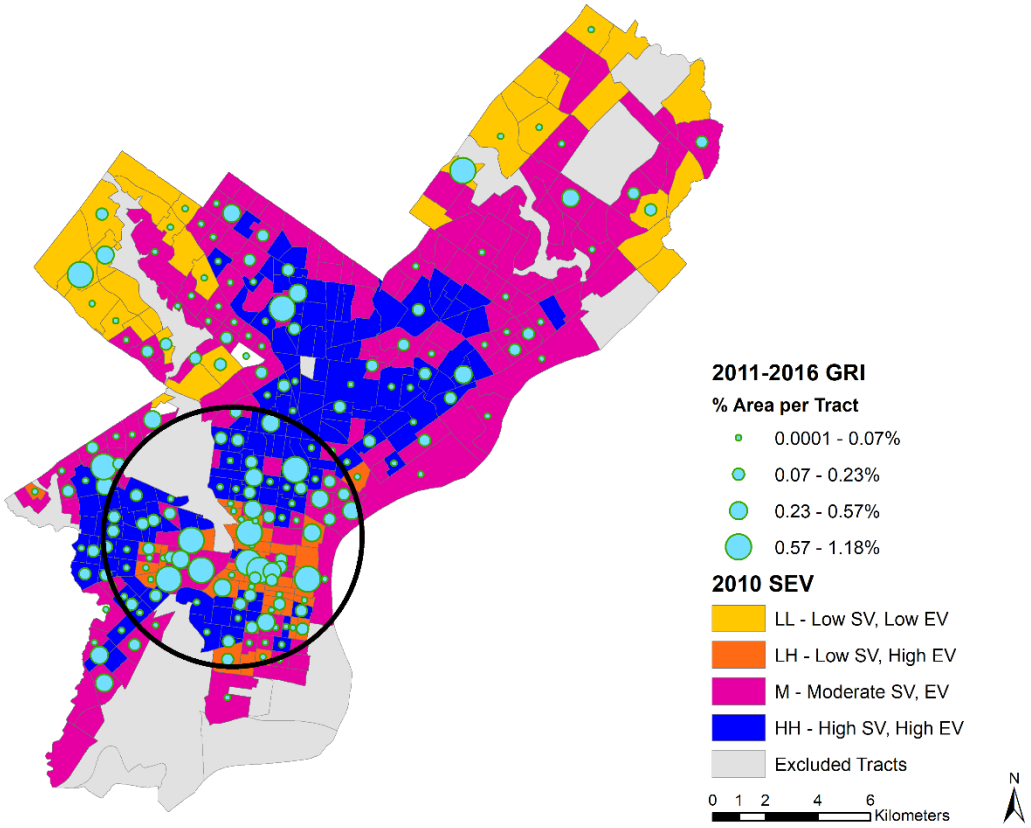

Figure 3: Sites of Omission, SEV in 2010 and GRI from 2011 to 2016, in the City of Philadelphia

5.1.3 SEV in 2000 and 2016 and GRI investment from 2000 to 2016

Lastly, for the overall period (2000-2016), we observe (Figure 3, Table 2c) that the tracts that would accumulate the greatest percent area of GRI (0.112%) were those which started with a low social and high ecological vulnerability (LH) in 2000, while tracts with moderate SEV (M) in 2000, would receive the highest number of GRI (3.22). Tracts with high SEV (HH) in 2000 were close behind. By the end-point of

the time period (2016) (Figure 4, Table 2d), areas which had accumulated the most GRI in count and percent area (4.3 and 0.160%) were those which had become low social and high ecological vulnerability (LH) tracts, surpassing high SEV tracts (HH) with twice the number and percent area of GRI (2.17 and 0.084%), $p < 0.05$. The discrepancy in GRI siting between HH areas and LH areas grew from 2000 to 2016. Therefore, in the overall period, high ecological vulnerability was a better predictor of GRI, but so was low social vulnerability. By 2016, 48% of the highest socially and ecologically vulnerable tracts (HH) were left behind with no GRI while among the least socially and ecologically vulnerable tracts (LL) only 38.5% had zero.

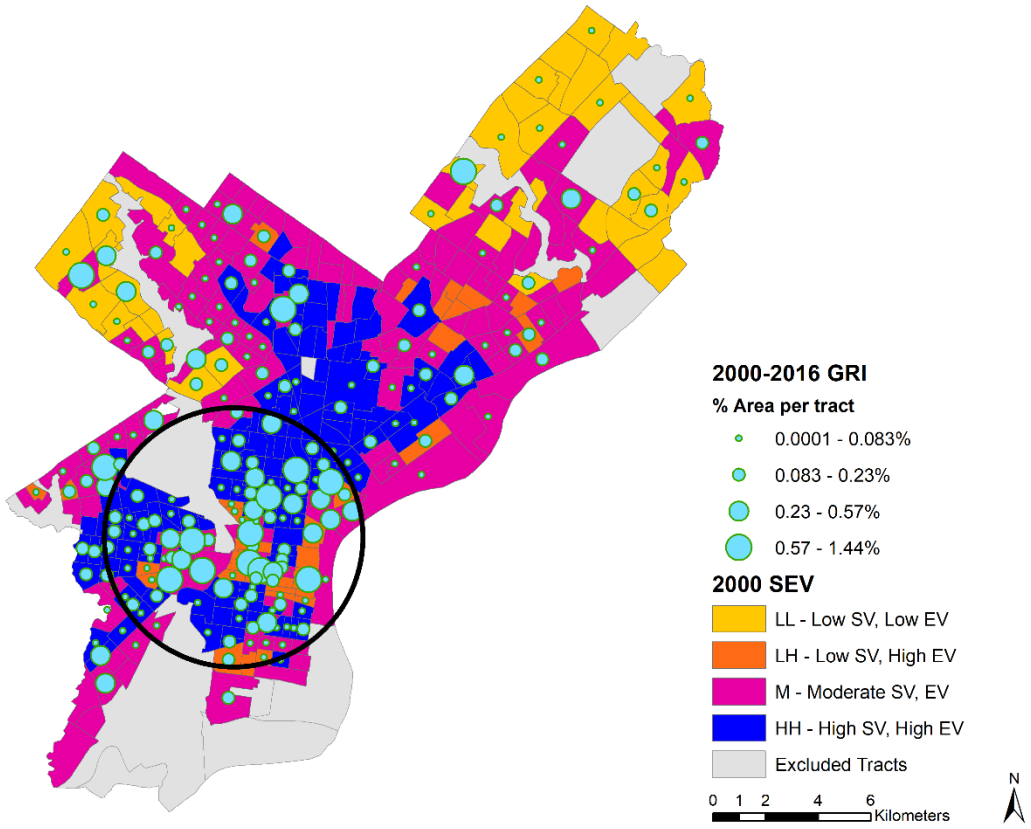

Figure 4: Sites of Omission, SEV in 2000 and GRI from 2000 to 2016, in the City of Philadelphia

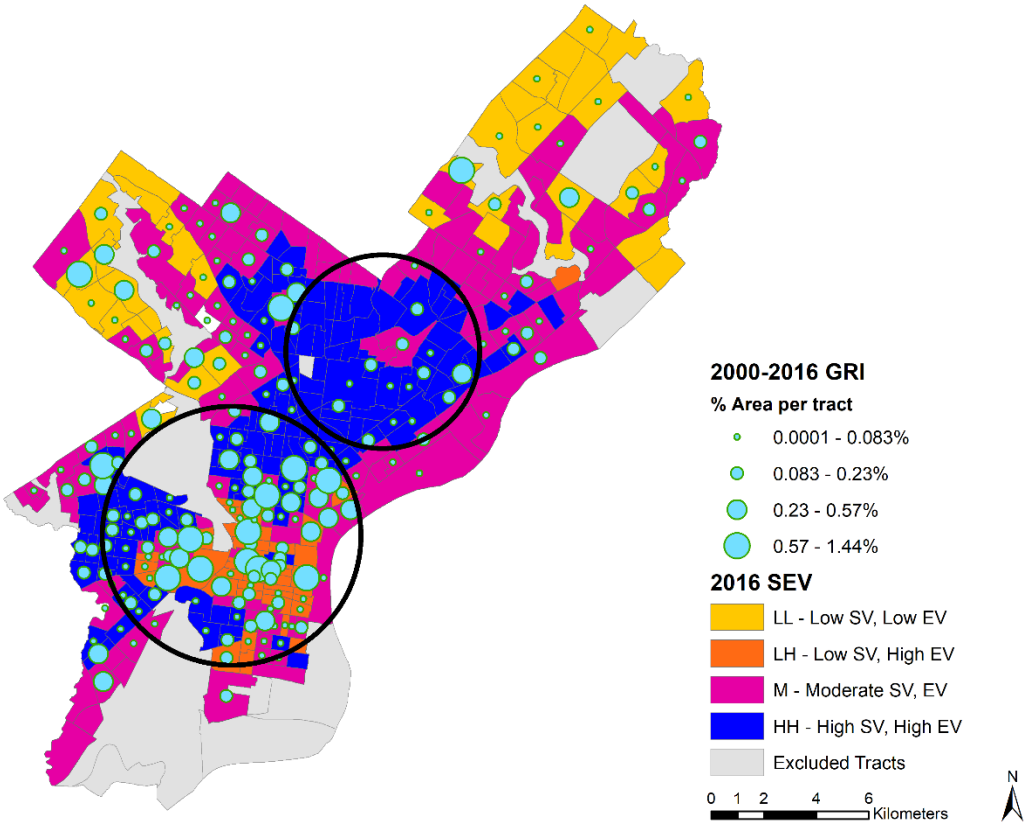

Figure 5: Sites of Omission, SEV in 2016 and GRI from 2000 to 2016, in the City of Philadelphia. By 2016, the upper circled area has grown more socially vulnerable and received relatively little to no GRI

	SEV Type	Average # GRI^	Average % GRI^	% tracts with no GRI
2a.	**SEV 2000**	**GRI 2000-2010**		
	LL	**0.95**	**0.029%**	58.5%
	LH	0.24	0.014%	90.2%
	M	0.40	0.013%	84.4%
	HH	0.48	0.022%	85.7%
2b.	**SEV 2010**	**GRI 2011-2016**		
	LL	1.15	0.076%	55.9%
	LH	2.73	**0.113%**	27.5%
	M	**2.91**	0.074%	46.1%
	HH	1.86	0.070%	49.6%
2c.	**SEV 2000**	**GRI 2000-2016**		

	LL	1.93	0.075%	43.9%
	LH	2.76	**0.112%**	41.5%
	M	**3.22**	0.088%	45.4%
	HH	2.67	0.103%	37.4%
2d.	**SEV 2016**	**GRI 2000-2016**		
	LL	2.46	0.116%	38.5%
	LH	**4.30**	**0.160%**	27.3%
	M	3.08	0.080%	40.8%
	HH	2.17	0.084%	47.9%

^GRI averages by SEV type include tracts with 0 values for GRI

Table 2: Summary results of GRI accumulation according to SEV type at different start and endpoint years of the study

5.2. Sites of Commission: How did areas receiving GRI (or not) change over time?

5.2.1 Gentrification trends in Philadelphia

Among the 371 tracts studied from 2000-2016, 188 were eligible to gentrify at the start of the study period, with median incomes below the 2000 citywide median. A total of 47 tracts received a composite gentrification score of 5 or 6 and met all or nearly all the criteria to be considered highly gentrifying. We further stratified the tracts as “moderately gentrifying” for those which scored 3 or 4 (94 tracts), “low gentrifying” for those which scored 1 or 2 (54 tracts) and “non-gentrifying” for those which scored 0 (186 tracts). The large number of tracts (141) experiencing moderate or high gentrification from 2000 to 2016 and their relative spatial concentration (Moran’s I z-score: 15.87, p-value: 0.00) seems to indicate a great deal of flux in and around downtown neighborhoods with concentrated gentrification, such as University City, Spruce Hill, Woodland Terrace, Point Breeze, Callowhill, Brewerytown, West Kensington, Ludlow and Center City-Chinatown (see figure 5).

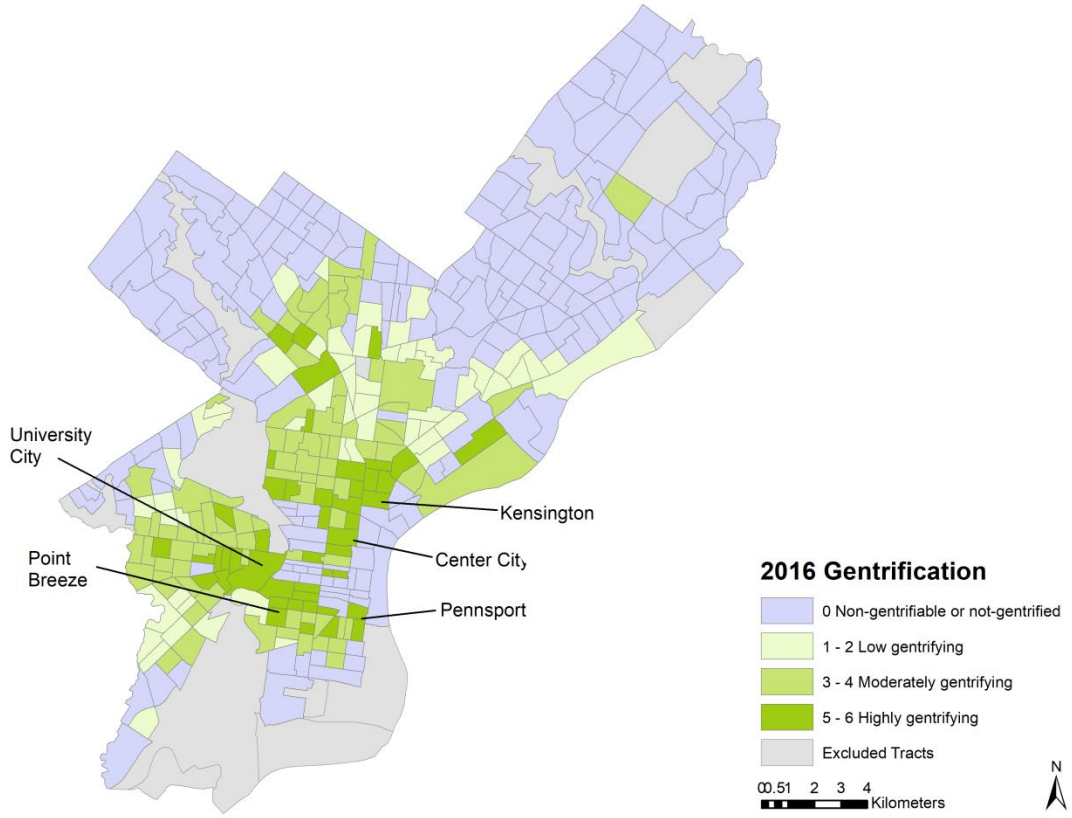

Figure 6: Gentrification in Philadelphia 2000-2016

5.2.2 Gentrification observed with GRI siting from the overall period of 2000 to 2016

Figure 6 demonstrates that green resilience interventions from 2000 to 2016 are tightly enmeshed with processes that generate Sites of Commission through the correlation with gentrification in Philadelphia. The 47 tracts with the highest composite gentrification scores of five or six (see Table 3a), received both the overall highest average number of GRI interventions (9.8 per tract) and the highest average percentage of GRI area (0.40% of the tract) from 2000 to 2016. This amounts to a 4 to 5 times higher average percent GRI than in the lowest and non-gentrifying tracts. These highly gentrifying tracts with high GRI were concentrated mostly in the neighborhoods of Southwest Centre City, University City, North Philadelphia East and West, and Brewerytown. In general, the higher the count or percent area of GRI, the higher the gentrification score of a tract. The bivariate association between GRI and gentrification score was highly statistically significant ($p<0.05$).

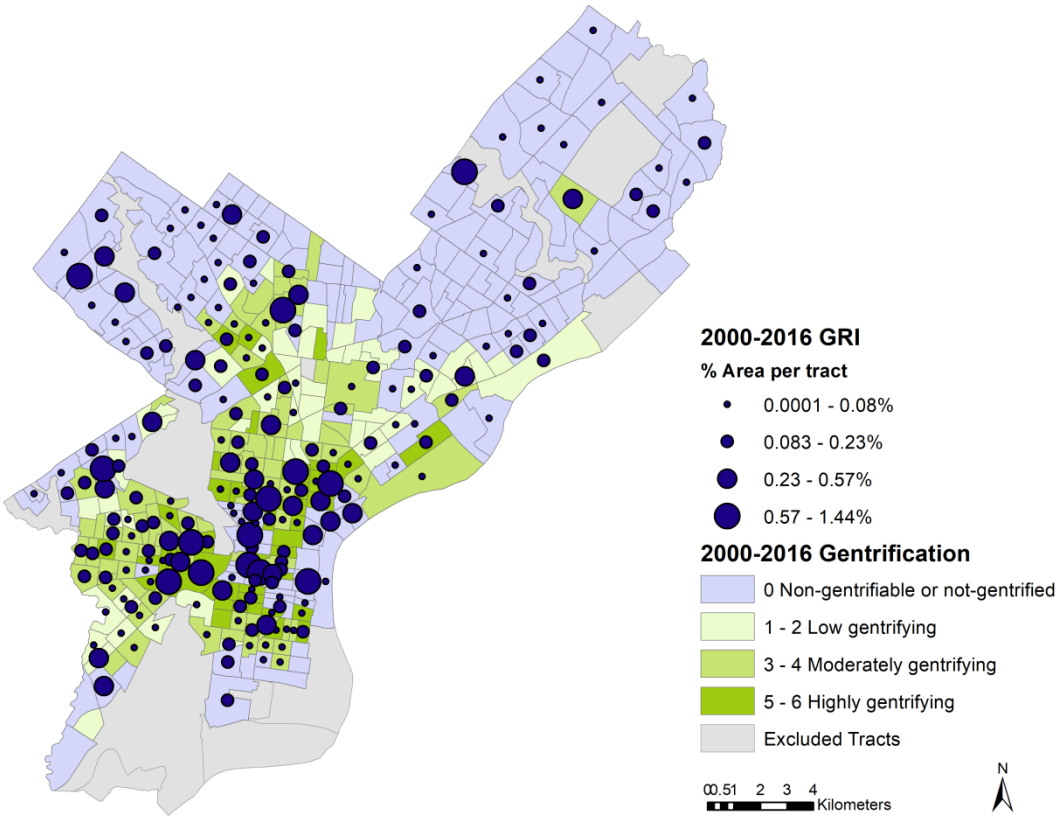

Figure 7: Green Resilience Gentrification in Philadelphia: Sites of Commission, Gentrification and GRI 2000-2016

5.2.3 Gentrification observed with GRI siting from 2000 to 2010 and from 2011 to 2016

We also divided the time period into 2000-2010 and 2011-2016 to test whether the announcement and adoption of the *Green City, Clean Waters* plan between 2009 and 2011, and the subsequent increase in GRI interventions, also correlated with gentrification trends. We found that in the first period (Table 3b), GRI and gentrification showed strong positive correlations, just as they did in the overall period. The highly gentrifying areas (scores of 5 or 6) by 2010 had received the highest percent area (0.06%) and the highest number (1.3) of GRI. However, in the second period (Table 3c), from 2011 to 2016, more GRI (5.7 interventions and 0.19% area) were invested in the moderately gentrifying areas. The highly gentrifying areas were close behind in percent area (0.18%) and number (4.67) accumulated. Further analysis below helps shed light on why this may be.

	Composite Gentrification Score	Tract Typologies	Average GRI Count by Tract Typology	Average % GRI by Tract Typology
3a. Do areas receiving GRI from 2000-2016 also gentrify in that period?	0	^Non-gentrifying	2.36	0.080%
	1 - 2	Low gentrifying	4.87	0.120%
	3 - 4	Moderately gentrifying	5.88	0.208%
	5 - 6	Highly gentrifying	**9.8**	**0.400%**
		r-squared:	0.9706**	0.9776**
3b. Do areas receiving GRI from 2000-2010 also gentrify in that period?	0	^Non-gentrifying	0.35	0.013%
	1 - 2	Low gentrifying	0.78	0.030%
	3 - 4	Moderately gentrifying	1.13	0.040%
	5 - 6	Highly gentrifying	**1.3**	**0.060%**
		r-squared:	0.9508**	0.9824**
3c. Do areas receiving GRI from 2011-2016 also gentrify in that period?	0	^Non-gentrifying	2.36	0.069%
	1 - 2	Low gentrifying	2.11	0.110%
	3 - 4	Moderately gentrifying	**5.72**	**0.192%**
	5 - 6	Highly gentrifying	4.67	0.184%
		r-squared:	0.7825	0.9027*
3d. Does 2000-2010 GRI siting correlate with 2011-2016 Gentrification?	0	^Non-gentrifying	0.4	0.013%
	1 - 2	Low gentrifying	0.44	0.010%
	3 - 4	Moderately gentrifying	**1.54**	**0.069%**
	5 - 6	Highly gentrifying	0.72	0.046%
		r-squared:	0.4766	0.7243
3e. Does 2000-2010 Gentrification correlate with 2011-2016 GRI siting?	0	^Non-gentrifying	2.04	0.064%
	1 - 2	Low gentrifying	4.23	0.108%
	3 - 4	Moderately gentrifying	4.66	0.135%
	5 - 6	Highly gentrifying	**6.24**	**0.256%**
		r-squared:	0.9353*	0.9620**
3f. Does 2000-2010 GRI siting correlate with 2000-2016 Gentrification?	0	^Non-gentrifying	0.34	0.013%
	1 - 2	Low gentrifying	0.7	0.019%
	3 - 4	Moderately gentrifying	1.02	0.053%
	5 - 6	Highly gentrifying	**2.34**	**0.076%**
		r-squared:	0.9590**	0.9920***
3g. Does 2000-2010 Gentrification correlate with 2000-2016 GRI siting?	0	^Non-gentrifying	2.38	0.077%
	1 - 2	Low gentrifying	5.01	0.132%
	3 - 4	Moderately gentrifying	5.79	0.178%
	5 - 6	Highly gentrifying	**7.55**	**0.316%**
		r-squared:	0.9433*	0.9769**

^Non-gentrifying tracts included both non-gentrifiable tracts whose median incomes were above the citywide median, and gentrifiable tracts that did not gentrify. There were 183 non-gentrifiable tracts in 2000 and 181 in 2010. *** indicates significant at $p < 0.01$; ** indicates significant at $p < 0.05$; * indicates significant at $p < 0.10$

Table 3: Gentrification Composite Scores and GRI concentrations (Counts and Percent Area)

5.2.4 Which came first: Gentrification or GRI?

We also tested if GRI, sited from 2000 to 2010, was correlated with subsequent gentrification (Table 3d), and further tested the reverse proposition: whether gentrification in the first period was correlated with subsequent GRI siting (Table 3e). Indeed, the strongest positive correlations appear for gentrification in the first period (2000-2010) and GRI siting in the second period (2011-2016, see Figure 7, Table 3e). This was the case for both average number (6.2) and average percent area (0.26%) of GRI. Results indicate GRI 3 times higher in number and 4 times higher in percent area than those found in non-gentrifying tracts. In other words, GRI tends to be sited in neighborhoods that were gentrifying in the previous period, showing that it is likely both cause and consequence of gentrification – it is likely integrated with and intensifies processes of gentrification.

We found that GRI siting in the first period (2000-2010) tends to precede moderate levels of gentrification in the second period (2011-2016), more so than preceding high gentrification levels (see Table 3d) for both average number (1.5) and average percent area (0.07%). Viewed in combination with the results in Table 3c, which also found higher levels of GRI in moderately gentrifying tracts from 2011 to 2016 (5.72 and 0.19%), these findings suggest that increasing amounts of GRI went to tracts that were highly gentrifying in the first period but in which gentrification had slowed to moderate levels by the second period.

5.2.5 Does earlier gentrification correlate with overall GRI or does earlier GRI correlate with overall gentrification?

Lastly, GRI in the first period strongly correlates with gentrification in the overall time period (see Table 3f) - increasing amounts of GRI see increasing degrees of gentrification. The reverse, however, is also true (see Table 3g) wherein increasing degrees of gentrification in the first period correlate with more GRI in the overall period. These findings may reflect the strong correlation between the two key variables, regardless of directionality, when both are considered over the whole study period. Green resilience gentrification may not occur subsequently to GRI siting – as we have defined Sites of Commission – but in conjunction with it, possibly generating a snowball effect, in which economically valued areas and more privileged residents are better protected at the expense of – and leading to the greater insecurity of – already more vulnerable residents.

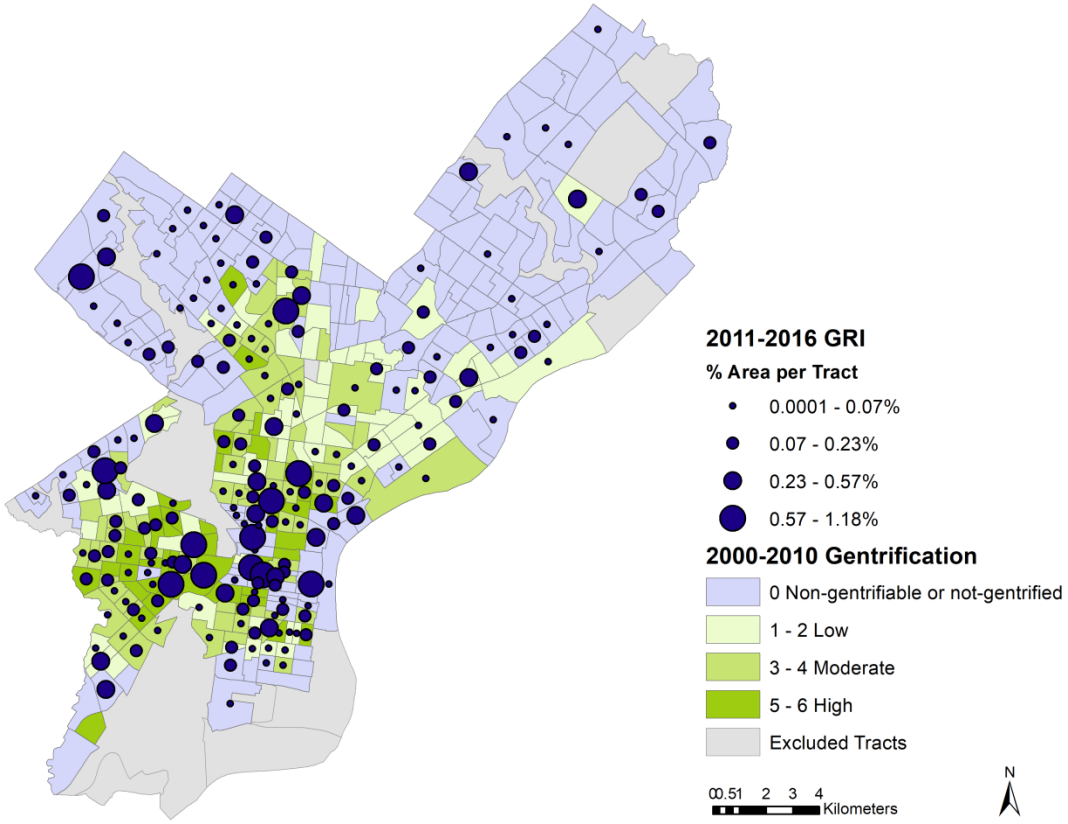

Figure 8: Green Resilience Gentrification in Philadelphia: Sites of Commission, Gentrification 2000-2010 and GRI 2011-2016

5.2.6 Changes in minority populations / income and GRI siting from 2000 to 2016

Finally, we examined tracts that increased in concentration of socially vulnerable populations over time and had little to no GRI – the corollary to trends above where areas receiving GRI gentrified. These are also Sites of Commission because we may observe an increased concentration of more socially vulnerable groups in less protected areas and/or a worsening of conditions. We did not measure for absolute change in populations; rather we tested for our hypothesized association of a negative correlation between percent minority/low-income residents and percent White/higher-income populations.

Figure 8 (left) shows the change in Black population from 2000 to 2016. The darkest red areas, totaling 24 tracts, represent an increase of 20-48 percentage points in Black residents. The blue areas represent a decrease in Black population during the time period, with most between 0 and 20 percent. We can observe an increase in percentage of Black residents where relatively few GRI have been installed and a decrease in the percentage of Black residents where high numbers of GRI cluster. These results were strongly significant for a negative association between GRI and Black population ($p<0.01$). Similar results were found for Hispanic residents (Figure 8, right). On the contrary, there was a strong positive association between high-income/White residents and GRI, especially in the overall period ($p<0.01$). Table 4 shows Pearson correlation coefficients for GRI by year and by each of four gentrification

demographic variables, pertaining to race/ethnicity and income, across the 371 census tracts in Philadelphia. Sites of Commission in the more economically valued neighborhoods of Philadelphia to which whiter and wealthier residents have increasingly moved are paralleled by increases in the percentage of lower-income and minority residents in under-protected, less climate-resilient areas.

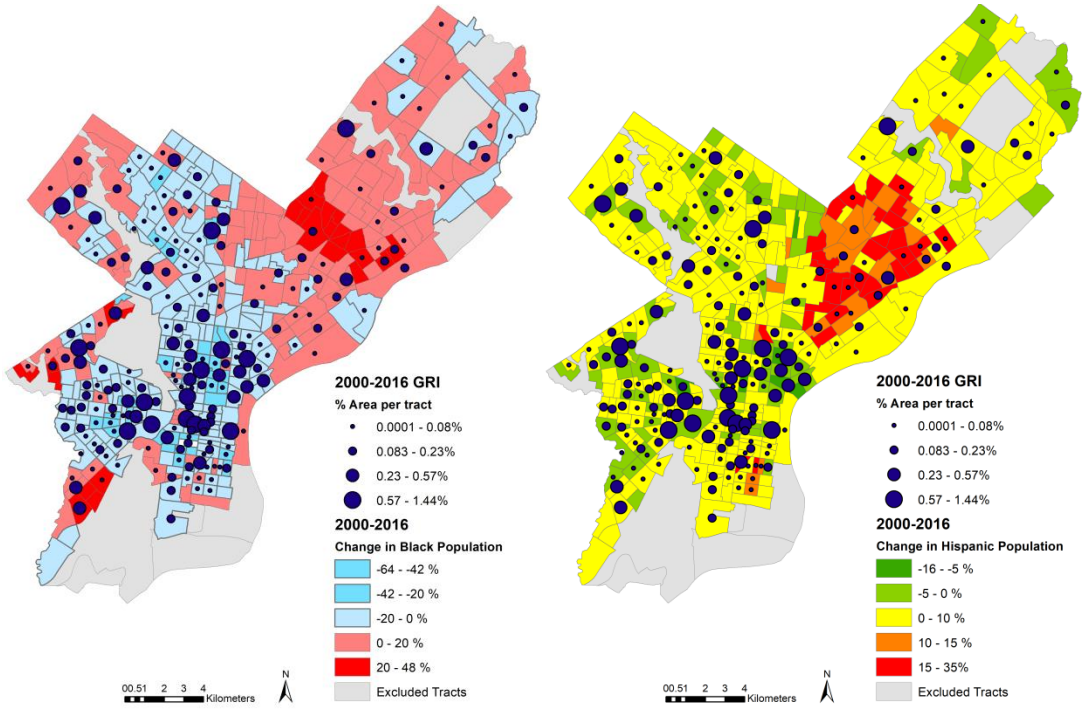

Figure 9: GRI and Change in minority residents, Black (left) and Hispanic (right), 2000-2016 - Sites of Commission

GRI in % Area per Tract	Gentrification Variables			
	White (non-Hispanic)	High-income residents	Black (non-Hispanic)	Hispanic
GRI 2000-2016	Gentrification Variables 2000-2016			
	0.173***	0.153***	-0.142***	-0.170***
GRI 2000-2010	Gentrification Variables 2010-2016			
	0.036	-0.011	-0.016	-0.163***
GRI 2011-2016	Gentrification Variables 2000-2010			
	0.170***	0.09	-0.162***	-0.136***

*** indicates significant at $p < 0.01$

Table 4: Pearson Correlation Coefficients for GRI by Year and selected Gentrification Variables among Census Tracts in Philadelphia (n=371)

6. Interpretation and Discussion

In this paper, we responded to calls for a better understanding of how adaptation or climate resilient infrastructure play out in the lives of socially vulnerable residents. We have sought to test whether green and resilient infrastructure siting addresses social-ecological vulnerability or if such practices reproduce uneven conditions, rendering historically marginalized populations actually more vulnerable to climate impacts and risks and less secure, while benefiting more privileged new residents.

Our study indicates that green resilience infrastructure in Philadelphia are not being sited or accumulating in such a way as to benefit the most socio-ecologically vulnerable residents. Had the landscape of social vulnerability remained unchanged from 2000 to 2016, residents with high social vulnerability would have almost equally benefited over time. However, residential stability did not occur in Philadelphia: As our analysis of gentrification and GRI shows, most of the benefits of protective infrastructure have gone to areas with wealthier, whiter and better educated residents over time. It is possible that green resilience investments and improvements made these areas more attractive and seemingly less risky (or more secure) for those newcomers.

However, our results also strongly suggest that early gentrifiers have themselves attracted or created the protections we see in these areas by 2016 – GRI is most likely both cause and consequence of gentrification in Philadelphia. It is thoroughly entwined in the processes of social change that are occurring.

During this period, marked by extreme gentrification in the city center, the numbers of Black and Hispanic lower-income residents declined in gentrifying resilience-invested areas while they increased in neighborhoods where GRI investments did not occur in the most recent period. This leads us to suggest that a dually – simultaneously or parallel – unjust process of omission and commission may be occurring alongside the planning, provision and siting of resilience investments in Philadelphia. On the one hand, climate protective infrastructure is becoming concentrated in wealthier and economically valued areas over other ecologically vulnerable, less favored areas; while on the other hand, minority and low-income residents have shifted from wealthy areas and are increasing in green resilience dis-/under-invested neighborhoods. This means that the landscape of vulnerability in Philadelphia shifted, but also that a new social-ecological riskscape and environmental insecurity shaped by resilience-building measures emerged.

6.1. Climate protection inequities in addressing socio-ecological vulnerabilities

As we first examined whether the most socio-ecologically vulnerable tracts were receiving GRI protection or not, our findings indicated that ecologically vulnerable areas were targeted for GRI from 2000 to 2016, but with a strong preference for less socially vulnerable areas. Here there may be two factors at work. Before the passage of the *Green City, Clean Waters* plan, as with other 'early adapters' (Chu et al., 2016), Philadelphia's watershed engineers may have taken an experimental approach that required some degree of 'learning by doing' and a strategy of deploying demonstration projects in neighborhoods with the lowest implementation risks, as well as the highest potential to achieve visibility (Bulkeley and Castán Broto, 2013) and boost political salience (Madden, 2010). In this scenario, engineers and planners would have seized on opportunities for inter-agency partnerships and ad-hoc initiatives proposed by private and community leaders (Anguelovski et al., 2014; van den Berg and Coenen, 2012) leading possibly to siting in centrally-located, higher income neighborhoods with strong private investment interest and potential.

However, even with the later passage of the *Green City, Clean Waters* plan in 2011, neighborhoods with low social vulnerability continued to be better protected by more recent GRI siting. Here, procedural justice issues may be structuring siting decisions such that less vulnerable neighborhoods are more capable of attracting and maintaining protective infrastructure, as opposed to high social vulnerability neighborhoods with a legacy of disinvestment and privatization of urban service provisions (Heynen et al., 2006). For example, the Philadelphia *Rain Check* program tends to privilege homeowners (Bulkeley et al., 2014) – that is traditionally higher-income residents – and individualizes the responsibility to adapt to those able to (Dauvergne, 2016; Zografos et al., 2016), in particular, those with the budget, time, space and physical ability to make and maintain their homes in a greener, more resilient condition (Heckert and Rosan, 2018; Mandarano and Meenar, 2017). In neighborhoods where residents do not have the income or capital to invest in these projects, they may lose out on GRI investment and protection, with this uneven outcome reproduced as another green resilient inequity over the program's continuation.

Furthermore, the strong clustering of GRI in the city center and in and around downtown university campuses, which have been sites of concentrated public and private investment in recent years (PEW Charitable Trusts, 2016), suggests that these economically-valued districts are being unequally protected, and possibly at the expense of more socio-ecologically vulnerable neighborhoods such as

Olney and parts of Lawndale, Oxford Circle and Hunting Park. As Mandarano and Meenar point out (Mandarano and Meenar, 2017, p. 11) in Philadelphia, "regulations mandating private sector investment in [GRI] prompt the inclusion of [GRI] projects in development, but do not shift the location of development." This reliance on private investment for protection and adaptation generates new Sites of Omission, leading to maladaptation and new landscapes of unequal socio-ecological vulnerability.

The city's climate resilience model may further assume that the economic (i.e. increasing real-estate values) and the hedonistic (i.e. beautification, recreation) are equally beneficial for all social groups. Overlooking the terrain of unequal and entrenched power dynamics among social and racial groups and the potentially contested space onto which new green technologies enter (Connolly, 2018; Finewood et al., 2019), technocratic approaches ensure that more powerful actors will benefit most from "urban ecological security" (Hodson and Marvin, 2009).

6.2. Climate protection: A new pathway towards green resilience gentrification?

In our study, we found a significant positive correlation between GRI clustering and highly gentrifying neighborhoods in Philadelphia from 2000 to 2016. The discrepancy between GRI clustering in highly gentrifying tracts versus non-gentrifying tracts was 3 to 1 on average for the number of interventions and 4 times the amount of "greened acres", Philadelphia's metric for green resilience infrastructure. We also found that the fastest gentrifying neighborhoods in the 2000s received the highest quantities and concentrations of GRI in the most recent years.

Our interpretation builds on nascent critical climate adaptation (Anguelovski et al., 2016), green gentrification (Anguelovski et al., 2018b; Checker, 2011; Curran and Hamilton, 2012; Gould and Lewis, 2017), and climate gentrification (Keenan et al. 2018) scholarship. By leaving open the direction of association between GRI and gentrification, our results suggest an important nuance – that gentrification correlates strongly with GRI and may also facilitate or accelerate climate protective infrastructure. It is a two-way relationship characterized by the embeddedness of social and ecological processes rather than a linear causation pathway. The Philadelphia case therefore indicates a new bidirectional pathway not yet described in the climate gentrification literature, one in which public-private investment in climate protection in gentrifying neighborhoods results in new ecological enclaves for privileged White/high-income residents. Those residents then reinforce those enclaves by drawing further investment after gentrification, thus producing a new geography of risk in the city.

Moreover, by including a racial component, our approach produced a key finding. In Philadelphia, racial composition tends to be the strongest predictor of which areas receive GRI, suggesting that race plays a key role in siting, even more so than socioeconomic and real estate variables (Mohai and Saha, 2015). Such results advise extending the analysis of gentrification conceptualized solely as increased property values or as changes in the proportion of highly educated residents, to investigating which social and racial groups of residents benefit from green climate resilience strategies over the short and mid-term and whose long-term security and livelihood is undermined. Older discriminations, lurking in past zoning decisions, infrastructural investments, and housing affordances, may continue to haunt present-day decisions (Mohai et al., 2009).

Thus, our study contributes to better understanding climate gentrification as a process of climate *protection* gentrification and climate injustice. Figure 9 below presents a framework for understanding

its pathways and implications by extending the theoretical development of sites of omission and commission that emerged from the analysis. Although we have not measured displacement – further research is needed – these results nonetheless point to trends that Black and Hispanic residents in Philadelphia seem to be shifting into less protected areas (future sites of commission should they gentrify with the siting of new GRI), and corroborate other findings that Philadelphia is re-segregating as minority middle-income neighborhoods grow more fragile with higher rates of eviction and foreclosure and declining incomes and employment (Reinvestment Fund, 2017). This re-segregation is thus marked by a new form of social-ecological polarization that arises from, on the one hand, an unequal distribution of environmental protections and possibly, on the other hand, a lack of social protections to prevent displacement. Even if physical displacement is always difficult to demonstrate in gentrification studies (Easton et al., 2019), the arrival of wealthier and whiter residents and the frequent next step (or accompanying step) of cultural and political gentrification (Hyra, 2015, 2017; Prince, 2014) signifies potential losses of social cohesion and political power, which are also key in urban adaptation and in harnessing adaptation projects and/or resources (Graham et al., 2016; Zografos et al., 2016). Therefore, coupled with patterns of gentrification, resilience efforts can lead to new landscapes of environmental insecurity and injustice by class and race characterized by increased livelihood insecurities, new climate protected enclaves for the privileged, privatized resilience, maladaptation and climate protection segregation.

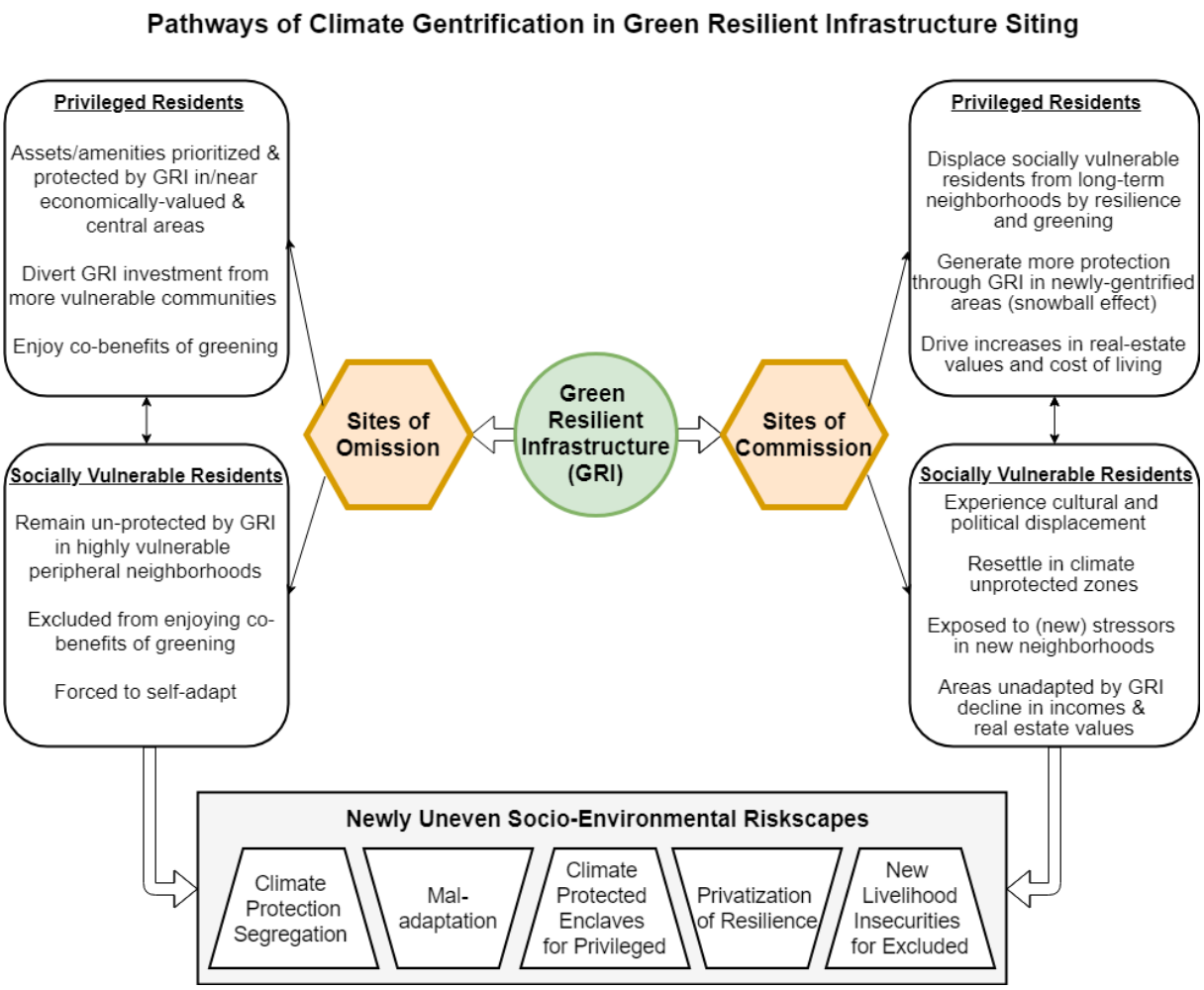

Figure 10: Pathways of climate protection gentrification in green resilient infrastructure siting

6.3. Policy implications: New pathways and methodologies for a more just green climate protection

Using a spatial quantitative analysis, we attempted to uncover mechanisms by which environmental inequalities of climate protection occur and perpetuate. Environmental inequalities today cannot be reversed by simply replacing “hazards” with “green amenities”, while leaving entrenched social, racial, and economic hierarchies untouched. We suggest here a process that re-couples an understanding of historic drivers of uneven geographies to the social-ecological model and to resiliency planning and explicitly ties a longitudinal approach to social-ecological vulnerability by integrating questions of gentrification and environmental and climate justice.

Based on our study, this requires 1) to evaluate social and ecological vulnerability across urban landscapes to ensure that green infrastructure not only builds resilience equitably, but is justice enhancing by prioritizing neighborhoods with higher socio-ecological vulnerability; 2) to analyze

neighborhoods for vulnerability to gentrification/displacement and identify intersectional drivers of climate injustice; 3) to proactively put in place anti-gentrification and anti-displacement measures before projects are underway; and 4) to prioritize community-driven climate resilience approaches so that they can be responsive in real time to social-ecological processes and ensure that benefits belong to vulnerable residents.

To do so, GRI programs must carefully consider race, socioeconomic and real estate factors - among others – in addition to environmental and climate ones (Ranganathan and Bratman, 2019), and to go beyond technocratic, colorblind approaches to building resilience, as they may subordinate alternative aspirations, politics and forms of knowledge (Finewood et al., 2019; Hardy et al., 2017). They should work closely with local organizations to prioritize GRI's wider adoption by lower-income residents, including fully subsidizing community driven efforts. They should also advocate alongside these organizations for protections ensuring that residents in long disinvested areas can stay in place if they choose. GRI programs can assist by endorsing tax breaks or incentives to low-income homeowners designed to keep housing costs and repairs (including green upgrades) down (Immergluck and Balan, 2018) and support a series of citywide community land trusts around GRI cluster areas or large-scale climate protection projects (i.e. waterfront resiliency redevelopments) which can secure long-term affordability and stability for lower-income residents (Anguelovski, 2014; Thompson, 2015). They can further call for other complementary housing affordability, tenants' rights and land rights policies, which also help preserve social networks and important local cultural institutions and symbolic places (Wolch et al., 2014). This also means advocating against the hazardous features of so-called community development programs that largely benefit wealthier homeowners and developers (i.e. federal opportunity zones and long-term city tax abatements on all new construction and major renovations). These policies increase vulnerability to gentrification and displacement, reduce city resources and therefore hinder their ability to ensure climate protection for socio-ecologically vulnerable areas.

Lastly, there is real opportunity for GRI programs and partners to participate in more transformative urban climate justice and reparations efforts. For example, by allying with and promoting low-income and minority community-driven efforts, cities can boost local workforce development and minority owned businesses as part of a broader Green New Deal, labor reform or other green climate economy initiatives. Beyond infrastructure itself, any work that strengthens local organizational networks, social ties and place attachments is more likely to benefit long-lasting climate resiliency and justice (Graham et al., 2016).

7. Concluding reflections and future research directions

In sum, we found that shifting patterns of vulnerability in correlation with gentrification created new urban riskscapes in which low-income and minority residents were shifted into conditions of heightened socio-ecological insecurity. Based on findings in Philadelphia, green resilient infrastructure is enmeshed in these processes, creating new urban conditions for the privileged and enlarged social risk (insecurity) for vulnerable populations – a key missing consideration of land use planning and decision-making.

Therefore, future research is needed to understand the social and political barriers to adopting green resilient interventions in high vulnerability neighborhoods, including residents' perceptions of and resistance to resilience projects (Kaika, 2017) and their association of green resilience projects with

locally unwanted land uses (green LULUs) and indicators of wealth, whiteness and status. People have indeed different perceptions of social-ecological risk and security shaped by confrontations within unequal power dynamics and rooted ultimately in uneven conditions and possibilities for flourishing and thriving.

A research agenda that engages with the politics of resiliency and adaptation planning is needed to better understand these dynamics. Future research should also examine the politics by which green resilient infrastructure siting decisions are made in the complex inter-agency and planning configurations of the city (Connolly, 2018; Pellow, 2000) and consider the political economy of drivers behind the clustering of protective infrastructure in new "resilience zones" (Teicher, 2018).

In future research we intend to examine vulnerability to future green resilience gentrification in correlation with private investment and new development as well as adaptive capacity to gentrification. Resilience carries with it a notion of security that suggests protection from the harms of future hazards (Vale, 2014) – including those that are more and less predictable – such as gentrification and its well-known social, cultural, and economic impacts. Future research could also try to unpack whether and why some more socially and ecologically vulnerable neighborhoods may succeed in acquiring green and resilient protection and yet stave off gentrification and displacement. These potential examples of social-ecological resilience are not well known or understood.

Building resilience in a context of uneven (unequal) conditions thus means confronting uneven socio-ecological riskscapes, vulnerabilities, and increased insecurities vis-à-vis people's long-time place of residence, their social ties and livelihoods, combined with new exposure to extreme weather events, so that today's green climate interventions and other environmental benefits do not become tomorrow's undesirable outcomes for the politically and economically less powerful and more vulnerable.

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Chapter 3 - "They didn't see it coming": Green resilience planning and vulnerability to future climate gentrification

Abstract

As cities strive to protect vulnerable residents from climate risks and impacts, recent studies have identified a challenging link between these measures and gentrification processes that reconfigure, but do not necessarily eliminate, climate insecurities. Green resilient infrastructure (GRI) may especially increase the vulnerability of lower-income, communities of color to

gentrification, an issue that remains underexplored. Drawing on the forerunner green city of Philadelphia as our case study, this paper adopts a novel intersectional approach to assess overlapping and interdependent factors in generating vulnerability and resilience through spatial quantitative data and qualitative interviews with community-based organizers, non-profits and municipal stakeholders. More specifically, this paper develops a new methodology to assess vulnerability to future climate gentrification and contributes to debates on the role of urban development, housing, and sustainability practices in climate justice dynamics. It also informs strategies that can reduce social and racial inequities in the context of climate adaptation planning.

Keywords: climate gentrification; vulnerability; climate justice; resilience; green infrastructure; adaptation planning

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Introduction

As cities strive to adapt to the increasing intensity and frequency of climate risks and impacts, from flooding to extreme heat and worsening air pollution, decision-makers are beginning to recognize that the most vulnerable urban residents often go unprotected. Among key measures to build resilience, cities are especially turning to green resilient infrastructure (GRI) such as rain gardens, green roofs, bioswales and climate-proof parks. But in an increasing number of cases, socially vulnerable residents are concerned about green gentrification. In other words, those with fewer resources to manage risks at the individual and neighborhood level fear that they will be excluded from the long-term benefits of new green investments. This points to a green *resilience* paradox in that green resilience measures which are meant to reduce vulnerability to climate risks and impacts, may do so for some even while exacerbating vulnerability to gentrification and displacement to areas at greater risk for other, socially vulnerable residents (Anguelovski et al., 2019; Gould & Lewis, 2018; Shokry et al., 2020). The "green space paradox" identified elsewhere (Pearsall & Eller, 2020; Wolch et al., 2014) therefore extends into climate resilience initiatives (Gould & Lewis, 2018).

The green resilience paradox is an essential consideration for urban policy given the wide support that green infrastructure and investment for climate resilience has received from federal and international agencies. In the United States, the Environmental Protection Agency (EPA) incentivizes green resilience in cities through implementation of the federal Clean Water Act (CWA), as a part of efforts to regulate storm and wastewater discharges from combined sewer systems (CSS) from entering the same streams from which drinking water is sourced (Heckert & Rosan, 2016). Under pressure to find affordable solutions to EPA mandates, which included hefty fines for breaching discharge limits, some frontrunner municipalities – including Philadelphia, Washington, Portland, and Seattle – began in the 2000s to promote green stormwater infrastructure as a cost-effective means for increasing ground permeability to reduce runoff. Convinced by these early efforts, the EPA increased support to municipalities through technical guidance, the sharing of best practices, and funding opportunities such as its

Superfund Redevelopment and Nonpoint Source Pollution programs (Johns, 2019; US EPA, 2015).

The incentives to create more GRI in cities extend beyond the EPA. Federal programs such as the U.S. Department of Housing and Urban Development (HUD)'s Sustainable Communities Initiative [18] also finance GRI through grants that support climate resilience and promote community revitalization. The HUD's Community Development Block Grants and Department of Transportation (DOT) Congestion Mitigation and Air Quality funding can also be directed toward GRI components of other public works initiatives (US EPA, 2015). Further fuelling this process of integrating GRI in urban regeneration projects are state initiatives such as Pennsylvania's Department of Conservation and Natural Resource Keystone Grants and Arizona's Department of Environmental Quality which funded a project in Tucson to convert vacant lots into pocket parks with green stormwater features (GCC, 2016). Lastly, cities themselves draw on local funds to finance GRI implementation through permit fees and income and property taxes, including tax increment financing of development projects which depend on future increases in property values (GCC, 2016).

There is a growing understanding that socio-ecologically vulnerable neighborhoods receiving green climate interventions are often simultaneously those being targeted for urban regeneration projects (Tubridy, 2020) which may spur new inequities (Arbaci & Tapada-Berteli, 2012; Dillon, 2014; Weber, 2010). Several studies have examined the link between urban

[18] See https://www.hud.gov/sites/documents/GREENINFRASTRUCTSCI.PDF (Accessed April 1, 2021)

regeneration and gentrification through new green spaces, transit and other amenities (Anguelovski, Connolly, Masip, et al., 2018; Cucchiara, 2008; Dawkins & Moeckel, 2016; Derakhti & Baeten, 2020; McGovern, 2013; Safransky, 2014; Shaw, 2005), but the role of climate interventions remains understudied (Shokry et al. 2020). There is a need to better understand the extent to which concurrent climate resilience projects, urban revitalization, and changes in housing markets may intensify inequities and vulnerability to gentrification or, in contrast, whether social support services and anti-displacement policies and practices are in place to build adaptive capacity.

Using spatial quantitative data on GRI and qualitative interviews, we examine the nexus between green resilience infrastructure and a process increasingly known as *climate gentrification* in Philadelphia, an emblematic case of urban green adaptation practice and of recent gentrification. We therefore offer new understandings of the equivocal role of green resilience interventions for climate justice and injustice dynamics. Moreover, we contribute to critical housing studies by unpacking how neighborhood (re)development and social support resources participate in either advancing sensitivity to gentrification and displacement, or conversely, strengthening adaptive capacity in the face of changing housing markets. Overall, our study enriches understandings of drivers for social and green resilience – or lack thereof – in cities (Kaika, 2017). It also offers some novel methodological aspects by using a clustering approach to weight vulnerability to gentrification factors – that is to theorize a community's level of sensitivity and adaptive capacity toward gentrification in terms of overlapping and intersecting concentrations resulting from differential exposure and access to systemic harms and structural resources. Results demonstrate that along with equity and inclusion, adaptation

must account for the uneven and historically produced urban conditions in which it is embedded. Or else, vulnerable residents face a perpetual double insecurity and displacement risk – one by climate risks and impacts and the other by green (climate) resilience gentrification. Next, we turn to the main theoretical underpinnings of the paper – social and racial inequities in urban greening and climate adaptation practice – before presenting the research design and data for our analysis of Philadelphia's green adaptation practice. We then present a comprehensive overview of findings before discussing their meaning in the broader critical resilience literature and in the more normative context of engendering urban green climate justice.

The complex entanglement of urban climate adaptation and green inequities

Urban greening for (unequal) adaptation and resilience

Today, urban climate adaptation planning in the global North increasingly translates into investments in green infrastructure (Meerow & Newell, 2017), such as green stormwater management tools (Liu & Jensen, 2018), to achieve greater climate resilience. Traditionally, the manifold co-benefits generated by exposure to green spaces are described as those for health and wellbeing (Douglas et al., 2017; Kondo et al., 2020; Triguero-Mas et al., 2015), greater citizen inclusiveness and social cohesion through collaborative and community-based actions (James J. Connolly et al., 2013; Mandarano & Meenar, 2017).

But as mounting evidence from environmental justice scholars and activists indicates, the historic distribution of and access to green goods – and therefore their benefits – is uneven (Checker, 2011; Dooling, 2009; Gould & Lewis, 2017). Recent research points to land availability but also political and financial factors as complicating planners' ability to green the most disinvested neighborhoods (Boulton et al., 2018; Pearsall & Eller, 2020). Even when low-income residents of color live in urban areas with green spaces or thick tree canopies, these

environmental amenities are often of low quality or overgrown, a result of enduring municipal disinvestment and neglect (Brownlow, 2006; Heynen et al., 2006). Some green initiatives such as tree plantings are the object of much skepticism on the part of residents due to perceptions that planting and maintenance is both time- and cost-intensive and that trees may cause costly structural damage to sidewalks and homes (Baptiste et al., 2015; Carmichael & McDonough, 2019; Newburn & Alberini, 2016).

Residents of color have also been shown to be less likely to frequent parks and gardens – many of which are being remodeled into green resilient infrastructure – in more integrated or whiter neighborhoods due to experiences of rejection, violence, racist "microaggressions," formal and informal surveillance, and fears of being reported to the police (Brownlow, 2006; Byrne & Wolch, 2009; Finney, 2014). This legacy of disciplining and Othering of Black and Brown bodies (Byrne, 2012; Pellow, 2016) may result in residents refusing outside efforts to improve or build new green amenities, knowing that urban greening often attracts White residents to their neighborhoods. A growing thread within the green gentrification literature (Anguelovski et al., 2020; Checker, 2011; Gould & Lewis, 2017) highlights cultural and political 'emplaced' displacement (Hyra, 2015; Wynne & Rogers, 2020) – how the exclusionary practices of newcomers empty a neighborhood of its soul and prevent more life- and dignity-affirming approaches to its regeneration (Brand & Miller, 2020; McKittrick & Woods, 2007).

Thus, new green or environmentally-cleaned up amenities can lead to the exclusion and displacement of the most vulnerable residents (Dooling, 2009; Essoka, 2010; Pearsall, 2010) while creating enclaves of 'pleasure and privilege' for wealthier ones (Anguelovski, Connolly, & Brand, 2018; Park & Pellow, 2011). Tied to this green space paradox (Wolch, Byrne, and Newell

2014; Pearsall and Eller 2020; Connolly 2019) are demonstrated rises in real estate values around greened spaces (Heckert & Mennis, 2012; Immergluck & Balan, 2018) rendering neighborhoods less affordable, increasing evictions, and generating residential displacement. Here, many green gentrification scholars agree that green projects are also a means for exploiting a 'green gap' (Anguelovski, Connolly, and Brand 2018) between underserved neighborhoods and those which have already been greened and gentrified (Gould & Lewis, 2017; Immergluck, 2009), usually located near to each other (Pearsall & Eller, 2020). Yet, these findings are mostly associated with larger-scale interventions. Less is known about the exclusionary and gentrification patterns and potentials of accumulated smaller-scale "acupunctural" interventions for climate resilience.

In relation to increasingly dedicated planning and funding efforts to climate adaptation (Aylett, 2015; Carmin et al., 2012; Hughes, 2015; Woodruff & Stults, 2016), cities' greening strategies to reducing climate vulnerability – even those with a social equity objective – are nonetheless built on existing legacies of racialized and class-based housing and environmental policies and uneven development (Anguelovski et al., 2020; Gould & Lewis, 2018). Cities tend to lean on existing planning and financing frameworks (Anguelovski et al., 2016; Bigger & Millington, 2019; Bulkeley & Castán Broto, 2013) to fund and market measures and adaptation is seldom transformational of unsustainable development pathways (Zografos et al., 2020). Yet, the racialized and racist foundations of these frameworks are often unacknowledged, let alone addressed, in discourse or implementation.

Green growth, capital accumulation, and dispossession

From a broader political economy perspective, cities' green adaptation practices have been linked to a neoliberal governance agenda through urban regeneration arrangements (Tubridy, 2020), including privatization, entrepreneurialism (Whitehead, 2013) and financializing nature (Bigger & Millington, 2019), which commodify and marketize urban resilience interventions (Leitner et al., 2018). As cities go green, they also develop a green city branding and nature-based solutions discourse as a key instrument of neoliberal governance strategies for attracting local and global capital and wealth (Garcia-Lamarca et al., 2019; Kotsila et al., 2020) to centrally disinvested neighborhoods and eventually stimulating economic growth (Dooling, 2009; Quastel et al., 2012).

Furthermore, by variously employing the discourses of sustainability, resilience and the smart city, municipalities justify new green infrastructure (J. J. T. Connolly, 2019), as a win-win or no-regrets solution for climate adaptation, and evade questions of equity and inclusion (Kaika, 2017) by framing benefits as inherently good for all (Anguelovski, Connolly, & Brand, 2018; Brown, 2014; Ziervogel et al., 2017). This depoliticized promotion of green and resilient solutions – presented as a kind of 'sustainability fix' (Long, 2016; While et al., 2004) – may especially overlook historical and ongoing racialized inequalities, justifying its approach by capitalizing on collective anxiety about a climate changed future (Harper, 2020) rather than re-investing in longtime residents' protection. Injustices therefore may be reproduced and aggravated by what Hardy (2017) calls 'colorblind adaptation planning' when interventions do not take account of social vulnerability (Connolly 2018) nor make of social justice an explicit goal (Agyeman, 2013).

Critical urban scholars have examined the role of urban transformation (i.e. regeneration, revitalization, renewal and redevelopment) in capital accumulation and dispossession of the urban poor, and more recently identified a process of 'accumulation by *green* dispossession' (Safransky 2014; emphasis ours). Resembling the location of toxic industries (Mohai & Saha,

2015) in working-class, Black and Brown neighborhoods (using the promise of jobs), in this case, it is green infrastructure that is pushed and sited despite its relationship with gentrification and displacement. By hinging greening and resilience efforts on business-as-usual growth-driven agendas, they perpetuate settler colonial practices together with racialized displacement and dispossession (Safransky, 2017).

Therefore, the greening of cities paired with climate adaptation actions may actually undermine the long-term security and livelihoods of the most vulnerable residents (Ranganathan & Bratman, 2019; Shokry et al., 2020). Green resilient infrastructure, like other amenities associated with urban regeneration and capital accumulation, are an ingredient in climate gentrification, potentially putting vulnerable residents at risk of displacement (Gould & Lewis, 2018) while possibly creating private intra-urban competitive regimes of resilience (Teicher, 2018). Recent research in Philadelphia uniquely shows that green resilient infrastructure have tended to be sited in already gentrifying neighborhoods, followed by more gentrification, and that Black and Latinx residents are moving to hotter, more impervious areas with little to no climate protection (Shokry et al., 2020).

Understanding vulnerability to future climate gentrification: a new framework for urban climate justice

In sum, while some scholars and practitioners view resilience as a necessary step to a deeper, more structural and systemic transformation of social-ecological relations (Pelling, 2011), green resilience measures as practiced may paradoxically be aligning adaptation with private real estate interests and urban renewal strategies that hazardously re-inscribe and re-configure existing risks and inequalities across the city (Anguelovski et al., 2016; Bigger & Millington, 2019; Shokry et al., 2020). In such circumstances, resilience scholars have recently argued, resilience should be reduced rather than enhanced since an 'abrupt transformation' is desired (Elmqvist et al., 2019; Langemeyer & Connolly, 2020). Rather than responding to the intersectional vulnerabilities, traumas, and precarity of working

class and minoritized residents as would be the case with an approach like “abolition climate justice” (Ranganathan & Bratman, 2019), green adaptation that disregards its normative implications (Fainstein, 2015; Wilkinson, 2012) and muddles toward a vague resilience goal, might create greater injustice and residential vulnerability over space and time.

Our paper builds on these critical insights to shed light on the role played by green resilient infrastructure in generating vulnerability to future gentrification, and thus to greater climate injustice. We address two critical research questions: 1) What are the vulnerability to gentrification characteristics of areas that are planned to receive GRI in the future; and 2) In what ways do GRI exacerbate vulnerability to gentrification for socially vulnerable residents? We thereby theorize and mobilize vulnerability to future climate gentrification as a critical analytical lens for examining (a) how cities' planned climate adaptation and protection efforts relate to pre-existing vulnerabilities, and (b) how the social justice implications of urban adaptation practice can be measured. We operationalize measures that indicate pre-existing vulnerability to gentrification in order to assess the potential future impact for the most vulnerable residents in neighborhoods exposed to recent and future green resilience interventions. We also account for neighborhood resources that might prevent displacement and thus might need to be bolstered.

This is, to the best of our knowledge, the first study to assess vulnerability to *future* climate gentrification and to evaluate the implications of planned green resilient infrastructure for *future* patterns of racial equity and urban climate justice. Processes of racialization which are foundational to explaining inequities and injustices in access to resources and protection are particularly underexplored in the urban resilience and climate adaptation planning literature (Bigger & Millington, 2019; Hardy et al., 2017) even as climate resilience measures increasingly

harness green urbanization and green growth strategies that have been linked with gentrification and the displacement of communities of color (Gould & Lewis, 2018). In this vein, our paper also uniquely employs a large range of diverse social and structural factors underlying vulnerability not typically considered in climate adaptation research or planning. In addition, whereas vulnerability indicators typically focus on the status quo, this paper offers new insights into climate justice and injustice dynamics by examining how resilience strategies (re)shape urban vulnerability and insecurity over time and space.

Transformation and greening in Philadelphia

Our analysis is based in Philadelphia, a post-industrial, redeveloping, and recently gentrifying city that has been dedicating substantial resources to urban greening over the last two decades. Despite several major population shifts throughout its history, Philadelphia remains a highly segregated city, with an uneven urban development trajectory which can be analyzed for spatial variations in social and structural vulnerability. Both its demographic and development landscape today are much influenced by post-industrial decline, a slow ongoing recovery and corresponding strategic policy decisions related to neighborhood investment and development (Hunter, 2013). We were able to construct the study thanks especially to a strong availability of data on both recently implemented and planned green resilient infrastructure, as well as an abundance of data on factors that our analysis reveals to be relevant to vulnerability.

The urban transformation and gentrification of a recovering Philadelphia

Amidst a mid-twentieth century transition to a post-industrial economy, the Philadelphia's Center City area became a key target for re-investment, which focused largely on office building construction and residences to re-attract middle- and upper- class residents (Beauregard, 1990) who had fled to the suburbs as Black residents moved downtown (Adams, 1991; Cooke, 2003). The demolition and resale of deteriorating housing stock to new homeowners was achieved through the application of eminent domain and the use of federal historic tax credits with the condition that investors rehabilitate the homes to reflect the city's colonial past. In each instance, neighborhood parks were created, and if applicable, waterfronts rehabilitated. Using this model, the Society Hill neighborhood became particularly emblematic of the "success" of renewal for urban transformation and gentrification (Beauregard, 1990; Smith, 1979).

However, other Philadelphia neighborhoods followed different paths, mostly gentrifying at slower paces. By the 1980s, success from reinvestment seemed worth the gamble, such that private developers and individual investors began taking more of a lead in speculating on the value of some surrounding Center City neighborhoods, with various media helping to transform neighborhood images. In the Spring Garden neighborhood, this spelled disaster for the majority Latinx, principally Puerto Rican, community. Despite active resistance that resulted in a few small victories, having little political clout in City Hall and being mostly renters, the Latinx presence was eventually erased block by block as reinvestment focused on attracting homeowners (Beauregard 1990).

At the turn of the twenty-first century, Philadelphia was still a city in recovery from deindustrialization and suburbanization with 40, 000 vacant lots, an ailing economy (Heckert & Mennis, 2012) and rising crime in some neighborhoods (Brownlow, 2006); meanwhile, others had started to gentrify (Hwang, 2016). In keeping with a broader housing boom, the pace and spread of gentrification increased rapidly from 2000, until the Great Recession of 2008, and

then restarted again in the ensuing recovery period (Ding et al., 2016). While real estate prices soared in many central neighborhoods, socially vulnerable residents displaced from those intensely gentrifying areas were moving to areas with worse housing and infrastructural conditions, especially post-recession (Ding et al., 2016). These residents tended to have lower-credit scores and were therefore rendered ineligible for new mortgage loans or even rental opportunities where landlords conducted credit checks.

According to the National Community Reinvestment Coalition (NCRC), Philadelphia was the fifth most gentrifying city in the US, from 2000 to 2013, with the top seven cities accounting for nearly half of all gentrification nationwide (Richardson et al., 2019). Shokry and colleagues' (2020) study of gentrifying Philadelphia identified 45 neighborhoods experiencing especially high rates of change from 2000-2016. During that same period, downtown gentrifying census tracts experienced losses of Black residents of up to 64 percentage points and Latinx residents up to 16 percentage points, while White, college-educated, and higher income residents increased. The NCRC study concurrently found that more than 12,000 Black residents moved out of gentrifying neighborhoods and that Philadelphia was among the top twelve cities with the highest rates of displacement for Latinx residents. The resulting widening racial wealth gap in Philadelphia is illustrated by Latinx residents having the highest poverty rate at 37.9 percent (PEW Charitable Trusts, 2016) and Black residents having a median income two-thirds that of White residents with twice the rate of unemployment (Anderson et al., 2018).

Philadelphia's green resilience turn: greening programs for climate protection and adaptation

Starting in the early 2000s, the Philadelphia Water Department (PWD) embarked on a mission to tackle flooding, stormwater runoff, drinking water pollution, and wastewater overflow with green

interventions that by the early 2010s became a major milestone in watershed planning in the United States (Fitzgerald & Laufer, 2017; Liu & Jensen, 2018; Uittenbroek et al., 2016). The program used a variety of data collection methods, green stormwater practices, and citywide public-private partnerships to reduce 85% of the contamination in combined sewer areas (PWD, 2009) and to mitigate urban heat island effects and air pollution. Efforts by the PWD to incorporate green stormwater interventions into vacant lots, schools, and local universities followed on decades of deindustrialization, suburbanization, population decline, and widespread land pollution and abandonment. PWD especially highlighted the economic and aesthetic co-benefits as well as cost-effectiveness and multi-functionality of green infrastructure.

PWD selected the most visible neighborhoods with the lowest implementation risks for demonstration projects in order to gain political backing (Bulkeley & Castán Broto, 2013; Madden, 2010) in the cash-strapped city. In 2009, this work was incorporated in the *Greenworks* sustainability plan, conceived to boost the city's revival by making Philadelphia the US's greenest city and increasing its economic competitiveness while delivering "equitable access to healthy neighborhoods" (Philadelphia OOS, 2009, p. 6). In 2011, the adoption of the *Green City, Clear Waters (GCCW)* plan (PWD, 2009)[19] set in motion a 25-year land and water strategy for improved urban permeability through green stormwater management with commitments to improve public access to water corridors.

In Philadelphia, these resilience-enhancing interventions increasingly greened and protected central gentrifying areas especially after the passage of the GCCW plan. Vulnerability – with regard to infrastructure and populations – came into focus in 2016 with the adoption of the climate adaptation framework – *Growing Stronger: Toward a Climate-Ready Philadelphia* – which identified climate risks and resilience strategies for various government sectors, with

[19] Also known as the Combined Sewer Overflow Long-Term Control Plan Update

green stormwater infrastructure a key tool for reducing climate vulnerability. That year, the Office of Sustainability also updated *Greenworks* and introduced the idea of a *Greenworks Equity Index* as evidence of its commitment to equity but has yet to publish it. As part of these endeavors the city plans to partner with lower-income and communities of color in the hottest neighborhoods – through *Beat the Heat* initiatives – to expand tree-planting and green stormwater infrastructure. In December 2019, the Philadelphia Department of Parks & Recreation also launched its *Future of the Urban Forest* planning process for a 10-year equitable tree planting strategy.

In sum, Philadelphia has become a model for wide-scale urban green stormwater infrastructure (Liu & Jensen, 2018) and appears to be successfully overlaying a new green and resilient brand atop a deeply racially and economically segregated past. Yet, a recent study (Shokry et al., 2020) has shown that percentages of Black and Latinx residents have significantly risen in some of the most impervious and least climate protected areas of Philadelphia, while whiter and wealthier residents have increased in cooler more permeable areas. These findings point to a process characterized by the displacement of communities of color through gentrification to more at-risk areas and the shifting – rather than the elimination – of climate risks and insecurities. So, knowing the widespread deployment of GRI throughout the city and, concurrently, increased social inequities, we ask: Are these protective measures indeed protecting all residents or actually making some more vulnerable to future climate gentrification?

Research design

Overall strategy

We designed this study as a mixed spatial quantitative and qualitative analysis of the relationship between the multiple overlapping and interdependent factors that generate vulnerability to gentrification and climate adaptive interventions, operationalized here as GRI.

Building on a previous study which explored associations between prior GRI siting, climate risks and past gentrification in Philadelphia (Shokry et al., 2020), we turn here toward understanding the extent to which neighborhoods that have been planned to benefit from protective climate infrastructure recently or in the near future are also those that will likely gentrify.

Identifying vulnerability to climate gentrification by green resilience

In order to identify the relationship between vulnerability to gentrification and recent and planned GRI, we (1) developed multi-variate indices of neighborhood vulnerability to gentrification, which we organized into typologies using cluster analysis; (2) compared vulnerability typologies, as well as social vulnerability characteristics with the amount of green (climate) resilient infrastructure using bivariate correlations at the census tract level; and (3) ground-truthed and contextualized our results in relation to qualitative data on local perceptions of vulnerability to climate gentrification gathered through semi-structured interviews. A visualization of the conceptual framework for variable identification, operationalization, and analysis is presented in Figure 1.

[Figure 1 near here; Conceptual framework for variable identification, operationalization, and analysis.]

A novel vulnerability framework in climate adaptation studies.

In this paper, we build a custom vulnerability index by adapting a common assessment framework from the global environmental change literature, which has three dimensions: exposure, sensitivity, and adaptive capacity (Gallopín, 2006; O'Brien et al., 2004; Turner et al., 2003). Exposure refers to how much a social-environmental system, such as a population and its neighborhood, is exposed to a particular risk or stressor (e.g., flooding or heat-island effect) that contributes to an outcome of concern (e.g., gentrification, displacement, new racial inequities). The system's sensitivity corresponds to factors that

down-regulate its response to the risk and/or intensify the impact of it (i.e., factors that might augment a neighborhood's likelihood of gentrifying), while adaptive capacity reflects factors that improve the system's ability to respond to and/or recover from risks to its well-being (i.e., factors that might mitigate gentrification and/or moderate the likelihood of the displacement of socially vulnerable residents) (Adger, 2006; Pearsall, 2010). Following Pearsall (2010), we apply this vulnerability framework to better understand the impacts and risks associated with the siting of green resilient infrastructure for residents vulnerable to gentrification and extreme climate impacts.

The novel aspect of our approach emphasizes the intersecting and compounding *neighborhood* and *structural* characteristics of sensitivity (e.g., urban renewal zoning, waterfront redevelopment, lower crime rates), whereas vulnerability research tends to define sensitivity as the *demographic* and *socio-economic* characteristics of population groups (e.g., race, income, education). Following the conceptual framework proposed by feminist theorists, Mackenzie, Rogers and Dodds (2014), we understand vulnerability to have both "distinct but overlapping" ontological and context-specific qualities and to be delineated by different sources (inherent, situational and pathogenic) and states (dispositional and occurrent). Therefore, we evaluate the demographic and socio-economic characteristics linked with the individual or household level sensitivity of socially vulnerable residents, separately, in order to understand who benefits from and is burdened by neighborhood contextual factors. We consider contextual factors especially relevant due to their embeddedness in urban policies, politics and institutional practices as well as their broader implications for social and racial equity and relations.

We therefore developed a list of potential neighborhood sensitivity and adaptive capacity factors, as well as individual and household social vulnerability factors based on a review of the literature pertaining to neighborhood gentrification drivers, anti-displacement resources, and

the characteristics of residents at-risk of displacement. Our selection of neighborhood factors was limited by the availability of open-source data for Philadelphia.

Second, we identified the spatial clusters of each variable that we theorized to contribute to neighborhood adaptive capacity and sensitivity to climate gentrification. We then identified the amount and type of overlap between clusters of each factor by census tract (see Cutter, Mitchell, and Scott 2000 for map overlay approach to identifying vulnerable areas) in order to build an index. Next, we examined the spatial overlap by tract between (a) degree of exposure to recent and planned GRI (as a percentage of tract area) and (b) degree of concentrated neighborhood sensitivity and/or adaptive capacity. The results indicate the neighborhood characteristics of areas with the greatest and least concentrations of contextual drivers of vulnerability to climate gentrification. We further investigate the correlation between those neighborhood characteristics and the spatial concentration of characteristics of residents more likely sensitive to displacement by gentrification and climate risks and impacts (rather than benefiting from the climate protective value of GRI).

Exposure

In this study, we operationalized GRI as our exposure variable, hypothesizing that, based on established green gentrification literature (see Anguelovski, Connolly, Garcia-Lamarca, et al. 2018) and emerging scholarly work on climate gentrification (Anguelovski et al., 2016; Gould & Lewis, 2018; Keenan et al., 2018; Shokry et al., 2020), green resilient projects may be linked with future climate gentrification in vulnerable tracts. This strategy allows us to assess the degree to which neighborhoods and residents exposed to GRI (compounded with other contextual neighborhood factors) are vulnerable and/or likely to experience climate gentrification.

Neighborhood Sensitivity to Gentrification

Sensitivity in our study refers to structural and systemic factors and risks that cumulatively contribute to augmenting a neighborhood's likelihood of gentrifying and displacing lower-income residents and people of color. We include them based on existing scholarship showing how these factors participate in unequal redevelopment and in the exclusion and erasure of vulnerable residents. It is important to note that no factor alone is sufficient to connote an overall sensitivity to gentrification and there are exceptions in all cases, but taken together these factors by-and-large demonstrate an underlying condition that makes an area a target for gentrification. The neighborhood sensitivity factors that could be mobilized in Philadelphia based on existing data include:

Urban renewal and redevelopment zones: Studies in real estate economics, urban geography, planning, and cultural anthropology have found evidence that urban renewal efforts are a core contributor to gentrification and displacement (ie., Smith, 1979). Large-scale state-sponsored urban renewal and redevelopment helps translate this gap into gentrification (Smith, 2005) through enabling reinvestment in housing markets following devalorization of capital in the inner city (Lees et al., 2010; Smith et al., 2013; Zukin, 1987). In the United States, Empowerment Zones (EZ) and Opportunity Zones are two federal policy instruments created to stimulate new revitalization, development, and neighborhood re-valuation. Yet, studies have shown that benefits accrue mostly to higher-income populations who have been attracted to EZs or to EZs that were already relatively better-off (Childers Roberts, 2012; Reynolds & Rohlin, 2014). Potentially worse social impacts are expected for lower-income residents of newly designated "Opportunity Zones" (Richardson et al., 2020). Linked to these new capital flows, is the arrival of gentrifier classes (Beauregard, 1990; Hackworth & Smith, 2001), who, in the

absence of mitigating policies and local capacities, displace socially vulnerable residents (Newman & Wyly, 2006).

Historic properties and districts: Gentrifiers tend to show a strong appreciation for the material, architectural and aesthetic qualities of historic buildings (Zukin, 1987), and neighborhoods with historical landmarks, especially historic downtowns, attract developers (Beauregard, 1990; Shaw, 2005). While historic designation may also be a protective tool for low-income homeowners by preventing demolition of historic properties and their replacement by taller denser buildings for newcomers with higher purchasing power, eventually this protection often generates rising property values, and fuels gentrification and displacement (Zukin, 1987). Therefore, city governments - as in Philadelphia - have seen in historic preservation an efficient tool for urban renewal and the gentrification of disinvested urban centers, which they further assist through formally certifying them for redevelopment (Beauregard, 1990; Brown-Saracino, 2013).

Proximity to waterfronts: Waterfront areas, especially those associated with current or future clean-up, sustainability, and greening programs and policies are hotspots of attractiveness and private investor attention, increasingly envisioned as new recreational, commercial, and residential spaces in the city (Harvey, 1989; McGovern, 2013). Encompassing substantial swaths of under-utilized often publicly owned land, especially in the postindustrial city, waterfronts tend to be sold to private developers as part of large-scale urban revitalization and intensification schemes (Bunce, 2009). In addition, even small-scale popups along disconnected

and/or derelict waterfronts, as seen in Spruce Street Harbor Park and Penn's Landing along Philadelphia's Delaware River may participate in the eventual privatization of these public spaces (Schaller & Guinand, 2018).

High proportion of cleaned & greened vacant lots: The cleaning and greening of vacant lands may be a channel for working-class, migrant and residents of color to reclaim an historically disinvested neighborhood – through, for example, community gardening - especially because vacant and derelict land has been associated with negative mental health outcomes, social stigma and fears of crime and insecurity (Maantay 2013; Branas et al. 2018). However, vacant lands may also be redeveloped for new housing, commerce, green spaces, and other urban amenities (Maantay and Maroko 2018). Heckert & Mennis (2012) have demonstrated in Philadelphia the role that greened vacant land has in raising property values, especially in moderately distressed neighborhoods[20]. This vacant land transformation has been shown to be part of a new settler colonial process (Safransky, 2014).

Improving or "higher performing" schools: Cities, including Philadelphia, have re-branded and marketed public schools to gentrifier families as urban amenities in efforts to restructure and regenerate central city districts (Cucchiara, 2008). Gentrifier parents tend to rely on school test scores and performance data as well as their personal networks or online forums to evaluate

[20] Highly distressed neighborhoods may still be too disinvested to be affected in the short-term by green improvements.

potential properties (Boger & Orfield, 2005; Godwin & Kemerer, 2010; Weininger, 2014). The competitive market for quality schools means that public and charter school performance is strongly linked with property values of surrounding real estate (Black, 1999; Figlio & Lucas, 2004)[21] as well as increasing race and class inequalities (Candipan, 2020; Kimelberg & Billingham, 2013). Therefore, through increased property taxes and the social capital of early gentrifiers, neighborhoods with improving schools see an improved financial base and become ripe for more gentrification (Childers Roberts, 2012).

Decreasing crime per capita: In neighborhoods where measures are in place to reduce crime, desirable amenities and appreciating house values may attract investors and gentrifiers (Taub et al., 1984). Some studies indicate that the arrival of wealthier residents actually contributes to new petty (Covington & Taylor, 2016) and property crime (McDonald, 1986; Papachristos et al., 2011). These, and a study in Philadelphia (Ferrick & Hall, 2017), further suggest that early gentrification is also correlated with declining homicides and other personal crime. Localized crime rates also tend to mirror changes in adjacent neighborhoods, for better or for worse (Kirk & Papachristos, 2011).

[21] Although Philadelphia charter schools and public schools (due to school choice policy) may draw students from the entire city, residential proximity to the school was still valued by parents.

Neighborhood Adaptive Capacity

Adaptive Capacity, in our study, refers to the types of hard and soft urban infrastructure that play a social support role for socially vulnerable residents (especially those historically marginalized from and by development opportunities or other neighborhood infrastructure due to income or race, for example). Their impact may be material, by for example reducing cost-burdens, or political through actions that underscore, expand and preserve those infrastructures. They also participate in mitigating gentrification and/or moderating the likelihood of the displacement of socially vulnerable residents. Adaptative infrastructure or resources may include affordable childcare (Banuelos et al., 2013; Bezanson, 2006; Ruhm, 2011); community health centers (Al-Kodmany, 2005; Jarvis, 2005; Pearson & Elson, 2015); housing counseling agencies (Levy et al., 2006; Pollack & Lynch, 2009; Quercia & Cowan, 2008); public-subsidized housing (Bates, 2013; Levy et al., 2006; Newman & Wyly, 2006; Pattillo, 2013; Pearsall, 2012); and community-based organizations (CBOs) (Graham et al., 2016; Pearsall & Anguelovski, 2016). The latter can play numerous roles that help stabilize low-income neighborhoods. These include services such as food banks providing critical support for lower income and working-class residents in everyday and disaster scenarios (Mathbor, 2007; Whittle et al., 2015), and advocacy, ensuring that community benefits (e.g. affordable housing, health care and childcare) are included in planning, zoning and (re)development efforts (Graham et al., 2016; Stokes et al., 2014). Housing counseling agencies can also assist families to locate and remain in housing they can afford whether for rent or for homeownership (Anderson et al., 2018; Levy et al., 2006). Different forms of affordable and publicly assisted housing are available to low-, lower- and moderate-income residents which together support those residents to remain in gentrifying neighborhoods (Pearsall, 2012).

Socially Vulnerable Residents

In our study, socially vulnerable residents are operationalized by those individual and household level factors (social characteristics, stratifications, and sensitivities) associated with a higher displacement-risk for underprivileged groups. Communities of color in Philadelphia continue to grapple with legacies of segregation, redlining, unequal development opportunities, and municipal abandonment (Beauregard, 1990; Brownlow, 2006) as well as influxes of whiter and wealthier residents. They also face entrenched institutional barriers to accessing adaptive capacity resources and climate protection (James JT Connolly, 2018). Indeed, studies have also shown that residents of color tend to live in aging housing stock and in areas that are especially vulnerable to climate impacts (Pearsall, 2017). They are also more likely to be displaced by gentrification to areas at-risk of flooding and extreme heat (Shokry et al., 2020) or excluded from adaptation planning processes in gentrifying neighborhoods (Heckert & Rosan, 2018; Mandarano & Meenar, 2017; Van Zandt et al., 2012). For these reasons, and persistent discrimination in the housing and jobs markets and in business ownership, displacement is especially onerous for these communities (Bates, 2013). Therefore, we give particular attention to the racialized dimension of social vulnerability to climate gentrification.

Data collection for spatial quantitative analysis

In this section, we briefly describe the data sources we used to construct each factor included in the vulnerability to climate gentrification index.

"Green resilient infrastructure" (GRI), our green spatial indicator and exposure variable, refers to "all surface-level, vegetated interventions, installed to mitigate environmental risk or impact, and improve adaptive capacity in the context of climate change, while enhancing neighborhood attractiveness (Shokry et al., 2020)". Adapting Shokry and colleagues' (2020) approach to our study of future climate gentrification, we therefore selected recent and proposed polygon features meeting these "green" criteria from the PWD Stormwater Management Practice (SMP) database. These included rain gardens, wetlands, green roofs, and tree trenches, among others

(see Figure 2).[22] We excluded non-vegetated or below-ground infrastructure such as underground cisterns and permeable pavements. We then applied the dimensions of each green polygon to calculate the surface area per tract of "greened acres (PWD, 2009)". Because GRI may be implemented in vacant lands, parks, and schoolyards, we joined those corresponding shapefiles with the SMP file to identify and integrate parcels with green stormwater features. Where GRI surpassed 10% of the surface area, we considered the entire green space to be GRI. The result was a combined shapefile of all active GRI from January 2016 to April 2020 and all GRI proposed for after April 2020. Out of 1,597 GRI data points included in the study, only 1 park/playground and 76 vacant lots met the conditions for including the entire space in the GRI dataset.

[Figure 2 near here; Examples of green resilient infrastructure in Philadelphia, Images © Philadelphia Water Department.]

Details are shown in Table 1 of each variable selected as a neighborhood sensitivity, neighborhood adaptive capacity or social vulnerability factor, its source and how it was operationalized. The

[22] Full descriptions of the various GI tools can be found in the Philadelphia Water, "Green Stormwater Infrastructure Design Requirements and Guidelines Packet," Philly Watersheds. Philadelphia Water Department, May 15, 2015, http://phillywatersheds.org/doc/GSI/GSI_Design_Requirements_&_Guidelines_Packet_5-15-2015.pdf. (accessed on July 26, 2019).

neighborhood-level factors (examined from 2010 to 2016[23]) were summed up in an index which we analyzed as the main indicator of the cumulative effect on neighborhoods receiving GRI. Each neighborhood-type factor was then examined independently in relation to individual and household type social vulnerability (in the year 2016) and GRI (from 2016 onwards). In the next section we provide a detailed overview of our analytical strategy.

[Table 1 near here; Descriptions of Vulnerability to Climate Gentrification Indicators.]

Analytical strategy

GRI and neighborhood vulnerability to climate gentrification

We begin by describing our spatial quantitative analysis. In order to address the first research question – What are the vulnerability to gentrification characteristics of areas that are expected to receive GRI from 2016 onwards? – First, we identified the spatial clusters of each variable that we theorized to contribute to neighborhood adaptive capacity and sensitivity to gentrification. Next, we examined the relationship between adaptive capacity clusters, sensitivity clusters, and discrete values for our exposure variable.

Identifying areas with hotspots of neighborhood sensitivity and adaptive capacity factors across tracts: A *Local Moran's I* spatial clustering method which is commonly used for urban and urban environmental applications (Mitchell, 2009; Pearsall, 2017) was employed to identify hotspots of sensitivity and adaptive capacity factors in Philadelphia (see Figure 3 for one example). We therefore theorize that a greater degree of neighborhood sensitivity or adaptive capacity derives from a spatial concentration of the factors that define them. In using a clustering

[23] Depending on availability, data collection may have started a year or two later or extended to 2018.

approach, first we understand that an area's characteristics are influenced by its position and proximity relative to another area's characteristics (Grubesic et al., 2014; Ransome et al., 2017). Second, cluster analyses help overcome the problem of fixed administrative boundaries (Maantay 2007) – such as census tracts – which tend to be static and arbitrary in relation to the more dynamic distribution of social and physical phenomena that occur across them (Rainham et al., 2010). Third, clustering allows analysts to overcome the issue of trying to similarly weight very different variables (Eakin & Bojórquez-Tapia, 2008) when it is their compounding effect that is of interest.[24] Hence, a clustering approach may better approximate the unevenness and relationality of the distribution of different urban populations, urban infrastructure, and climate risks, and thereby the differential but non-random distribution of social vulnerability.

Creating the neighborhood vulnerability to gentrification index: In order to visualize and evaluate the compounding effect of different neighborhood sensitivity and adaptive capacity factors across census tracts, in relation to GRI, we developed an index based on a simple additive score.

Neighborhood Vulnerability to Gentrification = Sensitivity to Gentrification + Adaptive Capacity

[24] A cluster analysis compares the internal value of a tract (using a combination of its local Moran's I value, z-score and pseudo p-value) with that of its nearest neighboring tracts in order to identify hot/cold spots (usually consisting of several census tracts) of correspondingly similar high and low concentrations of values. *Local Moran's I* also identifies spatial outliers which signify tracts with values dissimilar to neighboring tracts. Each cluster or outlier identified is statistically significant for a 95 percent confidence level.

For each factor (e.g., Empowerment Zones), we used the results of its cluster analysis to assign a score of +1, 0, or -1 to each of its four cluster/outlier (CO) types (see Table 1). In all cases[25], tracts with High-High (HH) CO types – which signify a high value tract surrounded primarily by other high value tracts – were scored +1 for sensitivity to gentrification, given that factor's role in increasing a tract's vulnerability, and -1 for adaptive capacity, based on that factor's role in reducing it. Depending on how we theorized the role of the variable in vulnerability to gentrification, we may also have given a +1 score to High-Low (HL) and Low-High (LH) outliers, which tend to be tracts situated adjacent to clusters. In those cases, we assumed that having a high value in relation to neighboring low value tracts (HL), or having a low value with neighboring high value tracts (LH), indicated the possibility of a future hotspot or spillover effect from a neighboring hotspot. Because our study is not interested in comparing concentrations of lower values with higher values of the same variable, Low-Low (LL) clusters were scored 0, as were tracts signifying a lack of non-random significant clustering.

We then used a simple additive method (Cutter et al., 2000) to generate a composite index score for overall degree of neighborhood vulnerability to gentrification (VG) for each tract. A minimum of -8 was possible and a maximum of +10, but the Philadelphia tracts yielded scores ranging from -3 to +7. From those results we developed five VG typologies by combining several ranges of scores. The resulting tract typologies were the following: moderately adapting to gentrification (score -1 to -3), balancing sensitivity and adaptivity to gentrification (score: 0),

[25] We decided to treat waterfront census tracts as spatially discrete due to the linear nature of this data point.

moderately sensitive to gentrification (scores 1 to 3), and strongly sensitive to gentrification (scores 4 to 7). A fifth typology – non-concentrated vulnerability to gentrification – indicates tracts which were not a part of any cluster and/or coincided with LL clusters. This process yielded a map of citywide trends representing each of the five typologies of neighborhood vulnerability (Figure 4).

Identifying spatial incidence of neighborhood VG factors with recent and proposed GRI: Next, we identified the spatial incidence of VG factors with recent and proposed GRI. We overlaid the neighborhood VG index map, with our GRI layer (see Figure 4). We then summarized our VG typologies according to mean values of recent and planned percent GRI per tract and conducted a one-way analysis of variance (ANOVA) to ascertain any significant differences between the means of GRI attributed to each typology. Finally, we conducted Pearson correlation analyses of percent GRI per tract, tract values of each VG factor, and tract percentages of socially vulnerable residents.

GRI, neighborhood VG factors and socially vulnerable residents

In a second step, we addressed our second research question: In what ways do green resilient interventions exacerbate vulnerability to gentrification for socially vulnerable residents? For this step, we focused on racial and ethnic characteristics as a key indicator of socially vulnerable residents in Philadelphia and mapped tract percentages of those particular characteristics and overlaid this with the GRI layer (see Figure 5). We last conducted a Pearson correlation analysis between tract percentages of residents of color and other demographic and socio-economic characteristics, and tract values of each of the 18 VG factors (Table 3).

Qualitative research design

In order to ground truth and expand the interpretation of our findings in the quantitative study and to further address our research questions, we drew on a sample of semi-structured interviews conducted in Philadelphia with community representatives, activists, developers, environmental non-profits, planners and policy makers from August through October 2019.[26] Following the transcription and coding, we selected 16 interviews which best helped to understand how GRI were being procured and incorporated in vulnerable neighborhoods, factors perceived as gentrification pressures and contributing to vulnerability to gentrification, and perceptions of green gentrification and anti-displacement tools.[27] These interviews were complemented by an additional review of all available and relevant policy, planning, and nonprofit documents related to green infrastructure, gentrification, and vulnerability in the city. For our qualitative analysis, respondents included representatives from a variety of key

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[26] The interviews were part of a larger multi-city study on green inequalities and green gentrification which covered 30 cities in 10 countries: US, Canada, UK, Ireland, Netherlands, Austria, Spain, Denmark, Italy, and France. Each interview conducted for this particular sub-study lasted between 45 and 90 minutes and followed a similar protocol focused on neighborhood social and health issues addressed by greening, urban partnerships, perceptions of green gentrification, and equity and anti-displacement tools; however, our interview guide was designed to allow for flexibility in adjustment to differences in cities' programs and urban gentrification processes as well as individual researcher interests. We identified key respondents in advance and used snow-ball sampling to reach a broad set of interviewees.

[27] The codes pertained to "climate resilience planning", "climate gentrification through green infrastructure", "protection of vulnerable neighborhoods through green infrastructure", "processes to improve green equity" and "anti-gentrification/displacement responses".

Philadelphia city and non-profit greening programs, GRI advocacy groups, citywide anti-displacement activists, and community-based organizations. We analyzed interviews using a mix of pre-defined thematic and grounded theory approaches.

Results for the spatial quantitative analysis

Results for the gentrification cluster analysis

[Figure 3 near here; Hotspots and coldspots of gentrification from 2010 to 2016 and GRI from 2016 onward.]

Our gentrification cluster analysis for 2010-2016 reveals that much of North, West and Southwest Philadelphia have hotspots of low to moderate gentrification (indicated by dark red census tracts in Figure 3), signaling higher risk of future climate gentrification and displacement. These tend to be in closer proximity to advanced gentrification and previously gentrified coldspots (indicated by dark blue tracts). We observe that most of the recent and proposed GRI is planned for the already highest gentrifying or gentrified areas (dark blue) and the part of West Philadelphia which is University City, which logically follows the recent study of greening and climate gentrification in Philadelphia (Shokry et al., 2020). Low to moderately gentrifying areas in North Philadelphia are also planned to receive GRI but in lesser concentration.

Results for the neighborhood vulnerability to climate gentrification index and map

In this and the next sub-section results correspond to the first research question: What are the vulnerability to gentrification characteristics of areas that are expected to receive GRI from 2016 onwards? Results are shown in Table 2 and Figure 4.

[Table 2 near here; GRI concentrations by VG typology.]

Results from our neighborhood vulnerability to climate gentrification index indicate that moderately sensitive to gentrification census tracts (1 to 3 factors; indicated in dark pink) represent approximately half of all census tracts (184) and correspond with 62% of total GRI area or an average area of 0.18% GRI per tract area. In combination with the 20 strongly sensitive to gentrification tracts (4 to 7 factors; indicated in purple) which have an average area of 0.16% GRI per tract area, 55% of all census tracts are moderately or strongly sensitive to gentrification and account for 71% of all GRI area. Moderately adapting to gentrification tracts (1 to 3 factors; indicated in orange) constitute 4.6% of all census tracts and correspond with 3.5% of total GRI area and an average area of 0.12% GRI per tract area – the lowest number of tracts and the least GRI of the main 4 VG typologies. There are no strongly adapting census tracts (4 to 7 factors) in Philadelphia. Tracts balancing sensitivity and adaptivity to gentrification (indicated in yellow) constitute 10.8% of all census tracts and correspond with 13% of the total GRI and an average area of 0.24% GRI per tract area. They have the most GRI as a percentage of tract area. There were 110 census tracts or 29.6% with no VG factors – non-concentrated VG tracts – meaning that they did not coincide with any neighborhood sensitivity or adaptive capacity hotspots. They align with 13% of total GRI area and an average area of 0.04% GRI per tract area. The difference in means (for average % GRI per tract) between the main four tract typologies was not significant for $p<0.05$ although the difference in means between them and non-concentrated VG tracts was significant (ANOVA and post-hoc testing results not shown). Tracts that are balancing neighborhood sensitivity and adaptive capacity factors may be destabilized by the addition of new GRI, which may then lead to the displacement of socially vulnerable residents, while tracts which are moderately or strongly sensitive to gentrification

may have already lost socially vulnerable residents by the time future planned GRI are implemented.

[Figure 4 near here; Map of neighborhood vulnerability to climate gentrification by green resilience index.]

Results for correlation tests between vulnerability factors and typologies and GRI

[Table 3 near here; Correlations between GRI, neighborhood and social vulnerability factors, and VG typologies.]

Neighborhood sensitivity to gentrification factors: As shown in Table 3, percent recently executed or planned GRI is positively correlated ($p<0.01$) with sensitivity to gentrification factors most representative of real estate activities and zoning changes. In other words, GRI is linked with neighborhood investment and redevelopment. Therefore, tracts with greater GRI coverage had more active construction permits (.283), redevelopment certificates (.227) and historic properties (.158) and were more likely designated empowerment zones (.211) or future opportunity zones (.142). GRI were however weakly correlated with other amenities and enhanced social conditions such as lower crime per capita, cleaned vacant land, waterfronts, or improved school performance.

Neighborhood adaptive capacity factors: Percent GRI per tract is positively correlated ($p<0.01$) with neighborhood adaptive capacity factors most related to the social and anti-displacement support work of non-profits and NGOs, such as providing essential aid for the lowest-income residents and protection from the negative impacts of private real estate development. Tracts

with greater GRI coverage had more affordable housing (.177), housing counseling agencies (.242), community service organizations (.273), registered community organizations (.154), and community health centers (.194). GRI were however weakly correlated with other off-the-market public programs and broader municipal neighborhood stabilization efforts such as affordable childcare, public housing or the Philly Rising program.

Social vulnerability factors: Percent GRI per tract is positively correlated with tracts that had higher proportions of Latinx (.111, $p<0.05$), and negatively correlated with tracts that had lower proportions of non-Hispanic Black residents (.123, $p<0.01$). Tracts with higher rents (.103, $p<0.05$) and college-educated residents (.137, $p<0.01$) – two indicators of gentrification – are linked with more GRI. The link was weak with percent non-Hispanic White residents and income.

Neighborhood vulnerability to climate gentrification index: Percent GRI per tract is weakly correlated with the composite neighborhood vulnerability to gentrification index score. A greater percentage of GRI per tract is significantly correlated ($p<0.01$) with having both more neighborhood sensitivity factors per tract (.329) as well as with having more neighborhood adaptive capacity factors (.286).

However, in Philadelphia only a very few tracts were adapting (17); therefore, even though tracts with factors contributing to adaptive capacity are receiving GRI, so are a far greater number of sensitive tracts (204).

Results for socially vulnerable residents, and correlations with GRI and neighborhood VG factors

Next, we examine the neighborhood vulnerability factors most correlated ($p<0.05$ or $p<0.01$) with percent of socially vulnerable residents, that is racialized residents in the case of Philadelphia, per tract and compare correlation results (Table 3) with observations from the maps in Figure 5 in order to address our second research question: In what ways do green resilient interventions exacerbate vulnerability to gentrification for socially vulnerable residents?

Latinx residents in 2016

Our correlation analysis suggests that greater tract percentages of Latinx residents in 2016 are positively correlated with more GRI coverage per tract (.111, $p<0.05$). However, when we observe the map of tract percentages of Latinx residents and GRI in Philadelphia, shown in Figure 5a, we find that still many neighborhoods of North Philadelphia, with higher concentrations of Latinx residents (from 20%-89% Latinx), do not have GRI. Rather, many more tracts with a lower to moderate concentration of Latinx residents (up to 20%), in or near the center and the Temple University campus, appear to have a higher concentration of GRI. These may be areas which have lost Latinx residents in recent years. There is a negative correlation with tract percentages of White residents (.231, $p<0.01$), but a positive correlation with tract percentages of college-educated residents (.137, $p<0.01$).

Higher tract percentages of Latinx residents are also positively correlated with the neighborhood adaptive capacity index (.227, $p<0.01$), and negatively correlated with the neighborhood vulnerability to gentrification index (.251, $p<0.01$). Comparing across the neighborhood VG index map and the map of percent Latinx residents in 2016, we observe that many tracts with higher percentages of Latinx residents tend to overlap with tracts that are either balancing gentrification risks or moderately adapting to them. This is further evidenced by the positive correlations ($p<0.01$) with community health centers (.177), affordable childcare (.381), the Philly Rising program (.160) and registered community organizations (.380). RCOs may especially have the capacity to mitigate the impact of neighborhood sensitivity factors, to help build adaptive capacity and meanwhile procure and balance the effects of more greening.

However, as Figure 5a illustrates, there is nonetheless little GRI planned for many areas with the highest concentrations of Latinx residents – especially Upper North Philadelphia – therefore leaving the most heavily-minoritized areas under-protected. Furthermore, there is a positive correlation ($p<0.01$) with empowerment zones (.185) and ongoing low to moderate gentrification (.245), serving as a warning that still more attention is needed to protect residents from the threat of displacement.

Black residents in 2016

Higher tract percentages of Black residents on the other hand were negatively correlated with more GRI tract coverage (.123, $p<0.01$). Figure 5b, strongly illustrates this point. Virtually all the GRI from 2016 onward is concentrated in areas with the lowest percentages of Black residents, except for several tracts in West Philadelphia. We also find that tracts with higher percentages of Black residents, although not correlating with the neighborhood sensitivity to gentrification index, do appear positively correlated ($p<0.01$) with several individual sensitivity factors which are especially indicative of highly unstable neighborhoods. These were: certified redevelopment areas (markers of blight but future possible investment) (.340), increasing crimes per capita (.175), future opportunity zones (.253) and declining school performance (.375). There is no correlation with affordable health care or organizational support systems, although tracts with greater proportions of Black residents in 2016 were more positively correlated ($p<0.01$) with public housing (.296) and Philly Rising program efforts (.151) as well as affordable childcare access (.205). While we find a positive correlation with low to moderate gentrification in Black neighborhoods (.223, $p<0.01$) from 2010 to 2016, the strong correlations ($p<0.01$) shown in Table 3 with lower median incomes (.545), lower rents (.461) and lower tract percentages of White residents (.841), suggest that the link may in many instances be explained by decreasing percentages of Black residents from these neighborhoods rather than a current influx of White residents. In other words, in some neighborhoods, like East Parkside and parts of Southwest Philadelphia, Black residents are likely also being pushed out due to the enduring crisis of disinvestment – which has meant investment and gentrification elsewhere or in non-community resources – the abundance of undesirable vacant lots, and the predatory practices of new private investors. These have created severe instability over time.

[Figure 5; Maps of social vulnerability to climate gentrification by green resilience, depicting percentages of (a) Latinx and (b) non-Hispanic Black residents per total census tract population and percent GRI acres per total tract area.*]*

Qualitative Results

In this section we analyze narratives from our semi-structured interviews conducted in Philadelphia to help ground truth and contextualize our spatial quantitative results and expand our findings. Our results build on our full coding work and data analysis. Here, we quote respondents to illustrate selected findings, but do not systematically incorporate quotations due to space limitations.

Our analysis reveals that while environmental public programs and nonprofits have become increasingly aware of residents' green gentrification fears, they continue to struggle with a full commitment to address these broader equity concerns which underlie the eventual exclusion of socially vulnerable residents from the climate protective benefits of greening. While the question of 'resilience for whom' remains elusive in these environmental efforts (Cote & Nightingale, 2012; L. J. Vale, 2014; Wilkinson, 2012), public agencies and non-profits tend to be especially short-sighted about 'whose city' is being planned for (Tozer et al., 2020; L. J. Vale, 2014) and who will actually benefit from resilience strategies – socially, economically, and environmentally – over the long-run (James JT Connolly, 2018; Gould & Lewis, 2018). Community-based housing and development groups on the other hand are struggling to lead and safeguard community-owned greening while entrenched in anti-displacement efforts and creating and preserving other community assets. The qualitative data affirms quantitative trends about the uneven landscape of GRI provision, compounded neighborhood sensitivity to gentrification, as well as the unequal organizational capacities and overall preparedness of neighborhoods in the face of displacement pressures. However, it also demonstrates nuances that need to be considered in the differing perceptions between environmental and community

groups regarding the drivers of vulnerability to green (climate) resilience gentrification and how to mitigate it.

Provisioners or visionaries? Implementing GRI equitably amidst intensifying green gentrification fears

Most of our municipal and non-profit interviewees – representatives from environmental groups – expressed concern about uneven climate risks and impacts and uneven greening across Philadelphia. They were also increasingly aware of residents' apprehensions about green gentrification – as voiced at community meetings and greening promotional events. In some cases, these views were heard as a fair interrogation of greening intentions: *Who* is really intended to benefit when a sudden interest in greening arrives concurrently with intense private investment in socially vulnerable neighborhoods? Addressing these perceptions while improving green equity has thus become a recent interest of municipal and non-profit environmental programming going forward.

This equity concern has meant a growing response that has consisted of environmental programs partnering with a few community-based organizations, mostly on a pilot basis, in socially vulnerable and environmental justice neighborhoods and supporting their leadership in greening efforts. This strategy seems to be linked with a prevailing logic – or simply a hope – that if greening is led by community groups, the problem of gentrification is avoided. A city staff member points out that this strategy may not be enough, suggesting that greening nonetheless caters to the tastes of whiter and wealthier groups, over time participating in attracting more gentrifiers:

We're trying to come to terms with the fact that no matter what the intention is, no matter what long-time resident community leader plants the tree, the property value goes up and it becomes a more desirable place to live and the people with more money – they're the ones that get the chance to have their desires fulfilled.

In some cases, there is emerging movement toward more holistically partnering across sectors and aligning with community-based organizations and leaders that are explicitly anti-displacement, especially those that own land and have a historical responsibility to avoid producing active gentrification in the neighborhoods that host their work. An interviewee from one nationally recognized environmental conservation organization acknowledges the limits of traditional environmental movements' approaches and discourse:

We need to be well-meaning environmental organizations. We can't just be pushing this one solution of 'environment is good' because we know what that has meant for the last 120 years – environment is good – well for sure for a certain swab of people who have privilege is what that has meant.

However, while environmental city and non-profit led programs may provide the vegetation to limit green adaptation costs for residents, already time and resource-strapped community partners might increasingly lead everything including promotional events, translation of materials, outreach to other longtime residents through their networks, site selection, envisioning the desired change, the planting of green resilience interventions, and ensuring their maintenance. This strategy may undermine CBOs' anti-displacement efforts, whose number and capacity – as our spatial analysis has shown – is uneven across Philadelphia neighborhoods.

Furthermore, environmental programs seem to maintain blinders to the more extreme and imminent dangers of intense and speculative private development which would more surely wipe out green resilience benefits for socially vulnerable residents. Indeed, even as awareness grows of residents' green gentrification fears, skepticism remains among some environmental

program leaders about the actual role of greening in gentrification, a belief that the evidence is still too thin to act on.

Overall, there is a strong will to continue greening no matter what. In this sense, there may be an overemphasis on the apolitical technicalities of inclusion while advancing a program's environmental contributions rather than adequately addressing residents' gentrification fears and ongoing threats to their security– that is, the policies and practices that back the dispossession of neighborhood assets from socially vulnerable residents and thereby undermine local adaptive capacity and resistance to displacement. City and non-profit environmental groups seem to feel that preventing displacement is simply outside their purview.

Reinforcing anti-displacement capacity and environmental protection in Black and Latinx neighborhoods

Thus, in Philadelphia, the work of creating and preserving community assets falls heavily on the shoulders of (non-environmental) community-based organizations, with higher capacity groups better able to organize both for anti-displacement and environmental protection. We briefly develop this point, focusing on Latinx and Black neighborhoods with contrasting recent attention and development: Hunting Park and East Parkside.

Hunting Park, one of the warmest neighborhoods in Philly,[28] has a mix of balancing and moderately sensitive tracts. It is a mostly Latinx neighborhood of North Philadelphia bordered by an active Opportunity Zone. Characterized by activists as facing an incoming gentrification

[28] Surface temperatures are 22°F above the average in Philadelphia (Office of Sustainability, 2018)

wave, Hunting Park has received the support of the Hunting Park Community Collaborative – a coalition of local stakeholders – to educate the community about the benefits of greening. These groups, led by Esperanza, the area's largest and most established CBO, have been translating materials to Spanish, finding and training volunteers, and partnering with non-profit and municipal programs to gain access to trees at low or no cost. They aim to achieve a 30% canopy cover by 2050. Although their educational outreach has increasingly made residents more receptive to trees, convincing local cash-strapped businesses with large impermeable surfaces to install green stormwater infrastructure has been more challenging due to the perceived costs of upkeep and land loss.

At the same time, Hunting Park is increasingly beset with displacement challenges. Through tremendous efforts and access to funders, several active and longtime CBOs have managed to create nearly 40 affordable housing units, improve public safety, bring quality programs to the neighborhood park by the same name, and expand social services for health and childcare, even before extensive greening gets implemented. A CBO employee in charge of greening programs discussed the challenge of establishing community land trusts and other community-owned infrastructure:

People may think that we're too early, we're not. There are a lot of organizations that are now too late. […] If you wanted to do something in certain areas, it's just harder now because you already have development happening and now you cannot purchase property at the rate that you could have purchased property before. Neighbors are selling their homes so they're already being pushed out. Once that's happening, you're a bit too late.

In just the last few years, homeownership in Hunting Park has dropped from 60% to 45%, most renters – most of them Latinx – are cost burdened, and the neighborhood is unbanked. In response, Esperanza, is

aiming to coalesce nationwide funders to secure more land for community land trusts and help stabilize renters.

In contrast, East Parkside is a 90% African-American neighborhood and is strongly sensitive to gentrification. Bordered by the extensive Fairmount Park, home to the new Please Touch Museum, and proximate to the expanding Drexel University campus, its community has little benefited from this major infrastructure in previous years. Until recently, the closest part of the park lacked safe and direct access points for East Parkside residents and the city had even allowed the for-profit museum to replace residents' free community recreation center. However, by forming the new Centennial Parkside Community Development Corporation (CPCDC), residents have managed to transform a city and local conservancy plan to create a nature playground with rain gardens near the museum into more of an accessible everyday community space along Parkside Edge and to employ residents to maintain them.

At the same time, the neighborhood faces complex development challenges: it is physically isolated and lacks basic services and everyday shops. While some vacant lands have been transformed into beautiful community gardens, many remain blighted properties held hostage by private owners and developers awaiting a more profitable market; furthermore, the Philadelphia Land Bank – which was created to oversee the return of vacant and tax-delinquent properties to productive use – has failed to make publicly held lots available to the community. Under pressure and harassment from "we buy homes" speculators, residents are selling off their homes at a fraction of their value, and many of the neighborhood's historic single-family homes have been converted into multiple profitable rooms for rent to transients. With its population shrinking, attracting businesses and convincing developers to build affordable housing has proven challenging. Yet, some respondents report being grateful that East Parkside has not been designated an Opportunity Zone – although surrounded by them – which they perceive as an acceleration of developer investment without community groups being able to propose alternatives.

Although local organizers report that a lack of community spaces to meet and organize continues to be a key problem, the new CPCDC provides a more cohesive local representation to politicians, developers, and funders. According to one employee, there is an eagerness to address the displacement component of gentrification and be prepared for upcoming changes:

I think you can prevent or at least mitigate displacement. We can't prove this because we haven't done it yet, but we're trying to, by preparing people for gentrification. Neighborhoods that get wiped out by gentrification are the least organized and the least prepared - they didn't see it coming. But if you see it coming, you can be prepared, you know what the effects of it are.

In this sense, they and other local groups have been active in affordable housing, re-zoning to prevent multi-unit residential conversions and educating residents about predatory buyers. They also advocate for residents' input on amenity design to achieve a greater sense of ownership in the process of urban greening and neighborhood redevelopment.

Overall, we note that both neighborhoods are juggling, on the one hand, a risk of displacement by future intensifying gentrification – in which recent and future green resilient infrastructure may participate – and on the other hand the already ongoing displacement of socially vulnerable residents due to the overwhelming pressures of enduring disinvestment, even while local CBOs struggle to build neighborhood adaptive capacity.

Discussion and interpretation

This study evaluates the role of small-scale green resilience interventions in relation to social and neighborhood vulnerability to climate gentrification and contributes to critical research on housing and sustainability, especially in the context of post-industrial cities undergoing redevelopment and gentrification. It unpacks the potential impacts of GRI for residents most vulnerable to social and climate

insecurities and the neighborhood anti-displacement resources that may mitigate undesired change. It therefore brings new critical understandings about the equivocal role of GRI and informs strategies that can reduce social and racial inequities in climate adaptation planning and support climate justice policies. It also has a notable original focus on adaptation impacts for racialized minorities.

Most notably our spatial quantitative study found that green resilience interventions are concentrated in the wealthier and gentrified neighborhoods of central Philadelphia and increasingly in those adjacent to them which are gentrifying and strongly associated with real estate development, economic reinvestment and growth-driven policies. These findings suggest that resilience efforts are embedded in both private (Teicher, 2018) and state-sponsored investments (Checker, 2011; Gould & Lewis, 2018) which are known to drive gentrification (Pearsall & Eller, 2020). This is the case even as 50% of the GRI in our study are being implemented on or planned for public land. Therefore, our study points to how green resilience planning is entangled in the uneven and unequal social dynamics of neighborhood revitalization and new housing developments, whereby future construction of both green infrastructure and housing might benefit new socially privileged residents rather than long-time or vulnerable ones.

Our spatial quantitative study also reveals the exclusion of more heavily minoritized neighborhoods from GRI planning and implementation, foretelling future climate insecurities. The highest percentage Latinx neighborhoods are some of the least climate protected. Furthermore, higher percentage Black neighborhoods also tended to be more strongly associated with historical and ongoing disinvestment or a mismatch between needs and infrastructure. They are also especially linked with open land that has been labelled “vacant” or “blighted” – a legacy of many iterations of crisis, government abandonment, and dispossession

– and today those are held privately or sold for private development by the city council, thereby embedded into new dynamics of gentrification. With this, a clear line becomes visible between long-standing racist housing policies and practices, and environmental racism and injustice that created these social and climate insecurities in the first place (Pulido, 2017). Today, while some lands have been cleaned or gardened, for instance, through the love and labor of longtime residents, these slow gains and healthful green amenities may be lost for Black or Latinx residents when gentrification takes hold (McClintock, 2018; Rosan & Pearsall, 2017).

The fact that GRI are also concentrated in tracts where higher capacity community-based non-profits are doing social support and anti-displacement work, but that these areas are *also* sites of intense, overlapping private development and neighborhood change, is another key finding that underscores the power asymmetries between capital accumulation strategies and community support and resistance in a pro-growth and neoliberal context (McClintock, 2018; Pearsall & Anguelovski, 2016; Pulido et al., 2016). This balancing act between what we have identified as neighborhood sensitivity and adaptive capacity is especially observed for Latinx neighborhoods closer to the city center, reflecting previous findings suggesting that Latinx residents have been increasingly displaced from those same areas (Shokry et al., 2020). Such dynamics highlight that Black and Brown communities vulnerable to social and climate insecurities are already overwhelmed by tremendous displacement pressures and that nonprofits – particularly environmental ones – are not always able to protect them or that their work might come too late.

Echoing activist Tracie Washington's now famous demand – 'Stop calling me resilient' – scholars have theorized that the growing urban resilience orthodoxy may simply perpetuate the

neoliberal paradigm of self-sufficiency while continuing to do harm (Kaika, 2017; Ranganathan & Bratman, 2019; L. Vale, 2016). In the post-Katrina context, Vale (2016, p. 17) wrote that "the language of resilience provides a seemingly empowering label for a process of double dispossession" through both disaster victimization and post-disaster investment. In this study, it is the pre-disaster planning itself that may place vulnerable communities at-risk for future dispossession and displacement by green (climate) resilience gentrification – despite the leadership of communities of color – when affordable housing and other social infrastructure and protections are too weak or overcome (Graham et al., 2016). Rather than assuming that resilience leads to justice, it is imperative in both research and policy design that action toward justice be an explicit and central aspect of resilience thinking and strategies.

Therefore, this study reveals a new climate gentrification pathway by green resilience wherein socially vulnerable neighborhoods – despite the anti-displacement efforts of community-based organizations – persistently face social and climate insecurities due to the overwhelming impact of private market-led investment that is unfettered (and even assisted) by more powerful institutions. Our qualitative findings also demonstrate that the narrow greening focus and current commitment of environmental non-profits may come at the expense of affordable housing advocacy and funding, thereby spurring environmental gentrification (see Rigolon and Németh, 2018). Our interviewees indeed shared fears of green gentrification and historically-rooted distrust in local government and environmental NGOs. Thus, our study also advances understanding of the *multi-faceted* vulnerability to gentrification of neighborhoods in which multi-sectoral CBOs already work. It shows how the power and privilege of environmental organizations to push a greening agenda may actually exacerbate and subordinate anti-

displacement efforts. While bridging CBOs also play a critical role in procuring new climate protective resources for vulnerable neighborhoods (James JT Connolly, 2018), environmental groups tend to prioritize techno-managerial solutions – such as GRI – and consensual politics (Checker, 2011; Finewood et al., 2019; Heckert & Rosan, 2018; Kaika, 2017; Pulido et al., 2016) and may thereby stymie efforts to prepare for climate gentrification. A key procedural justice issue in climate justice concerns, it may also be a limiting factor to achieving "emancipatory and antisubordination greening" aims and therefore to not only preventing discrimination and loss (preventative justice), but also guaranteeing permanent and secure rights to healing, liberating green spaces and other benefits (restorative justice) for marginalized communities (Anguelovski et al., 2020). Urban resilience and housing policies and planning must work to build trust and dialogue with vulnerable populations who do not have a permanent political and economic voice in these decision-making processes (Fitzgibbons & Mitchell, 2021) and – in a more material sense – guarantee their rights to affordable housing, collective ownership, and community control in establishing healthy, safe environments (Shi, 2020).

In sum, our vulnerability to climate gentrification framework considers exposure, sensitivity to gentrification and adaptive capacity, in a novel way, as the overlapping and intersecting structural and systemic deterrents, but also the supportive infrastructures of communities in responding to displacement threats. We theorize and operationalize a clustering methodology to measure and accentuate the role of these factors as compounded concentrations of harms and resources. This study highlights that on the one hand, there is a need for gentrification research to better evaluate the processes that help and hinder adaptive capacity efforts in order to better predict and understand gentrification effects. On the other hand, to offer a

fuller picture of the local processes of climate resilience at stake, vulnerability research would need to better integrate neighborhood sensitivity to gentrification factors which are often prior exposures that have become entangled in the deeper root causes of ongoing inequity, insecurity and injustice. Lastly, this research done in Philadelphia can be implemented in many cities and at transnational scales (Blok, 2020) in order to examine similarities and differences across climates, diverse urban development and growth trajectories (i.e., in cities with long-established economic growth) in the global North and South, and urban resilience and housing policy landscapes.

Concluding remarks and policy reflections

Even if the roots of injustice, exclusion and inequality are well-known, the work of undoing them to build a more socially and environmentally just city must overcome growth-oriented and elite interests that prevent urban greening from benefiting vulnerable groups through accumulation, dispossession and racialized displacement (McClintock, 2018; Safransky, 2017). Some cities such as Philadelphia are starting to place equity at the center of new planning interventions; yet their efforts do not always achieve expected or hoped for outcomes. According to recent research by Pew Charitable Trusts (2020), housing affordability is a persistent problem in this high poverty city, especially so for renters, 54% of whom are cost-burdened. Worsening matters, a ten-year full tax abatement for new construction and major renovation projects has been driving a construction boom that largely benefits wealthy developers and higher-income homeowners, while accelerating displacement and depriving underserved neighborhoods of revenue for schools. Organizers have recently helped reduce the

tax abatement and in 2020 the City Council passed Philadelphia's first residential development impact tax – a 1% tax on new residential construction to fund affordable housing[29]. These and other tools for preventing displacement and supporting equitable greening, such as Philadelphia's Longtime Owner Occupants Program (LOOP), a property tax freeze program for eligible households, and a "good cause" eviction bill which became law in 2019 are significant small victories, but often they are also watered-down versions of community groups' claims for protection of socially vulnerable residents. Most notably, the Philadelphia Land Bank for which the Garden Justice Legal Initiative and other community partners long advocated as a means to levy some of Philadelphia's 40,000 vacant properties to productive community use was finally passed by City Council in 2017. Management of the land bank however has fallen short of expectations[30] for community-controlled processes and transparency in land transfers, as well as permanent affordability through land trusts to prevent speculation and resale for private profit (BCNUEJ, 2021). If reformed, the land bank has the potential to help strike a balance between creating affordable housing while preserving open space, like parks and community gardens, for community uses, and thereby supporting both social and climate resilience.

Our study also highlights the need for a variety of social infrastructure, in addition to affordable housing, to provide material and organizational support for lower-income and residents of color and mitigate harmful development, by reducing other cost-burdens, providing social, child and

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[29] See: https://www.natlawreview.com/article/philadelphia-city-council-approves-changes-to-tax-abatement-programs-and-imposes (accessed on April 1, 2021)

[30] See: https://whyy.org/articles/philadelphia-land-bank-is-finally-selling-its-vacant-lots-now-the-question-is-who-will-benefit (accessed on April 1, 2021)

health services, and community space for education, exchange and building political power. At the time of writing, millions are marching in the US and around the world in the name of racial justice in support of the Movement for Black Lives. In parallel, many millions of low-income and underinsured workers, forced to work during the Covid-19 pandemic, risk their lives while facing deeply uncertain and precarious futures. The Philadelphia Area Cooperative Alliance – a support group for developing Black and Latinx workers' cooperatives – writes: "Since 2016, the Philadelphia police department budget has gone up $120 million. Imagine if even $1 million of that money went toward co-op development that would support Black people and communities of color through this economic crisis and well beyond." The latter is one of many life-affirming and re-dignifying strategies that other local movements like Soil Generation and the Alliance for a Just Philadelphia have also imagined and outlined, building on broader calls for addressing the multiple sensitivities of historically marginalized groups in the city and supporting place resilience. These efforts toward community organizing, education and advocacy could translate into not only channeling more support for affordable housing, community-controlled land uses and other adaptive capacity resources, but also directly taking back money, power, and resources from actors, programs and policies that commodify land and housing and consent to speculative growth, thus making of greening and resilience a polarizing urban land-use practice.

In Philadelphia, city offices and environmental non-profit organizations are increasingly recognizing green gentrification concerns, but their support for the kinds of initiatives outlined above remains marginal and often discursive at best. Housing programs remain disconnected from greening initiatives, each taking a siloed approach and complicating the ability to

comprehensively plan green neighborhoods without residentially displacing people. Greening, housing and other community advocates must therefore, work together to guarantee that when greening is negotiated into new developments, that affordable housing – whether through land value capture, inclusionary zoning or other measures – as well as support for the kinds of social infrastructure discussed in this paper are a key part of the plan. As climate resilience measures are taken, planners must also back and integrate anti-displacement tools from the very early planning of resilience projects so that benefits can be enjoyed by socially vulnerable residents for as long as possible and without perpetuating unjust and inequitable outcomes of the past.

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Declaration of Competing Interest

(2) The authors have no conflicts of interest to declare.

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Table 1. Descriptions of vulnerability to climate gentrification indicators.

Feature name	Description	Definition	Cluster-Outlier Type	Score	Data Source
Exposure					
Green Resilient Infrastructure	Green stormwater infrastructure implemented discretely or as a part of vacant land, parks, and schoolyards from 2016 onwards	% of tract area that is GRI surface area	n/a	n/a	Phil. Water Dept., Phil Dept. of Parks & Recreation
Neighborhood Sensitivity to Gentrification					
Active construction permits	Active permits for new construction, major alteration and zoning changes between 2011 and 2018	# of active new construction, major alteration and zoning change permits	HH, HL, LH	1	Phil. Dept. of Licenses & Inspections
Certified redevelopment areas	Areas deemed blighted and eligible for urban renewal, new or updated certificates since 2010	% of tract in a redevelopment area	HH, HL, LH	1	Phil. Dept. of Planning and Development
Empowerment Zones	Federal program to stimulate jobs and businesses in "distressed communities" through infrastructure, tax credits for businesses, and grants	1= tract in an empowerment zone	HH, HL, LH	1	Phil. Dept. of Planning and Development
Opportunity Zones	Federal program to incentivize investment in low-income communities by allowing investors to defer capital gains tax	1= tract in an opportunity zone	HH, HL, LH	1	U.S. Dept. of Treasury

Low to moderate gentrification	Composite score for 2010-2016. Max. score of 6 is based on the number of criteria, measured as rates of change, are fulfilled in relation to the citywide median: *increasing* median income, % NH White and college educated residents and median rents; *decreasing* % NH Black and Hispanic residents.	Modified composite gentrification score: low and moderately gentrifying tracts = greater sensitivity to future gentrification	HH, HL	1	2006-2010 5-year estimate - Geolytics database; 2012-2016 5-year estimate - American Community Survey

Table 1. continued.

Historic properties	Historic properties including districts, sites, and interiors	% of buildable area that is designated as historic	HH, HL, LH	1	Phil. Dept. of Planning and Development
Waterfront proximity	Waterfronts along Delaware and Schuylkill Rivers and Wissahickon and Tacony Creek	1 = tracts that intersect 400m buffer	n/a	1	Phil. Water Dept.
Cleaned vacant land	Vacant lots cleaned and greened as part of the LandCare program from 2010 to 2017	% of vacant land cleaned	HH, HL	1	Phil. Office of Housing and Community Development
Improved school performance	Public and charter school performance from 2012 to 2017 as measured by *School Progress Reports*	# of schools with improving report card scores inside tract or within 400m	HH, HL, LH	1	School District of Phil.
Decreasing crime per capita	Part 1 (homicide/robbery/theft) and Part 2 (arson/DUI/drugs/assault) crime incidents from 2011 to 2017	% change in crimes per capita per tract. Decreases = greater sensitivity to gentrification	LL, LH	1	Phil. Police Dept.
Neighborhood Adaptive Capacity					
Community health centers	Current low-cost or free healthcare centers include Federally Qualified Health Centers and (FQHCs) and City Health Centers operated by Phil. Dept. of Health	# of health centers inside tract or within 400m	HH	-1	Phil. Dept. of Public Health
Affordable childcare	Centers providing affordable childcare programs: federally	# of childcare centers inside	HH	-1	Pennsylvania COMPASS

	sponsored Headstart and Early Headstart, state and local Pre-K counts and PHLpreK	tract or within 400m			
Public housing	Existing developments and scattered sites owned and managed by PHA	# of public housing units inside tract or within 400m	HH	-1	Phil. Housing Authority
Affordable housing	Rental or for-sale housing built from 2000 to 2016	# of affordable housing units inside tract or within 400m	HH	-1	Phil. Division of Housing & Community Development

Table 1. continued.

Housing counseling agencies	Current HUD approved agencies supporting low-moderate income families navigate housing-related financial issues	# of agencies inside tract or within 400m	HH	-1	Phil. Office of Housing & Community Development
Philly Rising	Mayor's Fund Initiative to assist 19 Philly neighborhoods with chronic crime and quality of life issues; 2010-2016	% of tract that is Philly Rising	HH	-1	Phil. Managing Director's Office
Community services organizations	Emergency food and shelter services; legal, medical, dental	# of services inside tract or within 400m	HH	-1	Code for Philly
Higher-capacity registered community organizations	RCOs serve a fixed geographic area with a mission to conduct public meetings on projects that will affect the physical development of their community	avg. of combined income and assets of RCOs with service areas that intersect a tract	HH	-1	Phil. Dept. of Planning and Development; Charity Navigator
Socially Vulnerable Residents					
Individual and household characteristics	2016: Non-Hispanic Black, Hispanic/Latino, Non-Hispanic White, Limited-English speakers, College educational attainment, Median Household Income, Median Household Rent	% of tract population for each indicator except for income and rent, which are given as dollars per tract	n/a	n/a	2012-2016 5-year estimate - American Community Survey

n/a = not applicable.

HH = High-High cluster; HL = High-Low cluster; LH = Low-High outlier.

Data was joined to 2010 normalized census tract boundaries created by Geolytics. We excluded 13 of 384 tracts that had no or low population and/or housing.

Where the normalization process appeared to have created large discrepancies across years in a tract's population, we reapportioned the tracts to allocate population counts more evenly.

Table 2. GRI concentrations by VG typology.

VG Typology	VG scores	Number of tracts	% of total GRI area per tract type	Average % GRI per tract area
Moderately adapting	-3 to -1	17	3.46%	.12%
Balancing sensitivity and adaptivity	0	40	12.76%	.24%
Moderately sensitive	1 to 3	184	62.24%	.18%
Strongly sensitive	4 to 7	20	8.50%	.16%
Non-concentrated VG	0	110	13.04%	.04%
Totals		371	100.00%	

Table 3. Correlations between GRI, neighborhood and social vulnerability factors, and VG typologies.

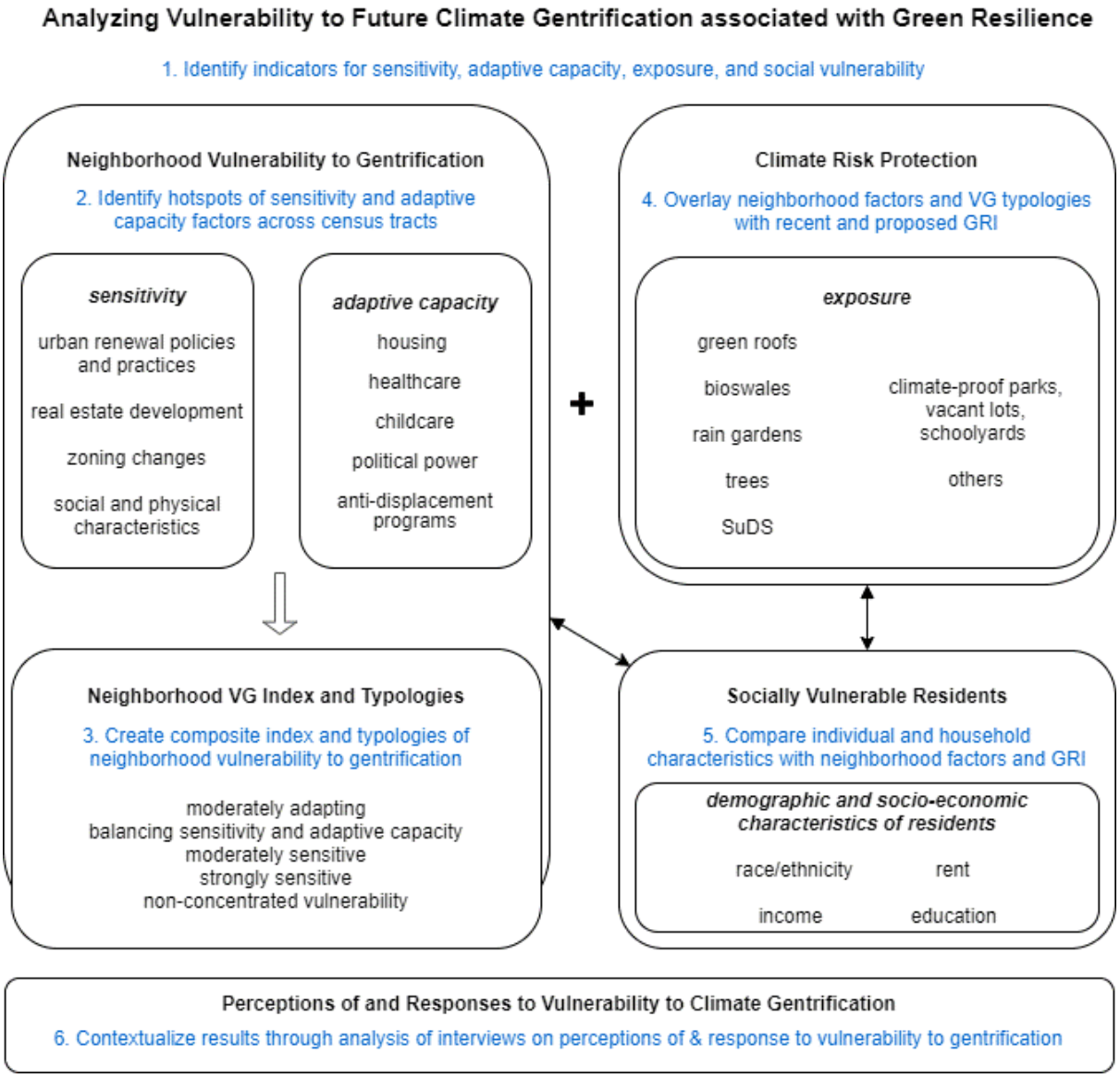
Indicators	% GRI per tract	% NH Black	% Latinx
Exposure			
% GRI per Tract	1	-.123**	.111*
Neighborhood Sensitivity to Gentrification			
Sensitivity Index	.329**	0.022	0.069
Active construction permits	.283**	-0.070	-0.082
Certified redevelopment areas	.227**	.340**	-0.080
Empowerment Zones	.211**	0.022	.185**
Opportunity Zones	.142**	.253**	0.032
Low to moderate gentrification	0.003	.223**	.245**
Historic properties	.158**	-.227**	-.107*
Waterfront proximity	0.044	-.184**	-0.014
Cleaned vacant land	0.001	.480**	-0.014
Improving school performance	-0.031	-.375**	-.208**
Decreasing crime per capita	-0.077	.175**	-0.035
Neighborhood Adaptive Capacity			
Adaptive Capacity Index	.286**	-0.083	.227**
Community health centers	.194**	0.000	.177**
Affordable childcare	0.044	.205**	.381**
Public housing	0.063	.296**	-.113*
Affordable housing	.177**	0.005	0.019
Housing counseling agencies	.242**	-0.037	0.094
Philly Rising program	0.010	.151**	.160**
Community service organizations	.273**	-0.081	-.108*
Higher capacity registered community organizations	.154**	-0.029	.380**
Neighborhood Vulnerability to Gentrification Index[a]	0.052	0.108	-.251**
Other Social Vulnerability Factors			
Median incomes	-0.027	-.545**	-.263**
Median rents	.103*	-.461**	-.141**
% NH White residents	0.052	-.841**	-.231**
% College-educated residents	.137**	-0.023	.137**

[a] Tracts with no factors were treated as missing; n=261.

**indicates two-tailed significance at p < 0.01.

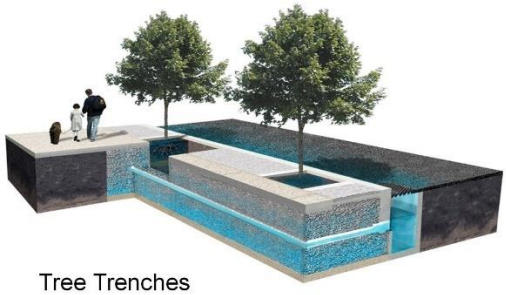
*indicates two-tailed significance at p < 0.05.

NH = non-Hispanic.



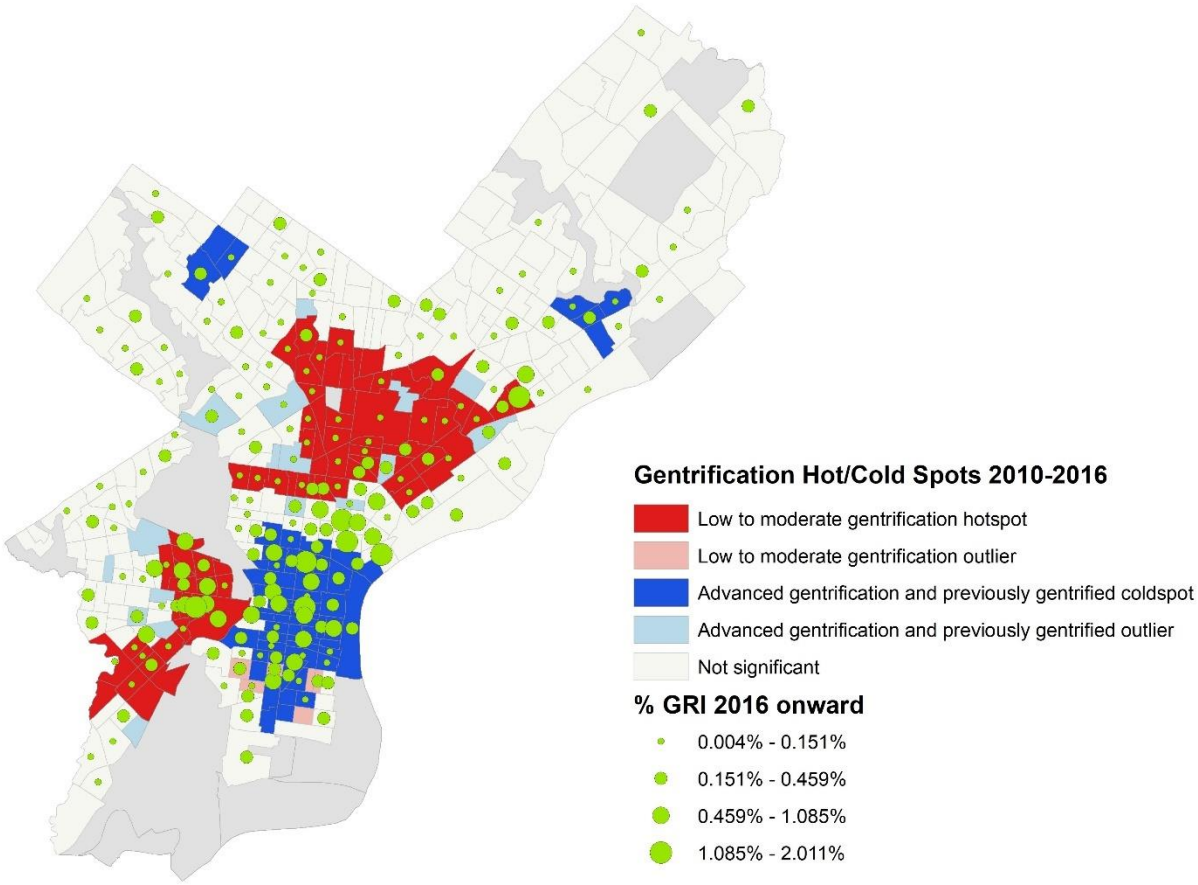
Rain Gardens

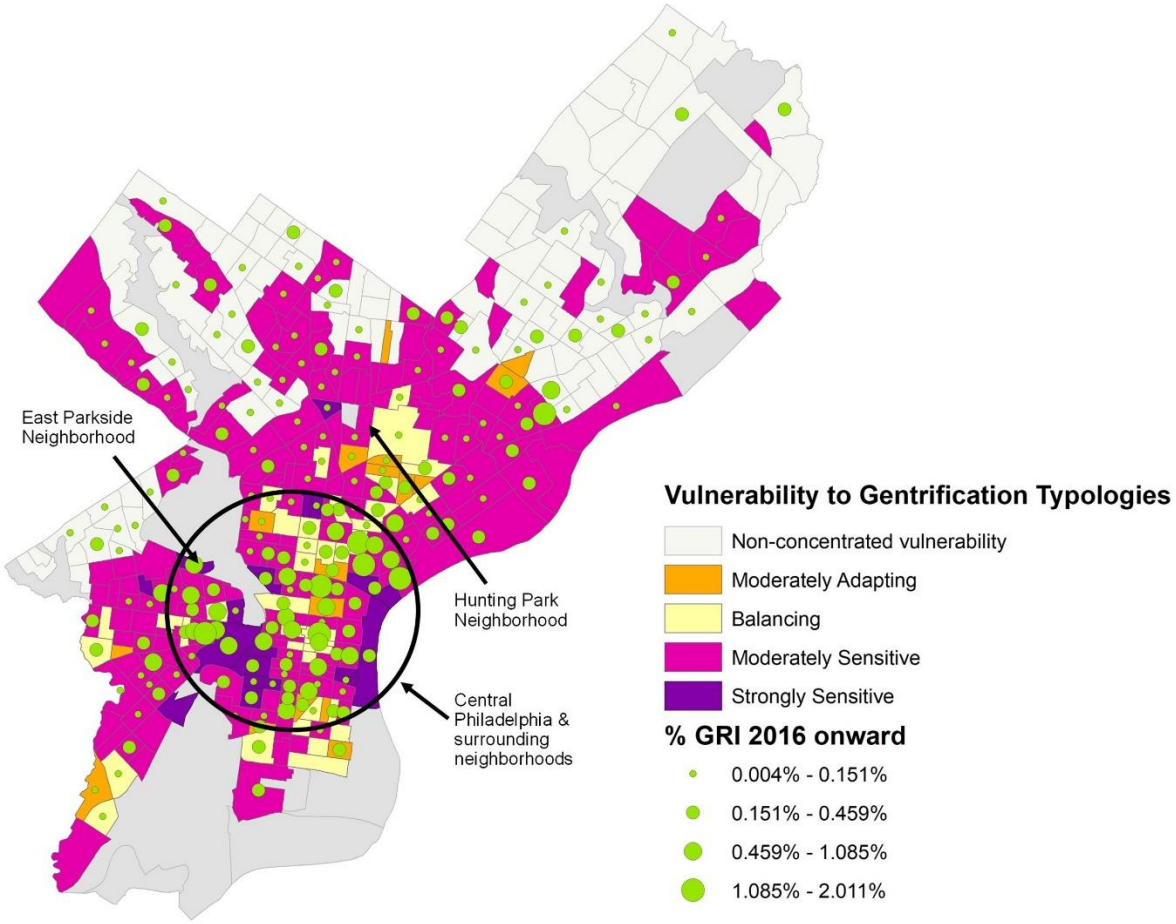
Stormwater Bumpouts



Tree Trenches

Green Roofs


Gentrification Hot/Cold Spots 2010-2016
Low to moderate gentrification hotspot
Low to moderate gentrification outlier
Advanced gentrification and previously gentrified coldspot
Advanced gentrification and previously gentrified outlier
Not significant
% GRI 2016 onward
0.004% - 0.151%
0.151% - 0.459%
0.459% - 1.085%
1.085% - 2.011%


East Parkside Neighborhood
Hunting Park Neighborhood
Central Philadelphia & surrounding neighborhoods
Vulnerability to Gentrification Typologies
Non-concentrated vulnerability
Moderately Adapting
Balancing
Moderately Sensitive
Strongly Sensitive
% GRI 2016 onward
0.004% - 0.151%
0.151% - 0.459%
0.459% - 1.085%
1.085% - 2.011%

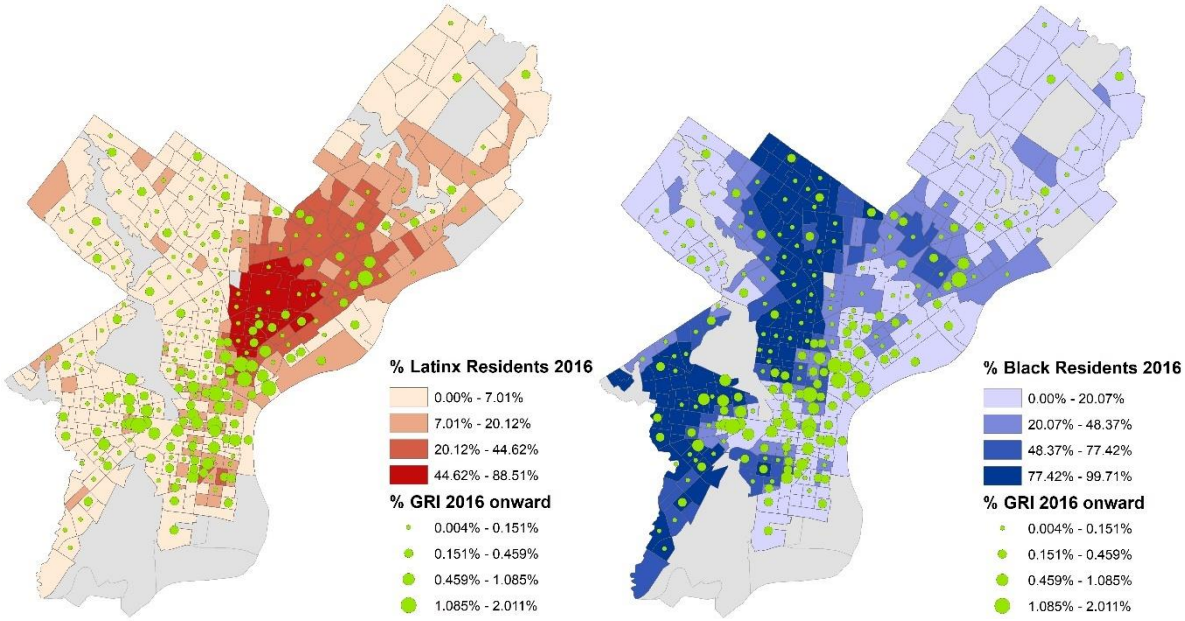

% Latinx Residents 2016
0.00% - 7.01%
7.01% - 20.12%
20.12% - 44.62%
44.62% - 88.51%
% GRI 2016 onward
0.004% - 0.151%
0.151% - 0.459%
0.459% - 1.085%
1.085% - 2.011%
% Black Residents 2016
0.00% - 20.07%
20.07% - 48.37%
48.37% - 77.42%
77.42% - 99.71%
% GRI 2016 onward
0.004% - 0.151%
0.151% - 0.459%
0.459% - 1.085%
1.085% - 2.011%

Figure 1. Conceptual framework for variable identification, operationalization, and analysis.

Figure 2. Examples of green resilient infrastructure in Philadelphia, Images © Philadelphia Water Department.

Figure 3. Hotspots and coldspots of gentrification from 2010 to 2016 and GRI from 2016 onward.

Figure 4. Map of neighborhood vulnerability to climate gentrification by green resilience index.

Figure 5. Maps of social vulnerability to climate gentrification by green resilience, depicting percentages of (a) Latinx and (b) non-Hispanic Black residents per total census tract population and percent GRI acres per total tract area.

Chapter 4 – (Mis-)belonging to the climate-resilient city: Making place in multi-risk communities of racialized urban America

Abstract

Climate adaptation planning is an increasingly key urbanism practice by which cities are transforming themselves, most recently through green climate resilient infrastructure (GRI). GRI's incorporation into existing, racialized infrastructure systems of urban development, regeneration and finance/investment has raised questions about the social impacts and justice dimensions of climate adaptation planning and urbanism. While scholars have criticized the close ties between green adaptation infrastructural development and neoliberal growth strategies, their socio-cultural dimensions and the pathways through which systems of neighborhood redevelopment and infrastructure-making shape and reconfigure (mis-)belonging in the settler city remain underexplored, especially vis-à-vis the compounding risks that residents are facing. To respond to these gaps, our paper asks: How are collective senses of belonging shaped and (re)configured through green climate resilient infrastructure? What do those pathways of belonging mean for urban climate justice? Through interviews with social and environmental justice actors in East Boston, we examine adaptation planning and place- and GRI-making in a rapidly gentrifying neighborhood facing mounting climate risks. Our analysis uncovers three pathways by which climate urbanism shapes (mis-)belonging into various alienated, subordinated, assimilated and emancipated forms. These, in turn, shape possibilities for climate justice in the climate-resilient city and beyond.

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Shokry, G., Anguelovski, A., Connolly, J. (forthcoming) (Mis-)belonging to the climate-resilient city: Making place in multi-risk communities of racialized urban America

Introduction

Climate adaptation planning is an increasingly key urbanism practice by which many cities – including places such as Philadelphia, Manchester, Barcelona, Lyon, Medellin and Durban – are transforming themselves through new infrastructure and investments, most recently through green climate resilient infrastructure (GRI). With urban areas at risk from more frequent and intense climate impacts, GRI, such as climate-proofed parks, street trees, berms and wetlands assist in efforts to mitigate climate risks and impacts, while complementing or replacing grey infrastructure. These flexible and cost-efficient means of addressing climate change impacts are often presented as multifunctional and "no regrets" solutions to addressing other social, economic, health and environmental risks through urban renaturing. In the United States, the promise of such co-benefits has helped green infrastructure for climate resilience receive wide public support and funding from, for example, the Environmental Protection Agency, Department of Housing and Urban Development and the Department of Transportation and local-level green bonds, permit fees and taxes.

GRI's incorporation into other existing infrastructure systems of urban development, regeneration and finance has, however, raised questions about the social impacts and justice dimensions of climate adaptation planning and urbanism. Most of all, scholars have criticized the close ties between green adaptation infrastructural development and economic growth strategies (Gould and Lewis, 2021; Long and Rice, 2019) which tend to prioritize techno-managerial solutions and consensual politics (Finewood et al., 2019; Kaika, 2017), undermining procedural justice and possibly healing and emancipatory benefits for marginalized communities (Anguelovski et al., 2020). Cities also instrumentalize green and "climate friendly" branding to advance neoliberal governance strategies and attract local and global capital and wealth (Garcia-Lamarca et al., 2019; Long and Rice, 2019) especially to centrally disinvested neighborhoods (Dooling, 2009) targeted for regeneration.

Rather than re-investing in longtime residents' protection, such narrow strategies risk overlooking historical and ongoing racialized inequalities and social vulnerabilities (Connolly, 2018) – what Hardy and colleagues (2017) call 'colorblind adaptation planning' – while playing on the sense of urgency and collective anxieties surrounding imminent climate-related dangers (Harper, 2020). In the American city in particular, injustices may therefore be reproduced, and risks multiplied via the quest to conjure a green and resilient utopian urban identity. While some adaptation practices are outright exclusionary, other resilience projects may present communities and civic actors with "difficult choices and trade-offs" (Harris et al., 2017) becoming "contested and negotiated as they materialize" (Long and Rice, 2019) or leaving residents to contend with new risks and insecurities emerging from implemented GRI, as the growing literature on climate or resilience gentrification argues (Anguelovski et al., 2019; Gould and Lewis, 2021; Shokry et al., 2021, 2020).

Yet, so far, in this climate resilient green future, relational issues of inclusion, recognition and citizenship – beyond the economic and physical impacts of infrastructure – remain underexplored. There is important intellectual space to examine the socio-cultural dimensions of the lived experience of these infrastructures and what belonging in the context of climate action means for social and climate justice. In particular, research needs to clarify the pathways through which the system of making and maintaining climate resilient infrastructure shapes and reconfigures senses of belonging to the city.

There is also intellectual space to examine the characteristics of communities that emerge in response to those processes, especially vis-à-vis the multiple, overlapping risks that residents face.

To respond to these gaps, our paper asks: How are collective senses of belonging shaped and (re)configured through green climate resilient infrastructure? What do those pathways of belonging mean for urban climate justice? Here, through analysis of qualitative data, we examine climate adaptation planning and GRI-making through the lens of social and environmental justice civic actors in East Boston, a rapidly gentrifying neighborhood facing mounting climate risks which has historically been a point of entry and settlement for lower-income immigrants and minorities. We argue that it is through the disaggregated practices and processes of placemaking, (dis-)possession and responding to multiple risks that new and/or intensifying forms of (mis-)belonging get constructed, thereby shaping possibilities for climate justice in the green resilient city and beyond.

The paper is organized in the following way: The next section takes inspiration from recent scholarship on climate urbanism, climate gentrification and risk communities to examine the tensions between resilience infrastructure-making and community-building/place-making processes. The second section explains our case study selection and methodology, while the third details our empirical findings according to three pathways: exclusion, negotiation and contestation. In the fourth section we analyze our findings through the lens of (mis-)belonging, risk communities and (re-) or (dis-)possession. Finally, we close the paper with reflections on what our findings and conceptualizations mean for climate justice at the city and broader scales.

Climate resilient infrastructure, exclusionary urban transformation, and belonging

In the growing critical adaptation literature, GRI is increasingly perceived as part of historically produced and racialized infrastructure systems or networks (Anguelovski et al., 2019; Gould and Lewis, 2021; Shokry et al., 2021) associated with urban planning practices of modernization, development and capital accumulation (Silver, 2019). Often an engineered and standardized product (Finewood et al., 2019), the most institutionalized, visible forms of green resilient and/or stormwater infrastructure, may be reminiscent of the 'modern infrastructural ideal' described by Graham and Marvin (2001), with a universalizing, homogenizing approach to achieving broader social and political objectives (Lawhon et al., 2018). The authors demonstrate how modernization is subverted and its systems "unbound" by neoliberalizations and new technologies (McFarlane, 2018). However, in the face of universalized climate risks, modernization seems to be resurfacing in urban development discourses like green growth and the green tech-based economy, and reconnecting resource flows to create the Smart Sustainable Resilient City (Connolly, 2019). In the name of solving the climate crisis, green resilience is utilized to attract investment, regenerate inner cities (Bigger and Millington, 2019) and reconsolidate urban systems through new infrastructure while still promoting limitless economic growth, the driving force behind ecological degradation.

In the United States, we may understand this process as a hallmark of American racial capitalism which drives abandonment and "infrastructural decay" while also being perpetuated by the regeneration and gentrification of those same decaying sites when "it repurposes the post-industrial city as a space of accumulation" for the benefit of privileged classes (Silver, 2019, p. 15). Many of these decaying sites

were those abandoned by inner-city white flight to the suburbs, benefiting little from municipal- and private-led greening in recent decades (Connolly and Anguelovski, 2021). Today, the new socio-spatial configuration of racial capitalism and white supremacy operates in ways that closely associate green infrastructure, whiteness, and urban growth (Pulido, 2017) with "development paradigms and policies, such as regional development, the War on Poverty, community development programs, surveillance, and public works, that have dismantled and disempowered African American and low-income communities" (Brand and Miller, 2020, p. 6). In the context of climate adaptation, the production of social and racial difference therefore appears central to modernizing and redeveloping cities even if it is through a lack of recognition that green adaptation programs differentiate and reinforce inequalities and racism.

The growing climate gentrification literature (Anguelovski et al., 2019; Gould and Lewis, 2021; Shokry et al., 2021, 2020) demonstrates the uneven impacts of adaptation action and resilience planning – especially vis-à-vis green resilience infrastructure – from privileging gentrifying neighborhoods to displacing socially vulnerable residents to less climate secure areas (Shokry et al., 2020). Climate gentrification illustrates how resilience infrastructure shifts insecurities, without eliminating them, and thereby adds a new layer of risk to already existing ones (i.e., risks from climate impacts and environmental hazards), negatively impacting the capacity of communities to adapt by protecting wealthier and whiter neighborhoods at the expense of already marginalized communities (Cole et al., 2021; Shokry et al., 2021). Thus, the redevelopment of long-disinvested neighborhoods of racialized communities into urban utopian resilience-scapes might also veil the spatial reconfiguration of poverty and segregation through appropriation, displacement (Kaika, 2017) and cultural erasure, making green resilience infrastructure a tool of "racial banishment" (Roy, 2017) and settler colonial practice.

Can green resilient infrastructure then *belong* to less affluent and racialized communities or does it only serve to *dispossess* them of local urban environments and natures? Belonging seems intimately bound up with property- and self-ownership (Butler and Athanasiou, 2013; Roy, 2017) considering the ideologies upon which the American city has been constructed. Sara Safransky has argued (2017) that urban transformation (i.e., regeneration, revitalization, renewal and redevelopment) combined with state- and market-led green infrastructure programs perpetuate settler colonial practices through racialized displacement and dispossession – what she calls "accumulation by green dispossession". Green gentrification scholarship (Gould and Lewis, 2017) further highlights how the exclusionary practices of gentrifiers, via their uses and designations of green infrastructure, lead to cultural and political 'emplaced' displacement (Wynne and Rogers, 2020), thwarting more emancipatory approaches to creating a sense of place and belonging in the green resilient city (Brand and Miller, 2020; McKittrick, 2011).

Instead, belonging may be better achieved through a social approach to infrastructure, or what AbdouMaliq Simone calls "people as infrastructure"— a "tentative and often precarious process of remaking the inner city"– which facilitates "the intersection of socialities", emphasizing cultural processes that support economic solidarity and collaboration for marginalized residents (2004, pp. 411, 407). These social infrastructures whose "liveliness" (Amin, 2014) would support social reproduction and cultural rooting are precisely those which are stripped of investment as new luxury resilient developments are prioritized, thereby emphasizing the socio-cultural value of possession and that certain surplus populations (Pulido, 2016) are unworthy of belonging (or possessing). In this paper, we

explore this dialectic of belonging (or mis-belonging) and (dis)possession (or re-possession) in the context of infrastructure-making and neighborhood redevelopment in the green settler city.

Placemaking and risk communities in the racialized climate resilient city

The work of activists in negotiating and contesting urban infrastructural projects and responding to risks plays an important role in shaping the meanings made about who the community is and how it relates to place and infrastructure. In this sense, white supremacy/nationalism and climate change are concurrent threats in the lives of racialized communities in the American city. In their work on "risk communities", Ulrich Beck and colleagues draw on Benedict Anderson's theorization of the social construction of imagined communities of the *nation* to hypothesize the extent to which perceptions of *climate risks* may condition the emergence of cosmopolitan risk communities. They ask whether social projects and collective action vis-à-vis climate risks may actually spur 'thick' affective bonds among strangers, strong senses of belonging and intense willingness to self-sacrifice" (Beck et al., 2013, pp. 6–7) – or whether they may perpetuate greater socio-cultural divisions in diverse urban areas? In this paper, we add the value of analyzing bonds and belongings not only through the lens of climate risks but also through unequal urban development and settler colonial lenses which may help explain how and why risk communities emerge in ambiguous ways.

As Barry and Agyeman (2020, p. 11) observe, "planning scholarship often approaches these questions of (dis)belonging through the lens of political and cultural recognition". However, recognition alone may not go far enough to address the actual power and resource asymmetries (Fraser, 2000) embedded in planning processes, even when community outreach and engagement is practiced – nor to prevent the displacement of people of color from neighborhoods targeted by new resilience infrastructure. Engagement practices may indeed reinforce essentialized identities and/or "conventional notions of belonging" that subvert and incorporate Indigenous futurities and aspirations into a multicultural nation-state with a settler identity (Barry and Agyeman, 2020). Furthermore, some rights-based frameworks of recognition may give rise to a problematic sense of belonging wherein ''struggles against dispossession too easily become struggles for possession" (Porter, 2014; quoted in Roy, 2017).

Recent scholarship therefore suggests the importance of understanding cities as indigenous places (Barry and Agyeman, 2020) and shedding light on less visible placemaking practices and alternative modes of addressing socio-climate vulnerability enacted by marginalized groups in more informal ways (Anguelovski et al., 2021; Robin and Castan Broto, 2020) than engineered GRI. Applying settler colonial and postcolonial theories may also reveal surprising ways of knowing and belonging that represent more caring and emancipatory ways of constructing and greening cities (Anguelovski et al., 2021, 2020) through speculative infrastructures of imagination and possibility that represent the alternative claims and desires of marginalized groups. Abolition ecologies (Heynen and Ybarra, 2021) and abolition climate justice perspectives (Ranganathan and Bratman, 2019) also call attention to an everyday life view of the multiple risks emerging from climate adaptation planning which may open possibilities for a more radical, yet grounded, placemaking model, overcoming such subordinating experiences.

We start from the proposal that these processes of responding to multiple risks via climate urbanism may create new and/or intensifying forms of belonging. Reflecting on these dynamics at the intersection

of belonging, risk, and infrastructure in green climate adaptation planning, our research offers a novel lens of analysis via the perceptions of civic actors as to how this interplay informs climate justice. We do this by 1) setting belonging as a possible spectrum or mosaic of (sometimes concurrent) experiences – it is not just belonging, or dis-belonging, as usually analyzed but possibly many forms and intensities of belonging that emerge depending on contexts and projects; and 2) allowing for the possibility of an expanded notion of possession, dispossession, and repossession via the risks associated with place-making and climate infrastructure. In short, we further build the climate urbanism literature by examining how the multiple risks faced by climate-exposed historically marginalized communities are shaping a sense of belonging to the city, and to (in)justice in the emerging green resilient city in particular.

Methods

The American city of Boston, Massachusetts, and the East Boston neighborhood in particular, is a critical case for understanding the social impacts and ramifications of green adaptation planning. Since its creation in the 19th century as a single land mass out of five small Harbor islands, East Boston has been a key point of entry and settlement for lower-income immigrants and minorities, with LatinX residents being the most numerous today (Shokry and Anguelovski, 2021). Throughout its history the island has developed into a mostly green space deprived and environmentally contaminated neighborhood, dominated by industrial and transportation sector activities along Chelsea Creek and Boston Harbor (Douglas et al. 2012). The creation of the ever-expanding Logan International Airport in the 1920s has perhaps been the most devasting infrastructural incursion.

Thanks to the efforts of environmental justice activists, the neighborhood began to enjoy a new era in its environmental trajectory starting in the mid-1990s with the sponsoring of 33 acres of green infrastructure by Massport to compensate residents for the airport's environmental and health impacts. From the mid-2010s onward, a series of new GRI interventions such as elevated berm landscapes, resilient shorelines, and flood-mitigating parks have been planned along the waterfront as part of municipal efforts to respond to climate risks in a neighborhood where estimates warn that half of the land could be flooded during a major storm in the next 50 years (City of Boston 2017). These GRI are a key tool for advancing two comprehensive municipal initiatives: the 2017 *East Boston Climate Ready Plan* and the 2018 *Resilient Boston Harbor Plan*.

We drew on a set of 32 semi-structured interviews conducted in July 2018 and October 2019 in East Boston. Among these, 15 interviews conducted with organizers and leaders from key civic action groups and community-based organizations have been central to this study. The civic groups we interviewed were engaged in climate action, environmental stewardship and justice and green and/or climate resilient infrastructural planning. The remaining 17 interviews with city planners, developers, elected officials and environmental non-profit leaders provided important case study background and context for the actions of neighborhood groups and organizations. Interviews lasted between 45 and 90 minutes and followed a similar protocol focused on neighborhood social, environmental and health issues addressed by greening, urban partnerships, perceptions of green/climate gentrification, and equity and

anti-displacement tools. We identified key respondents in advance and used snowball sampling to reach a broad set of interviewees. Interviews were complemented by an additional review of all available and relevant policy, planning, and nonprofit documents related to green infrastructure, gentrification, and social and climate vulnerabilities in the cities.

Following full transcription and initial thematic coding, we selected data which pertained to specific codes. We then used a grounded theory approach to organize and analyze this specific data into categories of belonging, followed by types of climate urbanism practices.

How climate urbanism shapes belonging in East Boston

We present our results in three subsections, each examining one possible pathway of exclusion, negotiation and/or contestation through which GRI-driven climate urbanism and resilience planning shape belonging even while also (re)configuring risk. We explored these broad pathways based on the perceptions of local activists and civic associations apropos climate resilience-building processes and practices in East Boston.

Exclusion

We understood exclusion – one broad pathway through which climate urbanism shapes belonging – to take place through the formation of alienated and subordinated forms of belonging. We observed these forms of belonging especially where residents have been excluded from GRI benefits or where externally imposed adaptation and risk mitigation was the main mode of climate urbanism in effect.

Alienated belonging

Many East Boston interviewees revealed an intensifying sense of **alienated belonging** imposed by a growing need for protection from climate impacts while affordable adaptation options and assistance have become increasingly inaccessible to socially vulnerable residents. Adaptive capacity however depends greatly on whose power and authority defines environmental risks and which modalities should be used to mitigate them (Nightingale, 2017). Alienated belonging therefore derives from processes in which both homeowners and renters are left to identify and protect themselves from social and environmental risks, thereby creating “atomized subjects” solely responsible for their personal and household security.

For East Boston homeowners, updated FEMA flood maps have placed many in the flood plain and therefore introduced flood insurance as a form of protection, but also as a new cost burden, since “it's either a) inaccessible or b) totally unaffordable for them,” according to longtime resident and elected representative, Adrian Madaro. For those already living in the old flood zone, the threat of increased

storms and flooding coupled with exponentially rising flood insurance fees has meant new financial and family considerations according to a community-based EJ activist – “Should I try to sell? How long can I stick around?” Homeowners tell of exponential increases in their flood insurance costs from $500 to $3000 in less than ten years combined with a tripling of property taxes in the context of neighborhood revalorization and gentrification. Without appropriate and adequate social support, homeowners are thus taking individualized approaches to protection from these multiple risks – including retreat – which intensifies an alienated sense of belonging.

For renters, the added cost burdens of flood insurance and repairs is often experienced through rent increases, just as rents have been increasing due to gentrification. “Many of the folks who would truly benefit from [better building resilience] are actually renters, but the owners of the buildings don't have the appropriate financial incentives to make the investments they should be making to protect their residents,” explains Madaro. On the contrary, other interviewees told us that the lure of rising rents in East Boston incentivize landlords to unnecessarily evict renters for climate-upgrading, only to remarket homes at higher prices. These actions create an alienated sense of belonging for all involved, as property owners protect themselves from escalating risks and seek ways to improve personal quality of life, rather than considering a more collective approach or public programs that may help both themselves and tenants (Pelling and Manuel-Navarrete, 2011). Immigrant renters in particular have been silently evicted, displacing themselves rather than facing a court battle in order to avoid a housing record and deportation risks, and thus experience a deep sense of alienation and isolation.

Additionally, top-down and privatized resilience planning has contributed to creating what some call “islands of resilience”. With the waterfront overtaken by luxury housing through developments such as *The Eddy (2016)* or *Clippership Wharf (2019)*, affordable or public housing built in the low-lying areas and historic working-class homes are especially susceptible to groundwater flooding and remain unprotected, as a local activist told us: “That means that as sea level rise occurs, it hits the waterfront building, but then it really just moves the water off to […] nearby homes and residents and businesses.” As a result, these “islands of resilience” have alienated residents from one another, both by class and by housing type. High-income residents have developed an alienated sense of belonging from the surrounding district by living in segregated, high-end protected spaces while working-class residents and homes are also alienated from these new resilient infrastructures.

These examples of alienated belonging derive from processes in which residents are expected to buy their way out of displacement and dispossession or consent to exclusion. Alienated belonging also impacts social bonds in the neighborhood by setting community members against each other – tenants versus landlords and wealthier newcomers versus longtime residents – by further polarizing residents according to income, length of stay, housing type and resiliency grade. Thus, through new power imbalances and segregated resilience, climate injustice is intensified in the community.

Subordinated belonging

Among exclusionary drivers, we also identify forms of **subordinated belonging** emerging from top-down, city and/or developer adaptation agendas that undermine or circumvent local adaptive capacity efforts, increase climate risks, support gentrification and drive residential displacement. This is GRI-

driven planning and development that disciplines, undermines and fails to recognize the sense of belonging of socially vulnerable and historically marginalized residents.

In implementing adaptation, the city and/or developers may invite participation from civic actors but ultimately set terms which disempower participants, through what Cristina Jackson refers to as “chess game politics” (2019). Alternatively, they may entirely omit resident participation, as a longtime local EJ organizer explained: “It's always, ‘We know what we're doing, and we will call you if we need you, and for the record, we don't need you’." For example, among efforts to find quick solutions to climate impacts like flash flooding, in 2018, the City of Boston created a deployable flood wall at the end of the East Boston Greenway but did not plan its test run with local organizations, according to a grassroots coastal resilience organizer: “They did a dry run last week but didn't tell us. We just have to constantly remind the city, ‘Let us know. We're here, we can help you.’”

Political narratives about housing scarcity as a key driver of housing unaffordability further validate subordinated belonging during adaptation. Rather than advocating explicitly for affordable housing to be central to climate resilient development, a logic of overall housing scarcity ultimately justifies inequitable and unsustainable development, as told to us by a neighborhood association leader: “the mayor has decided that the way out of the housing crisis is to build; I don’t think he realizes that overwhelmingly what’s being built, and by overwhelmingly, I mean like 90%, is luxury.” The priorities of large-scale developers and power elites are therefore presented as necessary to achieve small gains – such as 10% of affordable housing units in new market-priced developments – for low-income residents. Another leader from the same association suggested that “when they threw The Eddy in there, they knew what they were doing right? I think they’re trying to push people out.” Residents’ belonging and attachment to the coastal environment neighborhood is ultimately subordinated through their eventual displacement from the neighborhood entirely. Therefore, in many ways, this subordinated belonging manifests as a dis-belonging from both social and climate resilient infrastructures.

In relation to the broader waterfront planning process and the degree of community engagement, local organizers regret the numerous instances of procedural exclusion: “We have big developers who are coming from outside with a lot of money and saying, ‘I can pay a million dollars for the permits’”, explains one organizer. Development at this pace, with little permitting oversight or strategic planning guidelines has foreclosed any real inclusion in planning processes, or representation of longtime residents’ interests and needs in planning decisions, ultimately undermining their adaptive capacity. Referring to the luxury high rises and restaurants along the newly green and resilient East Boston waterfront, where most residents had long been low-income, a community EJ activist explained, “We have increased real estate prices so much that people that used to live there have now been cut off from the water and are leaving the neighborhood because they cannot afford to pay the rent anymore.” Subordinated forms of belonging engendered by exclusionary planning agendas combine with alienated forms of belonging emerging through private, uncoordinated efforts to build resilience and result in residents losing connection with the harbor and being put at greater environmental risk through maladaptation (Anguelovski et al., 2019).

“Outreach” type consultation in adaptation planning (Finney, 2014) also has subordinating effects. Community groups told us about those municipal practices with great suspicion: “We [The City] will call out the vote for the top three [of these adaptation ideas], right? Then, we'll suggest whatever ones we really wanted in the first place anyway.” This especially occurs in what Melissa Checker (2020) calls

“predetermined development projects” in which unfavorable trade-offs or options are presented which do not advance and more likely undermine local needs and desires. For example, while a community-led survey revealed that residents want active parks spaces; “of the 30 or so acres of park space Massport manages, only about 3 acres are covered with splash pools and play structures,” a local EJ advocate told us. “The remaining acreage is either considered by Massport as visual landscaping amenities or regulated such that there is no ball-playing, bike riding, frisbee-throwing, etc.” Where the neighborhood has gained active play spaces, there were tradeoffs based on costs: “A lot of [LatinX] communities are playing soccer. It's easy for the city to have artificial turf [...] but the downside is that we're losing green space. We're losing soil”, explained a grassroots coastal resilience organizer. Subordinated belonging therefore means that lower-income residents’ socio-cultural uses and desires, and affective bonds with place and their natural environment, have been devalued both materially and symbolically through planning and developer decision-making that cuts corners and eventually controls racialized uses and bodies, by opting for less costly and sometimes less resilient, even harmful, interventions.

In sum, municipal planning processes and decisions tend to subordinate urban climate justice goals, community-led responses, alternative resilience practices and uses of green spaces to more lucrative development-prioritized visions while renewing historic mistrust in government leadership. In return, this subordinated sense of belonging generated through exclusionary relations with the city and development interests limits civic action to protect the local community. The final effect is to possibly lead to future self-exclusion from politics and a disciplined, tamed response to climate gentrification, displacement and other growing risks.

Negotiation

Our examination of climate resilience practices revealed negotiation as a second broad pathway through which climate urbanism shapes belonging. This pathway mainly flows through what we identify as forms of **assimilated belonging**. This kind of belonging emerges as low-income and residents of color negotiate with White power structures (the city and private developers) for small wins and with new gentrifying residents for cultural presence and recognition.

Assimilated belonging

In East Boston, the extensive green regeneration of the waterfront through the development of luxury high-rises, expensive restaurants and a new public esplanade called Harborwalk (Anguelovski et al., 2019) seems to conform to the tastes and socio-cultural behaviors of new, wealthier and younger gentrifying residents. Many local groups report being taken by surprise by the sudden, speedy and opaque development as plans had lain dormant for years following the economic recession, thereby affecting their ability to organize. In the aftermath, some groups have made attempts to negotiate for small victories such as a few additional units of affordable housing or better access to the waterfront

which is actually a requirement of compliance with Massachusetts General Law Chapter 91,[31] the "Commonwealth's primary tool for the protection and promotion of public use of its tidelands and other waterways." Thanks to this statute, developers have been obliged to deliver new open, public space in addition to housing. These include the East Boston living shoreline with the planting of a salt marsh and the creation of a new marine habitat. The HarborWalk is one of these wins, but it is physically and financially dominated by the luxury high-rises and expensive bars and restaurants (Shokry and Anguelovski, 2021). Assimilated belonging is an outcome of these imbalanced negotiations in which the city and developers were able to leverage the urgency of climate impacts in the aftermath of Hurricane Sandy to push climate resilience projects and waterfront development that have helped to rapidly intensify gentrification in East Boston.

Assimilated belonging also manifests through longtime residents' feelings toward their new surroundings and a sense of unwelcome and estrangement generated through new green and climate resilient infrastructures that host gentrifiers and outsiders in this process of settler development. "My kids, or my neighbor, who's Moroccan or African American [should] be able to walk to the Harborwalk and not feel out of place, says an East Boston coastal resilience activist. […] It's like they need to welcome us, but really, it's our neighborhood." This sentiment illustrates a dynamic of assimilation and green climate gentrification: on the one hand, the expectation to conform to hegemonic cultural norms – often inscribed in green space plans, designs and norms of use and behavior; while protecting and sometimes invisibilizing aspects of one's own cultural identity in order to feel safe and "remain relevant in both worlds" (Finney, 2014). "Most people who created this [park] were white people. They created it so it was more of a calm park." As more families of color settled in the neighborhood, it started to "feel like it was our park" explained an activist for the East Boston LatinX community. With the recent fast-paced, luxury driven gentrification, however, "it's been couples visiting, and if you go, you have to be careful because it feels like it's their park… I think that most things they started to build have been thought for people who are now coming, and not for people who already lived here."

In other words, residents of color feel newly obliged to assimilate into the cultural tastes of wealthier and whiter newcomers and visitors. "We're back to being the strangers in our neighborhood." The diversity of the neighborhood, a longtime working-class and immigrant neighborhood – the Ellis Island of New England – was before perceived as a deterrent to these groups, but now, said an activist from the same organization, "developers are attracted by the multiculturalism they can sell to the kinds of people coming in." Not only does it draw them in, but they are "banking on an identity of diversity that then you eliminate", through cultural appropriation and dispossession. As a result, residents feel torn about how to adjust and respond to these changes. On the one hand, residents suffering from racism and exclusion may first feel pride in seeing cultural diversity recognized and valued, drawing visitors and new residents that some may even see as contributing to the social mobility of longtime residents; on the other hand, as others have argued (Hyra, 2017; Summers and Howell, 2019), the marketing of "cool", "creative" and "authentic" cultural diversity quickly becomes a disadvantage once again when it collaborates in their eventual displacement. The additional loss generated by such institutional, environmental and everyday racisms may be the invisibilization of some socio-cultural practices (i.e.,

[31] https://www.mass.gov/guides/chapter-91-the-massachusetts-public-waterfront-act

outdoor recreational activities such as barbecuing and large family gatherings) while trying to preserve any remaining sense of security and avoid complete erasure from the neighborhood.

Community groups therefore grapple with perceiving private development as the only available path to achieving their hopes for neighborhood revitalization and protection from climate risks. A local climate resilience activist explained, “the developers come in, they remediate sites and that's something that has to be acknowledged.” Furthermore, despite recognition that developer-centered climate urbanism and development worsen inequalities, there is a sense that this is an unavoidable tradeoff for climate protection and neighborhood improvements. According to the same activist, “Luxury condos or apartments certainly aren't accessible to me. I don't make a living wage and many people in the neighborhood don't, so there's this dichotomy - it's gentrifying but at the same time some of them are really building to a high building standard.” This is another dynamic of assimilated belonging, one in which conforming to hegemonic standards for modernization and progress is part of acculturating to an ostensibly colorblind and disowned mode of development.

On the other hand, efforts by outside green designers and architects to build adaptive capacity to climate risks in East Boston through community engagement have also been interpreted as unaligned with local needs and desires. “[They] provide a series of options, which are limited – not culturally attuned – created by academics and professionals who don't understand our neighborhood and the level of education here,” said one EJ activist. Despite the diverse backgrounds of climate resilience professionals, their efforts may be perceived as culturally elitist, harboring conscious or unconscious bias. “You never got into a street fight... so, when those people come to the neighborhood, there's a funny question that they sometimes ask them. Where did you play Little League? With locals?” Widening this cultural divide is a “[shared] common language, based on technical jargon and measures (cf. Raco and Lin, 2012; Swyngedouw, 2009)” which facilitates cooperation among city managers, developers/architects and environmental non-profit staff. This means that grassroots activists may feel obliged to use outsiders’ language to be understood or obtain a seat at the table rather than being recognized for their knowledge and belonging or being able to “deploy familiar attachments” to get their needs and desires addressed (Blok, 2014). There is little hermeneutical justice in this urban greening process – those opportunities for a marginalized community to “make sense of its distinctive and important experiences on a subject and have the discursive or material tools and spaces to reflect on and share them” (Anguelovski et al 2020).

In some cases, to advance alternative placemaking models and adaptive capacity to climate risks, local organizations make compromises that may translate into a degree of fragmentation between neighborhood activist groups with different perspectives on the prioritization of issues related to climate protection, development, gentrification, and community identity/belonging. The head of one local environmental organization explains: “We don't fight displacement, but we are very conscious of it; We're here to build environmental stewardship. So that's going to require collaboration with all stakeholders, and I think that's why we are getting a lot of support.” This relates to how Finney (2014) characterizes the “gatekeeper” who struggles to maintain a double-consciousness, understanding, translating and participating, in ways that allow them to remain relevant to both their local sphere and the larger institutional world. There is a sense not only that cooperating with the city and developers is necessary to maintain programs for lower-income and minoritized residents but also that gaining the trust and support of power brokers means keeping a distance from anti-gentrification and environmental justice “fights”. Alliances between housing justice groups and justice-driven

environmental stewardship groups do exist, but our analysis of assimilated belonging reveals how they may become more fragile and ad-hoc than strategic through cooperative arrangements with outside groups. This relates to a contradiction in the concept of "bridging" (see Putnam, 2000) such that collaborating with outside groups may undermine internal neighborhood bonds – a dynamic that describes the struggle of double-consciousness in a society structured by racialized power relations. Therefore, assimilated belonging may signal an increasing fragmentation of social cohesion and then of activism.

In sum, civic actors' negotiations for better outcomes and protection against risks may lead to an assimilated belonging that means conforming to both the rules of a structurally unequal system and to new wealthier and whiter residents' cultural norms. Assimilated belonging is therefore characterized in part by a pressure to compromise (and at times erase) existing social and cultural practices and conform to racial capitalist and settler colonial modes of development in exchange for climate protection, access and participation. The negotiation pathway, and its potentials for cooptation, therefore begs the question – are the benefits worth the tradeoffs? Power asymmetries and systematic incorporation help sustain white supremacy through greening (Connolly and Anguelovski, 2021) and resilience practices while undermining potentials for climate justice (Porter et al., 2020).

Contestation

Last, our analysis of the broad pathways through which climate urbanism shapes belonging reveals that in some cases, civic actors leverage contestation to set a radical agenda for more liberating green spaces, transformative responses to climate change, and fostering adaptive capacity and local capabilities without over-dependence on or even independently from external actors. In these cases, some degree of community control and equal power relations generates an **emancipated belonging** through efforts to contest and undo asymmetrical power relations and create "new institutional arrangements, practices, and policies [making the] control and use [of land, resources and nature] by marginalized groups secure and permanent" (Anguelovski et al., 2020). Actions that characterize this pathway may comprise decolonial and abolitionist projects aimed at cultivating a culture of care, equal human dignity and community wealth through recognition of multiple historically produced vulnerabilities and seeking healing through symbiotic relations with land and urban ecologies (Anguelovski et al., 2021; Heynen and Ybarra, 2021; Ranganathan and Bratman, 2019).

Emancipated belonging

In East Boston efforts to build adaptive capacity and cultivate **emancipated belonging** are initiated by civic organizations which aimed to not only transform climate resilience practices that have alienated, subordinated and subsumed marginalized residents and their identities, but also to (re)create affective bonds with local green spaces and the Chelsea River and Boston Harbor. They organize alternative placemaking and recreational activities that reassert their equal citizenship and belonging in the neighborhood. Those activities also make these spaces more visible while preparing residents for climate impacts through education and developing a familiarity and comfort with the non-human urban

environment. For example, renatured shorelines, beachfronts, kayak docks and other recreational infrastructure ideally improve access to blue and green spaces for some minority and immigrant residents who may have a lower sense of comfort and safety next to waterbodies and green spaces (Finney, 2014; Irwin et al., 2011). To address this issue, several nonprofit organizations provide environmental, safety and stewardship educational programs for residents that foster connection with and knowledge about their natural environment. The director of the community-based organization, Harborkeepers, explains “We are teaching people body safety thermals, climbing on to the boat, climbing on to the fire truck […] People never thought this could happen in East Boston, kids learning how to make rope, learning how to tie knots, learning about shells,”. Through a climate nature program, students also learn about soil, trees and flooding as well as the urban systems that control and exacerbate climate risks: “We had a lesson on storm drains. Whoever talks about storm drains to kids? What happens when the water doesn't flow? […] How do we advocate improvement of these storm drains?” These kinds of programs support knowledge- and confidence-building in residents to protest inequities in risk and protection and advocate for neighborhood improvement, while fostering inclusivity and community ownership of amenities, landscapes, and assets: “everybody can use the kayak, regardless of their income. So, it's an equalizing program,” explains a local EJ activist and civic leader: Eventually, those activities (re)build social ties within the neighborhood: “It puts families who never have that experience, together, and it makes a precious moment for them which improves their life”.

Emancipated belonging is further created by the activities civic groups organize and foster around historic and recent neighborhood green spaces. Parks built in the 1990s and 2000s to compensate for air, water and noise contamination from industrial activities and the nearby Boston Logan Airport (Douglas et al., 2012), including Piers Park, the East Boston Greenway (Fig 1), Bremen Street Park and Bayswater Street Park, have been enormously popular with locals. For example, the Bremen Street Community Garden, which opened in 2007, has provided Latinx and other families the highly popular pastime of growing fresh vegetables, herbs and flowers and the possibility of enjoying a peaceful, green space in a dense and heavily trafficked neighborhood. Eastie Farm is another community garden started in 2015 by residents who turned an overgrown, underused lot into a space for growing fresh food, accessing urban nature, and building new community ties, while offering educational programs on composting, sustainable growing techniques and environmental stewardship and resilience (Shokry and Anguelovski 2021). Some programs also attempt to restore residents’ connections to the early maritime history of East Boston and its historic waterfront. Harborkeepers’ director, stresses, “We're asking for this coastal, quote-unquote, community to be allowed to be coastal, which means interacting with the water, which means learning about the environment, which means accessing any place and not feeling like it's private.” Through these efforts to secure access to green and blue spaces, civic associations have been demanding a restorative and reparative agenda for green resilient infrastructure, and climate urbanism more broadly, wherein neighborhoods that have suffered from historic harms may find reconciliation and recovery through relations of care and repair with urban nature (Anguelovski et al., 2020; Low and Iveson, 2016; Porter et al., 2020) and a more emancipated sense of belonging. At the same time, they point out that intensifying green privilege is today limiting such healing and liberation while generating new risks and insecurities.

Other programs have a more explicitly political goal of achieving emancipatory belonging by changing power asymmetries in the way climate risks are addressed and engaging future generations to shape the direction of their neighborhood through science-led activism (Martinez-Alier et al., 2011) and other

knowledge-centered work. Local youth are leading community-based participatory research and bringing findings to community meetings where climate action alternatives are discussed alongside other issues from “youth violence, the lack of safe places for young people to get together” to immigration and residential displacement, explains the Neighborhood of Affordable Housing (NOAH) climate programs manager. They aim “to educate them and let them know what other people were saying and thinking. Then seek their support to move forward on solutions”. Youth are thereby leading conversations about the neighborhood’s future and expanding their own and other community members’ knowledge, building adaptive capacity and constructing a stronger platform from which to advocate for the neighborhood. Through this emancipated approach, they are claiming for “reciprocal relations” (Finney, 2014) with the city. According to a founder of the ClimateCare initiatives: “[They would] try to meet with the relevant people and say, hey, this is what we see the problem as, here's what people say about it, and this is the group of people who asked us to come on their behalf and discuss it with you. We're suggesting this, what do you think?”.

In a similar manner, other local groups have taken an emancipatory and socially transformative approach to building political power and addressing multiple risks with climate change and infrastructural challenges included among them. They have, for example, created workshops to train local leadership to influence city decisions on issues such as immigrants’ rights, electrical power and land use, launching also a campaign called Right to Remain to better understand and act on the growing threat of displacement in East Boston: “this is the reason they’re involved and interested in solidarity economy whether that expresses itself as control over land or direct control and ownership over businesses”, explains a city activist about Neighbors United for a Better East Boston (NUBE). As an alternative to profit-motivated, capitalistic modes of placemaking, residents of the Latinx community, have organized the Center for Cooperative Development and Solidarity to address various local issues using popular education techniques drawn from cultural knowledge and traditions of their home countries. “They can ignore a person, but they can’t ignore a group of people. And our objective is to gain enough economic and political power to have an impact on decision making in our neighborhood”. They are doing the work of building political power and agency, not just in negotiating neighborhood changes, but actually setting the agenda for which changes should take place while defying socio-cultural erasure. “This empowers people. It makes people feel they belong here. […] the best way to stay here, is to make a difference, to make culture here,” explains one of its founders.

In sum, these efforts to contest ‘business as usual’ practices support an emancipated belonging, one that challenges the pathways and multiple risks driving alienated, subordinated and assimilated belongings. . These actions affirm the “racial and socioecological indispensability” of residents of color (Pellow, 2016) through everyday acts of resistance – even informal and less visible ones – to risks through strengthening social and environmental bonds and/or more radical or explicit activities addressing structural drivers of inequality. Sometimes working together in loose alliances, the emancipatory belonging generated by these efforts helps support and sustain climate justice in the community.

(INSERT FIGURE 1: How climate urbanism in East Boston shapes (mis-)belonging and climate (in)justice via exclusion, negotiation and contestation)

Belonging: Possibilities for climate justice in multi-risk communities

Critical discussions of climate urbanism and green cities are increasingly linked to place and place-making and to the social implications of adaptation for at-risk neighborhoods and communities. In conjunction with recent research on local inequities in urban adaptation practice, the question of belonging both to local places and to shared risk communities which shape imaginaries of socio-climate futures is critical to excavating how mobilization for climate justice might address these multiple, concurrent risks. Scholarship on belonging has brought important understandings to why belonging matters for place attachment and placemaking (Antonsich, 2010; Low and Altman, 1992) and how it is constructed through performance (Butler and Athanasiou, 2013), politics and boundaries (Yuval-Davis, 2011) and relations with people, objects and the state (Lynn-Ee Ho, 2006; Youkhana, 2015), among others. However, this literature tends to treat belonging as either belonging or not, typically painting it in a positive light. In response, we unpack this understanding by assessing how people collectively gain and construct myriad senses of belonging and mis-belonging through climate urbanism and their interaction with climate resilience infrastructure. Our analysis reveals at least three broad pathways through which climate urbanism shapes and reconfigures collective senses of belonging in East Boston – exclusion, negotiation and contestation (see Figure 1).

We show that belonging can take diverse forms which overlap and combine through similarly diverse responses to climate change risks and that it may be experienced in various ways, creating possible mis-belongings. As Robin and Castan-Broto (2020) have pointed out, analyses of climate urbanism "rarely discuss interventions that are never just neoliberal nor purely radical but that fall somewhere in between", nor those responses that fall outside state or market led strategies (MacGregor, 2021). Countering this trend in the climate urbanism literature, we have instead examined everyday practices and strategies of civic actors in response to risks emerging from climate change and resilience planning and infrastructure which has helped reveal how climate action can construct a variety of cultural expressions such as alienation, subordination, assimilation, and emancipation as well as diverse relations of cooptation, fragmentation and reciprocation. We also show why the multifaceted nature of belonging matters for how multiple social and environmental risks are approached, and therefore for climate justice. While studies (Manuel-Navarrete and Pelling, 2015) have shown that development leads to consent, adaptation to belonging (or not), and transformation to emancipatory subjectivities, in this paper we argue that development, adaptation and transformation cannot be separated. Rather, belonging reaches into all these areas and the effect of adaptation is not bifurcated, but rather leads to various subjugated, consensual or potentially decolonial and emancipatory modes of belonging. These various belongings coexist because GRI is a powerful historical infrastructure system dominated by longstanding development and transformative politics which cyclically create and address risks. Climate urbanism is subject to this history and therefore produces contradictory and complementary forms of belonging. No one actor necessarily produces one single form of belonging, rather their adaptive actions vis-à-vis each other, governmental and private actors may each represent these forms which together produce a mosaic of belongings.

These belongings also help illustrate how adaptive capacity to climate change gets constructed and congeals in a neighborhood facing socio-environmental risks linked with climate change and gentrification. In other words, by unpacking belonging in this way we start to better understand how

communities respond to climate change but also to *climate or resilience gentrification* and how they remain vulnerable to it because of the ways in which climate gentrification/urbanism is lived and becomes embodied by residents and embedded in their way of life. Climate gentrification is therefore actually this combination of climate change risks and climate urbanism that emerges from development-centered and colorblind or perhaps *color-averse* resilience planning. So, through unpacking belonging in this way our study contributes to theorizing climate gentrification and how vulnerability and adaptive capacity to it is collectively lived and embodied through processes of exclusion, negotiation and contestation.

This paper suggests thinking of risk communities as communities at-risk from not one, but *multiple* exposures that threaten their displacement and dispossession: these may be environmental hazards (including climate impacts), gentrification and now climate adaptation planning (Cole et al., 2021; Shokry et al., 2021), but also White nationalism and supremacy and settler development practices. Inspired by Beck's inquiries, we may ask about the kinds of collectives that emerge in response to these socio-climate risks. We may also ask to what extent these emergent "risk communities" give rise to new and intensified senses of belonging among not only neighbors in a given place but also strangers across cultural and political boundaries and scales. Our analysis grounds Beck's notion of risk communities and the problematic of cosmopolitization – wherein inclusive and exclusionary politics and geographies are generated by transnational flows of peoples and cultures (Lynn-Ee Ho, 2006) – in gentrification processes at the neighborhood scale. The new cosmopolitan resident – the "citizen of the world" who disrupts rootedness and particularities and imposes new universalisms – may pose a perceived threat to existing residents thereby generating and intensifying mis-belongings and racial banishment (Roy, 2017). The dialectic between belonging and dispossession is therefore important to understanding how settler (development) practices combine with the compelling force of climate risks to suppress "alternative hows" (Kaika, 2017, p. 98) and deprive people of land, livelihoods, desires and other ways of cohabiting the political (Butler and Athanasiou, 2013).

Through this paper we have examined what kinds of collaborations might benefit and help realize more emancipated, reciprocal and intercultural forms of belonging at the local and broader scales as opposed to alienated, subordinated and assimilated ones. Our analysis has shed light on the work of local organizations to connect "policy and popular narratives, climate change, disaster risk and their management" with "the imaginaries of everyday life" (Manuel-Navarrete and Pelling, 2015). As opposed to allowing risk to be managed by governmentalized authorities and developers, their practice in East Boston has revealed the possibility of different spaces for a more just green adaptation practice. We have also contributed to thinking through ways that a "dis/possessive collectivism" (Roy, 2017) may emerge through climate urbanism practices that subvert alienated, subordinated and assimilated senses of belonging deriving from processes of dispossession, cultural erasure and racial banishment. Such efforts may be key along the pathway to forming decolonial and emancipatory senses of belonging, free from "possessory politics" (Porter, 2014; see also Roy, 2017).

As cities begin to engage communities more directly in resilience planning processes, and experiment with more equitable approaches (Meerow et al., 2019; Shokry et al., 2021), research should examine green climate resilience mobilization and community politics and the complexity of building climate justice strategies and tactics. Such an analysis would help unpack and increase understanding about how local knowledges, senses of belonging, adaptive capacity and ground up coalition building shape and are shaped by climate resilience planning processes which our study demonstrates are increasingly framed

by larger-scale organizations, developers and city practitioners but also contested through grassroots struggles.

Community practices in East Boston reveal how new or intensified forms of belonging may help, or hinder, the struggles of marginalized urban neighborhoods and communities in building resilience, transcending local politics and even compelling global movements for climate justice. Sense of belonging resonates at various scales from the very local to the national and the global. Connecting the cultural-political aspects of urban displacement and racialized dispossession via a dual process of gentrification and climate change adaptation – both of which have planetary drivers – may be key to theorizing climate justice at various scales and strengthening global mobilization efforts for more transformative adaptation (Goh, 2020; Shi and Moser, 2021). Future research could conduct the kind of climate gentrification analysis we have done here – via the racialized forms of belonging emanating from exclusionary urbanism – across cities and at transnational and/or planetary scales (see Blok, 2020).

Conclusion

This paper contributes to a burgeoning interest in and understanding of the socio-cultural implications of urban climate action at the neighborhood scale, doing so through the analysis of an assemblage of ordinary, ambivalent, radical, incremental, (in)visible, and/or (in)formal practices responding to everyday risks and larger-scale threats. Our case study of East Boston demonstrates how alienated and subordinated senses of belonging emerge via an exclusionary climate urbanism pathway which constrains visions for alternative futures and social and environmental placemaking models, as well as drives displacement and engenders distrust of climate protection. We also found that in East Boston the pathway of negotiating with development and city powerbrokers led to an assimilated sense of belonging, one that means both conforming to the rules of the game in a structurally unequal system and to new wealthier and whiter residents' cultural norms (i.e., racial capitalist and settler colonial modes of development in order to access climate protection). Our analysis also revealed that a contestation pathway could lead to a more emancipatory sense of belonging through placemaking and adaptation practices that challenge the pathways and multiple risks driving alienated, subordinated and assimilated belongings. These practices in East Boston include the education, stewardship, and environmental protection work led by civic groups – some more explicit than others about addressing structural drivers of inequality – as well as everyday acts of resistance – even informal and less visible ones – to risks through strengthening social and environmental bonds. Sometimes working together in loose alliances, a growing sense of emancipatory belonging can support and sustain climate justice in the community.

The question of for whom is the green resilient city is more than a question of equity, right to the city or even recognition. It is also about who belongs and how that (mis-)belonging is experienced which in turn decides who gets to make, remake and unmake places, the city, the nation and the world. Green climate resilient infrastructure participates in the system of relations which govern this question and ultimately shape what kinds of cultures and societies are produced through these efforts and infrastructures. In other words, GRI are subject to similar dynamics as historic infrastructure systems. Planning needs to

recognize this or else it continues to shape culture and place in ways that are retrogressive, exclusionary and dispossessing.

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Chapter 5 – Discussion and conclusion

ADD ONE SUMMARY PARAGRAPH ABOUT THE OVERALL GOAL OF YOUR THESIS TO REMIND THE READER OF YOUR CORE RESEARCH QUESTION AND INTERESTS WITH THE THESIS.

Overview of Empirical Findings

In my introductory chapter, I identify three main research gaps that this study addresses. They include:

1. Expanding our understanding of the role of green resilience planning in relation to changing patterns of uneven urban development and racialized landscapes

2. documenting the barriers to redressing the drivers of social vulnerability as part of urban climate change adaptation efforts

3. the socio-cultural dimensions of the lived experience of the new planning orthodoxy of urban resilience remains underexplored

- Greening and Climate Gentrification

In Chapter 2, I reconceptualized a qualitative environmental justice framework developed by Isabelle Anguelovski and colleagues (2016) for a spatial quantitative approach, and conducted a two-part study to identify where and to what extent GRI implementation resulted in sites of omission and sites of commission across the urban landscape. Overall, this study demonstrates that despite the many promises of green and resilient interventions (e.g., health, recreation and social benefits, and economic value), the most socio-ecologically vulnerable residents of Philadelphia are less likely to benefit from adaptation due to gentrification and displacement over time.

I examined sites of omission through a cross-sectional study of the geography of social and ecological vulnerability in Philadelphia at three points in time. This investigation revealed that municipality-supported green resilient infrastructure does not ultimately have a protective role for the most socially vulnerable residents (i.e., low income and residents of color, elderly) even though GRI were sited in ecologically vulnerable areas. The preferred ecologically vulnerable neighborhoods for GRI implementation tended to be those where more privileged groups (i.e., upper income, white, university educated residents) resided and, as other ecologically vulnerable parts of Philadelphia became more socially vulnerable, GRI continued to expand in low social vulnerability neighborhoods in the city center. These were the sites of omission.

The study also identified sites of commission through a longitudinal examination of the landscape of gentrification over time in relation to GRI accumulation. This analysis first revealed that the expansion of GRI in the city center strongly corresponded with gentrifying areas. Second, it also showed that the

displacement of socially vulnerable residents from the urban core to the unprotected peripheries meant that climate gentrification in Philadelphia is clearly linked with increasing insecurity and ecological vulnerability for historically marginalized groups and, in particular, the city's Black and Latinx populations who, over time, moved to areas with low GRI.

More broadly, the study reveals the significance of the city's planning and policymaking context to climate gentrification pathways. Successive moves in city plans from a broad greening to a green stormwater approach followed by a climate adaptation framework corresponded with an increased green resilient identity for the city's gentrifying core and an overall increased GRI implementation and formalization in city plans. The perception by city planners and elected officials of growing climate vulnerability seems to be a strong driver behind the implementation of a greening policy agenda, which continues to help greening gain further political backing. However, the city's financial constraints remain, and so, as the case study shows, a cost-effectiveness agenda – one based largely on non-profit, volunteer, private landlord and developer efforts – dictates how these infrastructures are financed and therefore where they get sited. Stormwater management regulations for new developments and major retrofits, as well as parcel-based stormwater fees and grants incentivize residential and commercial property owners to install green stormwater infrastructure (Mandarano and Meenar, 2017). These practices and policies stack up to make GRI more likely in areas undergoing redevelopment – in short, these initiatives become wrapped up in processes that produce gentrification.

While finding that socially vulnerable residents are less likely to benefit from greening over time further builds the emerging green and climate gentrification literature; my study, on the other hand, points to a new pathway tied to green climate gentrification which suggests that gentrification may precede greening for resilience. Or, at the very least it is a two-way relationship characterized by the embeddedness of social and ecological processes in gentrification which results in new climate protected enclaves for privileged White/high-income residents. Those enclaves perpetuate the displacement of Philadelphia's most socially vulnerable residents, Blacks and Latinxs, to unprotected areas, thus reconfiguring the racialized geography of climate risk in the city rather than eliminating it.

- Vulnerability to future climate gentrification

Through a combined spatial quantitative and qualitative approach, my second study extends this investigation of green climate resilience planning in Philadelphia to examine vulnerability to future climate gentrification. This study allows me to not only retroactively identify the relationship between greening and gentrification, but also to start predicting how greening might further contribute to gentrification and displacement, and thus climate injustices, due to neighborhood and ecological characteristics. Through this analysis, I thus contribute to the emerging literature on climate gentrification, and green climate gentrification in particular, by proposing new methods and by identifying neighborhood indicators that can help predict how present and future greening might contribute to new climate injustices through gentrification processes.

By using a novel spatial clustering methodology to analyze a set of sensitivity and adaptive capacity indicators in relation to GRI exposure, the study suggests that these factors are best understood and measured as compounded concentrations of harms and resources put in place to deal with those harms. It also proposes a customized vulnerability framework that examines sensitivity and adaptive capacity as

neighborhood contextual characteristics rather than strictly social (e.g., Individual and household) characteristics in order to unpack and understand the structural pathways of vulnerability to climate gentrification and climate (in)justice.

My results reveal that much of the city is sensitive to gentrification and that future GRI continue to be planned for central, but also adjacent neighborhoods that are strongly associated with real estate development, economic reinvestment, and other growth-oriented indicators. These findings confirm that resilience efforts tend to be embedded in both private (Teicher, 2018) and state-sponsored investments (Gould & Lewis, 2018) that are known to drive gentrification. The findings also confirmed that exclusionary GRI planning will continue well into the future with higher percentage Black and Latinx neighborhoods remaining unprotected. The sensitivity analysis therefore underscored just how much GRI itself is a tool of public-private investment with similar implications for social and racial inequity.

GRI are also concentrated in higher adaptive capacity tracts. These neighborhoods are characterized by a greater number of community-based non-profits engaged in social support and anti-displacement work and may also have more affordable housing and community health centers that can thus protect fragile residents against climate gentrification; however, both my quantitative and qualitative analyses suggest that these areas are also sites of intense, overlapping private development and neighborhood change. Civic leaders from the two neighborhoods I analyzed which are home to communities of color underscored increasing displacement risk due to gentrification pressures as well as the ongoing displacement of socially vulnerable residents due to enduring disinvestment. Building and/or maintaining neighborhood adaptive capacity to gentrification is a mounting struggle they face as they also engage in building climate resilience through green amenities. Therefore, community-led climate resilience remains constrained by this other struggle of the right to remain in place, one that environmental organizations and planners continue to neglect even while incorporating an equity lens.

- Protecting place for vulnerable residents under climate gentrification

My third study (chapter 4) goes deeper into the placemaking dilemmas explored in chapter 3, this time focusing the analysis of green resilience planning on a different city. East Boston is a rapidly gentrifying neighborhood of the North American city of Boston, Massachusetts, facing mounting climate risks. It has historically been a point of entry and settlement for lower-income immigrants and minorities and shares similarities with Philadelphia's Hunting Park neighborhood, one of the two neighborhoods I examined in chapter 3. Both neighborhoods are sites of concerted climate resilience planning efforts and with a majority Latinx and immigrant population. East Boston however is a heavily gentrifying coastal neighborhood in which climate resilience planning has been and continues to be undertaken at a much larger scale with strong private developer involvement through major green space additions and improvements, waterfront redevelopment, and high-rise luxury developments, thus heavily compromising place-making abilities for vulnerable groups as well as their ability to stay. My choice of East Boston also responds to my interest in examining a variety of community organizations and groups working at the intersection of climate justice and housing rights, opening up the findings to wider applicability.

The qualitative analysis explores the placemaking practices of civic actors in relation to climate urbanism in East Boston to understand the socio-cultural dimensions of the lived experience of green resilient

infrastructures. The study asks: How are collective senses of belonging shaped and (re)configured through green climate resilient infrastructure? What do those pathways of belonging mean for urban climate justice? My analysis of an assemblage of ordinary, radical, incremental, (in)visible, and/or (in)formal practices of civic groups responding to everyday risks and larger-scale threats, reveals three pathways of exclusion, negotiation, and contestation through which GRI-driven climate urbanism and resilience planning shape belonging into various alienated, subordinated, assimilated and emancipated forms. This process helps theorize how climate gentrification emerges from development-centered and colorblind resilience planning and understand its socio-cultural implications in a socially and racially diverse neighborhood.

First, the study demonstrates how climate gentrification as experienced in East Boston is a combination of risks from climate change and risks from climate urbanism implemented through development-centered and colorblind adaptation strategies (Hardy et al). From this understanding the paper reveals how climate action that aims to address these compounding risks reconfigures bonds and belonging, playing an important role in shaping the meanings made about who the community is and how it relates to place and infrastructure.

Therefore, the study contributes to a new understanding of "risk communities" (Beck et al., 2013), a concept based on Benedict Anderson's (2006) work on the rise of nation-states as 'imagined communities'. I suggest that risk communities emerge not only through responding to the "compulsive force of climate change risks" but also through responding to unequal urban development for climate resilience. The kinds of emerging (mis-)belongings demonstrate how planning and development – even for climate resilience – still operate through hidden settler colonial logics and thereby continue to exacerbate the vulnerability of racialized communities by placing them at risk of displacement and cultural erasure via gentrification. This finding demonstrates how climate change, but also Anderson's idea of the force of nationalism – an often-invisible White supremacy/nationalism – are concurrent threats in the lives of racialized communities in the American city and in how they imagine their communities and futures.

Lastly, the paper contributes to new understandings about the concept of "racial banishment" which Ananya Roy argues may more accurately describe the process of gentrification, as more than capital accumulation and displacement (Roy, 2017); rather it may be understood as an instantiation of white supremacy through disciplining and cleansing communities of color. My study expands on this thesis by grounding it in processes of environmental and climate (in)justice, which reveal the cruel irony of a process of racial banishment that emerges as residents strive to protect their neighborhood by greening it, strengthening their climate resilience and addressing underlying social vulnerabilities through whatever means they can. While for Roy, racial banishment results from evictions and housing insecuritization, the East Boston context demonstrates that what makes racial banishment particularly brutal is how it disrupts an intimate process of finding healing, safety and belonging through improving one's neighborhood and deepening social and ecological connections as a coastal community. Residents of color are seemingly punished for attempting to make a better life.

This exploration of the experience of displacement and dispossession and its affective qualities, which emerge as sense of belonging, also helps uncover how possessory logics form and collectivize through a deepening attachment to place through processes of exclusion negotiation and contestation. In exposing how sense of belonging serves to formulate risk communities in climate adapting cities, this

study particularly directs our attention toward the ways that placemaking practices which contest public and private developer-led climate urbanism in East Boston reveal the possibility of different spaces for a more just green adaptation practice and emancipatory sense of belonging.

Toward a Critical Model of Urban Resilience: Transversal Findings

[start with an intro that LINKS this section back to the emerging lines of thinking that are discussed in the intro chapter…A critical model of urban resilience involves a better understanding of how resilience urbanism shapes place and identity; a tighter incorporation of climate justice, and strong awareness of climate gentrification.]

Pathways of Climate Justice

My dissertation contributes in X ways to new understandings about climate justice and injustice dynamics and to the XXX about possibilities for a just transformation via climate adaptation and resilience.

I use an environmental justice lens to approach questions about the uneven distribution of climate protection via green resilience, the recognition of differential vulnerabilities to climate risks and adaptation strategies, and the power asymmetries involved in climate action to green and build resilience. All of my studies grapple with these different facets of justice and more specifically with the urban aspects of climate justice. Chapter 2, in particular, demonstrates how the disproportionate burdens of climate risks and impacts, which are unevenly distributed across the urban landscape, continue to be borne by the most socially vulnerable residents due to their displacement by climate resilience. Chapter 3 also examines these distributional aspects but also grapples with the issue of the lack of recognition by city agencies and environmental non-profits of the social vulnerability of residents of color to neighborhood redevelopment processes, in which green resilience initiatives are embedded. Even if I have not specified acapabilities approach to my work, my 3rd and 4th chapters especially visibilize the disproportionate capacities required of lower-income communities of color to mitigate both climate risks and displacement pressures. A wide range of basic needs and capabilities related to housing, healthcare, childcare, social cohesion, cultural practice and also good environmental conditions are required to build up adequate adaptive capacity. My last empirical chapter, Chapter 4, continues building on these justice questions by investigating how power asymmetries in the climate resilience planning process result not only in displacement pressures but also mis-recognition which may lead to less advantageous decision making that reduces adaptive capacity. In these ways I have connected with an environmental justice approach through my empirical studies in order to theorize climate justice, particularly at the urban scale and thereby excavate novel findings for both.

My studies also help highlight the value that an urban environmental justice approach can have for climate justice scholarship and activism which tend to have a global-scale outlook (Schlosberg and Collins, 2014). Roberts and Parks (2007) raised the issue of a “triple inequality” in which the poorest groups or nations, least responsible for climate change are those made most vulnerable to its impacts

and are also the least likely to benefit from climate adaptation and mitigation efforts and/or pay disproportionately for them. While crucial to the formulation of climate justice theory, the distribution of power and privilege at the local scale tends to be missing from these analyses, which focus more on differences between global North and global South asymmetries. Increasingly, climate justice scholarship and activism has aimed to have an on the ground impact without always fully understanding the stakes at play (Schlosberg and Collins, 2014). My dissertation illustrates why and how a grassroots perspective is key to climate resilience policymaking for the city but also how "looking both ways" helps ground the global perspective with a more nuanced understanding of smaller scale socio-spatial and power inequalities, in particular how climate risks interact with racialized geographies, an issue which tends to be ignored in global scale climate policy discussions. In this way, my dissertation also contributes a more contextualized understanding of the drivers of vulnerability which may vary across cities, regions, and nations.

While EJ scholarship and Also missing from the CJ movement – including EJ understandings of CJ – is a CG with CJ. And how CG is planetary and connecting just like CC so helps demand for fairer distr. Of CA but also demand for changing the economic system which is a bonus for mitigation. My chapter shows a transnational CJ can and should be built from the ground up with community-based, grassroots movements leading the way. And that sense of belonging (shaped by CG) can help connect the lived experience of CC to make policymaking more substantive at every level. In this sense, we can say that climate gentrification (climate risks + climate urbanism) is also a mobilizing force for new risk communities as much as are climate change risks alone and that the kinds of coalitions that emerge may be more capable of advancing a climate justice agenda that is more in tune with structural inequalities and vulnerabilities. This is CJ built up from an understanding of struggles at the local level.

Need to integrate a more transformative agenda about CJ rather than the repairs/adjustments approach of EJ. Bring in our justice paper for this…

Third – challenges of coalition building for climate justice. Use cut parts from Paper 3.

Are resilience and justice compatible? (Pelling). See Fainstein's point 2018: "If, however, it is tightly connected to the interaction of disadvantaged groups with the physical environment, it has the capacity to contribute to greater justice."

See also Linda Shi's work (roadmap and recent papers). IA and DP brief. Metropolis Report.

Pathways of climate gentrification

My dissertation work on understanding climate gentrification uncovers several new pathways by which green resilience is linked with new inequities, insecurities and the displacement of socially vulnerable groups. Chapter two finds that green resilience gentrification is implicated in the process of generating ecological enclaves for whiter and wealthier residents while displacing Black and Brown communities from central Philadelphia to more peripheral neighborhoods. In particular, the study demonstrates that while central neighborhoods gentrify and become greener and more climate protected, climate insecurities increase for residents of color who are likely displaced to more climate vulnerable

neighborhoods with little green resilient infrastructure. The chapter also uncovers a new bidirectional pathway for climate gentrification characterized by the embeddedness of social and ecological processes. Not only does GRI siting create enclaves for privileged residents, but those residents are also found to reinforce the enclaves by being able to attract more green investment after gentrification. The study also shows how public-private partnerships help drive this process of displacement and increased climate insecurity for communities of color.

Chapter three builds on these understandings of climate gentrification drivers through an exploration of the embeddedness of green resilience infrastructure in urban and neighborhood development mechanisms, amenities and characteristics and an investigation of where efforts to constrain gentrification effects get stymied. The study demonstrates that socially vulnerable neighborhoods are continually faced with social and climate insecurities due to the unfettered force of private market-led investment and that potent governmental and nongovernmental, nonprofit institutions are unable to do little to prevent this. They may even support harmful private investment for historically marginalized groups if it means achieving resilience goals faster and more cost-effectively. My findings also reveal that the anti-displacement efforts of community-based organizations so far fail to fully withstand the force of growth-oriented and urban renewal activities such as Opportunity and Empowerment Zoning, redevelopment certifications, and concentrated new construction and major renovations. Not only that, but future green resilience initiatives are actually planned for exactly those areas that are most sensitive to gentrification in these ways.

The lived experience of climate gentrification in a collective sense and through new green resilient infrastructure, the focus of Chapter four, has also been underexplored in the literature. How does climate gentrification by resilience affect people's everyday lives and senses of belonging in communities of color and through which pathways? My research helps expose the kinds of (mis-)belongings that emerge from efforts to remain in place while confronting a variety of compounding risks, including climate risks but not only. As I outlined above, my dissertation contributes to theorizing risk communities (Beck et al., 2013) and racial banishment (Roy, 2017), but these concepts also help us understand climate gentrification. For one, my research suggests that any understanding of climate gentrification theorized as gentrification driven by climate risks is not enough for it leaves out the key role of unequal urban development and growth centered politics that drive gentrification. But seen together with findings from Chapters 2 and 3 we may also begin to understand that climate risks are themselves deeply embedded in gentrification processes. What this means is that gentrification and displacement may actually be thought of as generative of climate risks through the act of shifting communities of color into new or greater exposure to harm. This process therefore exacerbates the vulnerability to climate change of communities of color.

My research also draws out the settler colonial logics embedded in climate gentrification processes of racial banishment through its analyses of these shifts in the geographies of racialized minorities and the destabilization of their lived experiences. In other words, climate gentrification may be understood as a racialized process of dispossession and cultural erasure provoked by colorblind adaptation planning and development and not only a change in real estate values or class variables. More than that, my studies illustrate how climate resilience planning becomes a land grab by developers, aided by government institutions, ostensibly to protect low-income residents of color while actually displacing them to resettle whiter and wealthier groups. This emerges from the study in Chapter 2 which demonstrates how central Philadelphia neighborhoods, most desirable to the city's green growth agenda, were

gentrified and greened while the Black and Latinx population declined, and peripheral neighborhoods gained ever more residents of color.

Future research avenues and questions

Scholars are therefore calling for similar scrutiny of climate resilience planning rooted in green infrastructural interventions, asking how benefits from these interventions can be expanded beyond the privileged few (Davoudi et al., 2012; Fainstein, 2015; Shi et al., 2016). At its core, this emerging line of critical urban resilience thinking seeks to understand how cities might adopt more transformative and just planning frameworks as an adaptation pathway (Pelling, 2011). From this perspective, research is needed to understand how climate change adaptation and resiliency planning, constructed on centuries of environmental racism and uneven development, can avoid perpetuating already entrenched inequalities. This need for understanding how the link is formed or hindered between broad societal transformation and green infrastructure planning rooted in resilience urbanism is the starting point for my research.

ADD A FEW PARA ON THE CORE RESEARCH QUESTIONS THAT YOU THINK NEED ANSWERING KNOWING YOUR FINDINGS SO FAR AND ON WHERE THE FIELDS OF URBAN GREENING, CLIMATE GENTRIFICATION, AND CLIMATE JUSTICE SHOULD BE MOVING. JUST A FEW

Reflections on my research practice

Building different research practices

Looking back on my research practice and the skills I have developed and put to use during my doctoral training, I feel quite pleased with the range of experience and knowledge I have acquired through writing and collaborating with colleagues of various interdisciplinary backgrounds as well as through my research experiences in various countries. All of this was thanks to being part of a large-scale, well-funded and comparative research project. The project's original goal was to identify the scope and magnitude of green gentrification, and the factors behind it, in over 40 cities across the US, Europe and Canada, provided many opportunities. This involved a massive data collection effort, allowing me to understand how demographic and greening data are collected and processed by public agencies in the US, France, Italy, the UK and other countries. I also had the chance to travel and conduct fieldwork in Boston and Philadelphia in the U.S., Bristol, England, and Lyon, France. However, with such a rich and ambitious program, achieving its goals in a limited timeframe and with strict intermediary, funder-imposed deadlines, did also place constraints on my individual research plan and its implementation.

One of my goals going forward is to develop a more embedded research practice building on my skills with grounded theory investigation, case study analysis and quantitative and GIS spatial analysis. I am interested in developing more participatory and community-based, possibly action, research methods

that would involve community-based organizations in vulnerable neighborhoods in the actual planning of my research questions and methodologies to data collection and co-writing. There are many challenges to this kind of research agenda, from finding a community to work with, to being mindful of their time, remunerating fairly and balancing diverse and competing interests; in short, all of the same challenges that any participatory model entails. I think it may however be a way to have a more situated and contextualized impact through my research, and also to have a clearer idea of what its actual impact has been for vulnerable communities..

Implications for urban policy and planning

While mitigation remains the key to sustaining human life on this planet, adaptation is also increasingly necessary given the impacts generated by change climate conditions and the risks they pose. Through my dissertation research I have tried to disentangle the processes and pathways that perpetuate urban social and racial inequities through green climate adaptation and resilience planning. The work of building a more socially and environmentally just city needs the cooperation of public and private, city, non-governmental and grassroots organizations to overcome this persistent reconfiguring of socio-spatial inequities and insecurities through neighborhood redevelopment processes. So long as growth-centered, elite interests and settler colonial logics remain central to greening and adapting cities, socially vulnerable residents will continue to remain disproportionately vulnerable to climate risks.

Knowing how entrenched these interests and logics are, I draw here from my research to suggest a few incremental responses or adjustments that cumulatively and purposively, may lead to a more just urban greening and adaptation. The key will be making them more salient to politics than a green growth agenda has been made.

- The need for anti-displacement and pro-housing rights tools

Cities are increasingly developing tools to visualize the geography of urban climate risks and vulnerability in order to inform resiliency planning, and increasingly – albeit very slowly and sporadically – these tools are including demographic factors in order to identify the most socially vulnerable areas and plan for equitable resilience. This form of assessment can help cities understand which areas are most in need of protection based on an overall understanding of their combined social-ecological vulnerability. It would be key to ensuring that green infrastructure not only builds resilience equitably but is justice enhancing by prioritizing neighborhoods with higher social-ecological vulnerability.

A key finding of my empirical research, especially in Chapter 2, demonstrates however that the landscape of social vulnerability is rapidly changing in central urban areas due to gentrification and displacement. This shift in social-ecological vulnerability means that green infrastructure would be unlikely to protect the most vulnerable residents over the mid- and long-term. Therefore, I suggested that it would be necessary for cities to evaluate neighborhoods for vulnerability to gentrification/displacement and identify intersectional and compounding drivers of neighborhood sensitivity and adaptive capacity. As my review of the literature in Chapter 3 demonstrates, urban renewal and redevelopment tools such as Opportunity and Empowerment Zoning, blight certification,

historic building protection and waterfront redevelopment all point to significant reinvestment and ongoing or increased sensitivity to future gentrification. A spatial vulnerability analysis using a methodology like the one I developed in Chapter 3 could help predict the likelihood of greening and resilience benefiting socially vulnerable residents or, on the contrary, playing a role in their displacement. Such an assessment would also shed light on which areas of the city may need increased anti-displacement protection and intervention and in what ways. Therefore, a vulnerability to climate gentrification assessment integrated with a climate vulnerability assessment could be a valuable tool for long term resiliency planning. Moreover, if the data and findings are ground-truthed early on through community-based organizations, or even better, carried out in partnership with them, the results could help generate especially meaningful and relevant anti-displacement policies for a more just climate resilience.

My research has also shown that a diversity of high-capacity social infrastructure such as affordable housing are needed for community resilience, but also social, child and health services, and community spaces for community education, exchange and political power building. Such infrastructure provides material and organizational support to socially vulnerable residents and helps mitigate the effects of harmful development. But this is not enough. These residents also need political support through legislation, such as Just Cause and others that permanently secures housing affordability and the long-term viability of these services and facilities. GRI programs should advocate alongside community-based activism for such protections and against the harmful aspects of so-called community development programs that largely benefit wealthier homeowners and developers (e.g., long-term city tax abatements for new construction and major renovations). Furthermore, housing programs will need to work closely with greening and climate resilience initiatives to comprehensively plan green and climate resilient neighborhoods without residentially displacing people. The current siloed approach or working only with other departments most directly aligned with their primary missions, complicates equitable planning, especially with affordable housing and other city services currently threatened by increased commodification, privatization and neoliberalization. Greening, housing and other community advocates should therefore, work together to guarantee that when greening is negotiated into new developments, that affordable housing – whether through rent control and subsidies, inclusionary zoning, density bonuses, and the use of land banks or other measures – as well as support for the kinds of social infrastructure discussed above and in Chapter 3 are a key part of the plan. Concerted and sustained action of this kind may help decouple climate adaptation from green growth objectives and at least significantly temper the effects of green and climate gentrification on socially vulnerable residents.

- The need for more community-driven, community-centered greening that builds on and strengthens the capacity of community-based groups

As a part of urban climate adaptation planning, some cities partner with community-based organizations to advance the greening of their neighborhoods. These collaborations tend to involve the use of local volunteers to plant trees and gardens and clean up vacant lots. This kind of partnering, unless fully subsidized, may however actually reduce a community's capacity to attend to other social services, organizing and anti-displacement work, as my third chapter has shown.

Nonetheless, prioritizing community-driven, community-centered climate resilience approaches is key to ensuring their integration with ongoing social-ecological processes and safeguarding benefits for vulnerable residents over the long run. With such an approach, greening and resilience work could also support and strengthen the capacity of local organizations that deliver social services, by providing healthy food, meeting spaces for community building, education and health benefits, cooperative workforce development and green jobs (Wolch et al., 2014).

However, to achieve such ambitions, community ownership and control of land is vital. A just GRI and resilience process would therefore support the permanence of community greening and resilience-building efforts through for example community land trusts around GRI cluster areas or large-scale climate protection projects (e.g., waterfront redevelopments) which can secure long-term affordability and stability for lower-income residents (Anguelovski, 2014; Thompson, 2015). Inclusionary zoning via city planning efforts that integrates substantial and affordable housing and community infrastructure such as public libraries, community meeting spaces, affordable health and childcare facilities, and so on, may also provide a solution. In this case or in direct negotiation with developers, community benefits agreements that represent low-income and resident and communities of color would need to be successfully negotiated and put in place (Federal Reserve Bank of Boston, 2017).

With such protections and resources, it may also be possible to tip the power balance in favor of supporting more informal and/or alternative modes of greening for resilience that may better fulfill reparative and emancipatory benefits for lower income and communities of color than green stormwater infrastructure. As seen in Chapter 4 and elsewhere (Finewood et al., 2019; Hardy et al., 2017), green infrastructure led by city planning agencies and large-scale environmental nonprofits tends to prioritize techno-managerial solutions, subordinate alternative approaches and push consensual politics in order to move forward with one-size fits all GI or developer-driven GI that may finally benefit future gentrifiers more than current residents. By strengthening local organizational networks, bonds and place attachments, greening is more likely to reduce vulnerabilities and foster long-lasting climate resiliency and justice (Graham et al., 2016).

Therefore, greening that is community-led can better respond to the needs, identities, aspirations and place-making practices of vulnerable residents, helping achieve recognitional justice and a more emancipatory sense of belonging (Chapter 4). This means being willing to recognize and address historic legacies of trauma, violence, erasure, and dispossession. It also means recognizing and integrating diverse representations and uses of space by racialized minorities and integrating the preferences, knowledges and needs of socially vulnerable groups as a necessary part of planning collaboratively with communities and central to a just climate resilience and neighborhood revitalization.