How Cities Can Become More Flexible in the Wake of COVID-19: Housing Case Study

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Abstract

The COVID-19 pandemic has stress-tested cities in ways nearly unimaginable, from shuttering retail to depleting crucial tax revenues that will cripple public service provision for years to come, to fundamentally disrupting the concept of commuting for millions of people. In this paper, we discuss ways cities can leverage this period to increase their ability to "flex," meaning to adapt in the face of adversity and to building back stronger. Such lessons and potential transformations will serve as a "trial run" for the impending and almost certainly much larger impacts of climate change.

We apply these assessments and recommended learnings to a case study of housing. With an imminent eviction crisis due to widespread inability to pay rent, the timescale for innovative housing solutions has become immediate. Potential solutions include repurposing existing buildings, innovations in the construction and licensing of new housing, and revised transit scheduling. Ultimately these strategies can help mitigate housing issues stemming from climate migration, homelessness, and the need for urban density in light of expected urban population growth. Their common thread is a more intelligent assessment of resource allocation based on novel data and forecasting techniques.

Background

The Need to Flex: Trial Run for Climate Crisis

Given the megatrend of rapid global urbanization, and the likelihood that 250 million or more climate refugees will need new housing by 2050 (Biermann & Boas, 2010), cities and regions will need to increase their flexibility and resilience. While the term urban resilience is used in a variety of ways, we relate urban flexibility to the notion of resilience defined by the urban system's ability to "survive and thrive in the face of uncertainty, adversity, and change (both incremental and rapid)" [Sharifi & Yamagata, 2018]. Given the complexity of cities, urban flexibility will incorporate a number of levels of interrelated systems (physical built environment, social, governance) and include plans for how to increase flexibility, who will benefit from urban flexibility and in what ways (Meerow & Newell, 2016).

We focus on how flexible urban responses to COVID-19 can serve as a "trial run" for urban preparedness and resilience in response to climate change, and specifically with respect to housing. Such a trial run is analogous to the culture of masking that predated COVID-19 in countries such as Vietnam and Taiwan, which used knowledge gained in response to the SARS and MERS outbreaks to more effectively combat COVID-19. Compared to the COVID-19 pandemic, the climate crisis is likely to result in far greater loss of life, social unrest, and economic collapse. Highlighting the crucial role of urban flexibility will play in the next three decades, cities are projected to house 68% of the world's population by 2050, the same year in which global carbon emissions are supposed to be cut to zero to stay on a path consistent with below-1.5C warming, per the Paris Agreement. COVID-19 also provides a preview of the impact of increased likelihood of infectious disease outbreaks that anticipated in parts of the world due to climate change.

The economic and financial hardships caused by COVID-19 may also preview those to be caused by climate change. In the case of COVID-19, beyond the immediate public health recovery, cities face financial hardship due to massive and unexpected reductions in sales, income, and property taxes resulting from employment losses, the closing of retail, and decreased usage of urban transportation systems. Some estimates put the recovery of municipal financial resources on par with that of the Great Recession of 2007, which took 12 years for full financial recovery.

Thus, more than ever cities will need to act resourcefully and nimbly, and hopefully emerge from the COVID-19 crisis with an improved ability to flex. The COVID-19 pandemic provides an opportunity to test many ideas and strategies. By making our cities more flexible, equitable, and sustainable now, we can expand the capacities necessary to house present and future climate refugees, fight climate change, and improve urban quality of life.

Impending Housing Crisis

Longstanding housing problems are becoming crises during the COVID-19 pandemic, with over 25% of US renters facing evictions because of lost income. (Aspen Institute, 2020). A core problem of the COVID-19 public health crisis is that it hits the most vulnerable populations in multiple ways, including increased job loss and heightened risk of exposure, with effects then magnified by pre-existing health conditions and financial insecurity. This inequity means COVID will hit renters harder than homeowners. In New York City, recent research indicates that neighborhoods with high pre-existing rent burdens are likely to be hardest-hit due to COVID-19 (Kazis, 2020). Vulnerable residents include gig workers and low-wage restaurant labor, whose monthly paychecks barely cover living expenses. Most of these workers live paycheck-to-paycheck, rent their home, and are losing much if not all of their income because of COVID. As counties and cities implemented "shelter-in-place" policies after the national emergency announcement in March, low-income communities suffered the most from this disruption with lay-offs, wage cuts, or unemployment. Housing affordability concerns suddenly became housing security threats, with renters facing eviction and homelessness.

While emergency response networks for natural disasters are well-investigated and implemented across cities, urban pandemic response mechanisms in the United States are still largely unexplored (Lai et al. 2020). Although FEMA has a transitional sheltering assistance program, most of its testing has been during natural disasters such as hurricanes, flooding, or earthquakes. The need to safely and effectively house large populations during an economic downturn, while keeping them safe from community spread of a highly infectious virus, makes these sheltering systems extremely difficult to design, build, and operate.

The effect of COVID-19 on housing innovations and emerging business models to provide more affordable shelter are unknown. Companies including Common, WeLive, Ollie, and PodShare are innovative real estate start-ups that test housing models based on concepts of communal living and space sharing. In recent years, cities have been actively working with these innovators to test possible solutions for future housing. In 2019, the NYC Department of Housing Preservation and Development (HPD) launched ShareNYC, a pilot project seeking a private-public partnership for a co-living housing development. However, as an easily -transmitted, infectious respiratory disease, COVID-19 brings new public health concerns jeopardizing these new housing models.

On the positive side, the COVID-19 pandemic may push innovations in housing regulation, architectural design, and building technology. For instance, aging HVAC systems pose many risks to residents, but the need for better building ventilation systems because of COVID may hasten new HVAC technology that will provide many benefits.

One popular narrative is that the reduction of the economic and cultural benefits of urban living, together with increasing ability and acceptance of remote work will lead to people moving out of cities, thus boosting supply and lowering prices of homes in cities. Historically, cities have proven incredibly resilient to disaster [Vale & Campanella, 2005], suggesting that such an impact on urban housing is unlikely to be substantial, though the potential for remote work is novel and may play an influential role. Shifts to remote work, particularly those associated with high paying technology sector jobs, have been highly visible, with major companies such as Google, Facebook, and Twitter announcing extended work from home policies.

Although it is too early to tell whether this narrative will be true, we can look at initial signals. First, supply of homes available for sale is in fact at an all-time low (see the National Association of Realtors July 2020 report), causing a significant increase in home prices – the opposite of this narrative. This is largely attributable to fewer people choosing to move as part of a broader hunkering down during COVID, and thus could be a short-term effect that will either wear off as the pandemic drags on or evaporate rather suddenly should a vaccine become widely available.

What about the longer run? Will people move away from cities if they can work remotely, especially if COVID-19 appears to be heralding a new era of infectious diseases or as a response to climate change? Again, forecasts are murky at best, but search behavior on real estate sites like Zillow give some indication of the extent to which people are at least exploring this option. Redfin does report an increase in demand to move from cities, but crucially, these potential moves are to other cities rather than to the countryside or otherwise more rural locations. The most common destinations for those looking to escape the high cost of living in cities like San Francisco and New York are Phoenix, Sacramento, Las Vegas, and Atlanta. Somewhat similarly, Zillow is reporting substantial increases in traffic to their web-listed properties, but is not seeing relative increases in prices and demand for suburban homes compared to urban homes. However, Zillow is reporting that rents in urban markets have fallen more than their suburban counterparts and that home values are dropping and homes are staying on market longer in ultra-expensive cities (Manhattan, San Francisco) even compared to merely expensive cities like Miami and Seattle.

In a broader scope, increased working from home and a slight shuffling to relatively less expensive cities may provide an opportunity for cities to shift toward the 15-minute city concept popularized by Paris mayor Anne Hidalgo (and promoted in Portland since 2008), in which every resident of a city is no more than 15 minutes away from everything they need to live, without the use of a car. If cultural and daily living amenities are distributed more equitably across a city, so too will the cost of housing spread more evenly. Potentially the development of new urban village areas within the 15-minute city will allow for new construction technologies and building materials that, along with zoning changes, can significantly increase the stock of housing to help cities flex to accommodate housing crises.

Housing Crisis Mitigation: Existing and Best Practices

As a prominent example of response to an acute housing crisis, New Orleans faced massive destruction of built environment and housing displacement from Hurricane Katrina. Regarding housing, New Orleans was forced to re-plan one third of the city in support of housing for 40% of its population. If tens of millions of Americans become homeless before the end of the year, where will they go? As a rapid response to COVID, there simply may be no alternative to meet the sudden surge in need for housing other than prioritizing radical solutions that utilize any and all available housing options, including vacant hotels, dorms, and rapid-build housing (see New Housing and Related Technologies: Innovating the Built Environment below) on available land.

In the medium and longer term, to prepare for climate-related housing stress, cities should adopt policies now that will make them more flexible by planning for housing density and anticipated need for nimble solutions. To that end, many cities are enacting plans and policies that support housing flexibility. The Seattle Planning Commission, for instance, published its Neighborhoods for All plan in December 2018 that outlined a multifaceted strategy to move away from dominant single-family zoning in order to support housing diversity and density. Among other changes, this plan expanded support for accessory dwelling units (ADUs), proposed zoning modifications for converting houses into multiple units, including design standards for a variety of housing types, reduced minimum lot sizes, and approved a designation that supports more housing types on previous single family zoned areas near schools, parks, and other services. The plan also removed the occupancy limit for unrelated persons in single family zones, which could provide crucial housing to those in need due to eviction and other housing shocks.

Similarly, in March 2019, Portland's Residential Infill Project capped single family house sizes, allowed more housing types, opened small lots to housing development, added more flexible ADU options, and

modified and removed garage and alley access requirements. Again, these changes support density and generally affect housing supply in such a way as to minimize rent and price inflation, ultimately making housing more available and affordable.

Cities are already connecting these longer-range housing policy plans to the immediate impacts of COVID-19. The City of Seattle, for instance, had declared a homelessness state of emergency back in 2015, when more than ten thousand people, including two thousand under the age of 17, were homeless in the city. People of color were found to be far more likely to be homeless in Seattle. In response, the city followed up on the Neighborhoods for all plan with a Racially Equitable and Resilient Recovery plan that specifically addresses mechanisms for building back better in the wake of COVID-19. Among other elements, this plan extends an eviction moratorium, increases funding for land trusts and limited equity cooperatives to increase access to affordable home ownership, and helps create and expand neighborhood commercial zones that include small office and co-working space along with childcare space to better support working from home.

Research and Innovation Plan

To better understand the housing crisis exacerbated by COVID-19 and help maximize efforts to build back better (see Sendai Framework), we propose a three-pronged approach to research and innovation:

- First, measure, model, and predict where COVID-19 will likely cause evictions and housing shortages.
- Second, determine where existing infrastructure, such as empty homes, hotels, dormitories, and commercial office space, may be available to repurpose as temporary housing for those displaced.
- Third, investigate new technologies for accelerating the construction of temporary and permanent housing.

Data, Analysis, and Forecasting

Turning to the current COVID-induced housing crisis, as a first step we recommend a data-driven assessment of the extent of the crisis: how many people are facing imminent homelessness and where are the areas hardest hit? Although each city will have a unique set of relevant data, examples of representative data sources are listed below, acknowledging that these cross public-private boundaries, as well as a number of governmental agencies that serve a range of municipal aggregations. From a governance and policy perspective, we must keep in mind that housing policy is affected by a large number of governmental agencies, including but not limited to, Departments of Building, City Planning, Health, Housing Preservation, Finance, Homeless Services, Housing Authority, and Economic Development.

- Building-related: building stock and housing supply at regional, city, and neighborhood scale. These data characterize the state of housing supply for both rental and ownership, and include land use (zoning), building information, and new construction activity (permitting).
- People-related: housing demand and population information, including volume, density, and demographics at appropriate spatial units.
- Resource-related: physical and social resources to support urban living, including utilities, infrastructure (e.g., access to public transit), environment, services, opportunities (e.g., jobs), safety, and other quality of life factors.
- Home rental and ownership: rental price, availability, and zoning; volume and median home sale prices, new residential construction permits, including ADUs. Data can be found in web-based rental services such as RentCafe, Zumper, and Zillow, though rental data should be used with

caution given known disparities across communities [Boeing et al., 2020]. A partnership with one or more of these companies would be useful.

- Eviction: Eviction record data resulting from formal eviction processes may be available and would provide a direct record of loss of housing. The Eviction Lab at Princeton makes available eviction data at county level aggregation and would be a strong partner.
- Resident-contributed data: *311 and other social data contributed by citizens*. 311 (a service utilized by many cities to collect citizen reported concerns regarding public infrastructure) reports related to loss or potential loss of housing may provide indicators of current and imminent loss of housing. Similarly, various forms of relevant social media (e.g., Nextdoor) may provide aggregated metrics of neighborhood-level housing issues.
- Internet searching: *search query-based metrics* related to loss of housing. Search engines are common information sources, and are likely to be used by people seeking information on eviction, new housing options, disputes with landlords, mortgage rates, debt relief, etc.

Given the number of data sources and variation in schemas, access methods, and format, as many of these measures as possible should be combined into a single data structure for each municipality that updates automatically, supports descriptive analytics, and provides a foundation for forecasting. National-scale aggregation is unlikely due to the immense challenges of schema merging across so many datasets, along with other data ownership, privacy, and provenance issues. Descriptive analytics are detailed below (see Data-Driven Housing Health Index). These measures and analytics can also direct efforts to repurpose existing built environment resources, including vacant homes, but also hotels, dormitories, and office and other retail space that may become available in the wake of COVID-19.

New Housing and Related Technologies: Innovating the Built Environment

A number of new housing options and home building technologies could be leveraged and paired with city planning and zoning changes to quickly expand the supply, density, and range of housing options. For instance, the current renaissance in prefab home construction utilizes advances in off-site robotic construction to reduce construction costs. Importantly, many of these homes can be delivered and assembled in far less time than that required for traditional on-site home building. Cities can increase housing flexibility by zoning for areas that can accommodate quick increases in these prefabricated homes. The prefabricated nature of these homes provides financial stability that cities can take advantage of to increasing housing flexibility. For instance, through partnerships with manufacturers, home designs can be largely preapproved to minimize permitting delays. Also, because the costs of these home are largely known, cities can help prepare steps for quicker financing across a range of designated price points, which should help provide lower-cost homes more quickly. Additionally, prefabricated homes tend to be more energy efficient with better indoor air quality (Doiron, 2011).

In acute crisis scenarios such as in response to natural disasters or rapid onset housing stress following COVID, where time is the most important variable, something like hexayurts offer an option that costs less than a tent, and can be made from standard 4’ x 8’ industrial panels of plywood, plastic, or other materials. Cities could rapidly deploy hexayurts as supplemental housing in parks and parking lots, or the backyards of willing homeowners or even renters. Though mostly a Burning Man curiosity to date, the hexayurt technology was intended for disaster relief applications. Implementing any such radical measure would surely test any city’s ability to “flex,” and there could be much gained from such experimentation to update governance structures to evolve urban flexibility.

Turning to advances in building materials science, by 2060 cities are expected to add 2.48 trillion square feet of building floor space, or double the amount existing today, resulting in massive carbon footprint increases. Producing cement and steel, both essential for building concrete structures, account for 13% of global CO2 emissions annually, in addition to CO2 emitted from transporting building materials and the construction process. In fact, the demand for concrete has risen so much we may be on the verge of over-extracting sand [cite], with potentially far-reaching social and ecological consequences.

However, there are positive developments as well. Moves to electrify all components of American systems, including transportation, heating, and cooling, linked to increasingly affordable renewable energy can nearly eliminate US emissions by 2035, add 25 million peak (and 5 million permanent) jobs, and reduce average household energy costs ~$1,000—$2,000 (Griffith et al., 2020). In addition, construction with materials like cross-laminated timber promises to lower the carbon intensity of the built environment. As with housing affordability, the problem is not a lack of solutions, but rather inadequate commitment to their implementation. Improved data analyses can build support for the necessary targeted action.

Thus, as part of leveraging the COVID-19 crisis to prepare for climate change, we recommend leveraging green technology and other COVID-19 regrowth stimulus packages to accelerate efforts to drastically reduce the embodied carbon of new buildings. CO2 emissions from manufacturing building materials constitute the majority of the embodied carbon in buildings. In 2018, leading cement manufacturers pledged to take steps toward reducing their carbon emissions by switching to renewable energy or reducing energy consumption [cite]. It will be important to create mechanisms for holding manufacturers accountable for these pledges, either by limiting the amount of emissions through regulation or putting a price on carbon at the point of emission. Further, more resources should be directed toward researching alternatives to traditional cement manufacturing, such as using biocementation and upcylcing industrial byproducts to replace carbon intensive processes like clinker production [cite]. Research shows that once cured, concrete can absorb and sequester CO2 through carbonation [cite]. This means that if we could make cement production a zero-carbon process, our cities and their concrete structures could potentially act as massive carbon sinks.

We should also incentivize research into green concrete alternatives like sustainable timber and novel bioengineered materials (e.g., mycelium). Some of these new materials still face challenges in terms of being economically competitive (compared to concrete) and meeting building safety standards. However, safety concerns of concrete alternatives are increasingly alleviated through new architectural designs, computer modeling, and new construction approaches like additive manufacturing. Such advances could even usher in a new wave of buildings made with sustainable materials and nature-inspired designs.

Compared to CO2 emissions from building materials manufacturing, emissions from transporting these materials and construction are relatively small but not insignificant. To minimize embodied carbon, it will be important to leverage advances in electric transportation and new construction technologies like additive manufacturing, while minimizing the negative impacts and job displacements such transitions will incur. If action at the scale of the Green New Deal is politically afoot, Rewiring America's 2020 report on the benefits of economy-wide electrification offers nationwide interventions to decarbonize the US and improve public health.

Data Service: Housing Health Index

As a data-driven service to help facilitate research and practitioner decision making, we outline here a Housing Health Index service and dashboard based on the data sources catalogued above, along with corresponding descriptive statistics and forecasts (see *Data, Analysis, and Forecasting*). The dashboard can be tailored to the unique needs of relevant departments in city and other municipal governments but will be combined into an overall housing health index. This primary metric summarizes the current stress on housing in a city by combining zoning, availability, cost of home rental and ownership, eviction records, and resident generated data (311, search query, etc.). Individual components of the housing stress index will be available for drill down, as will sub-city area aggregates (e.g., neighborhood level metrics if available). To interact with the housing health dashboard, data will be available via API and via interactive web components, including timeline and map views. All measures will be derived and evaluated using back-testing on archival measures of negative (and conversely positive) housing indicators: evictions, rent disputes, housing supply.

The housing health index will be characterized in two dimensions: flexibility and utilization:

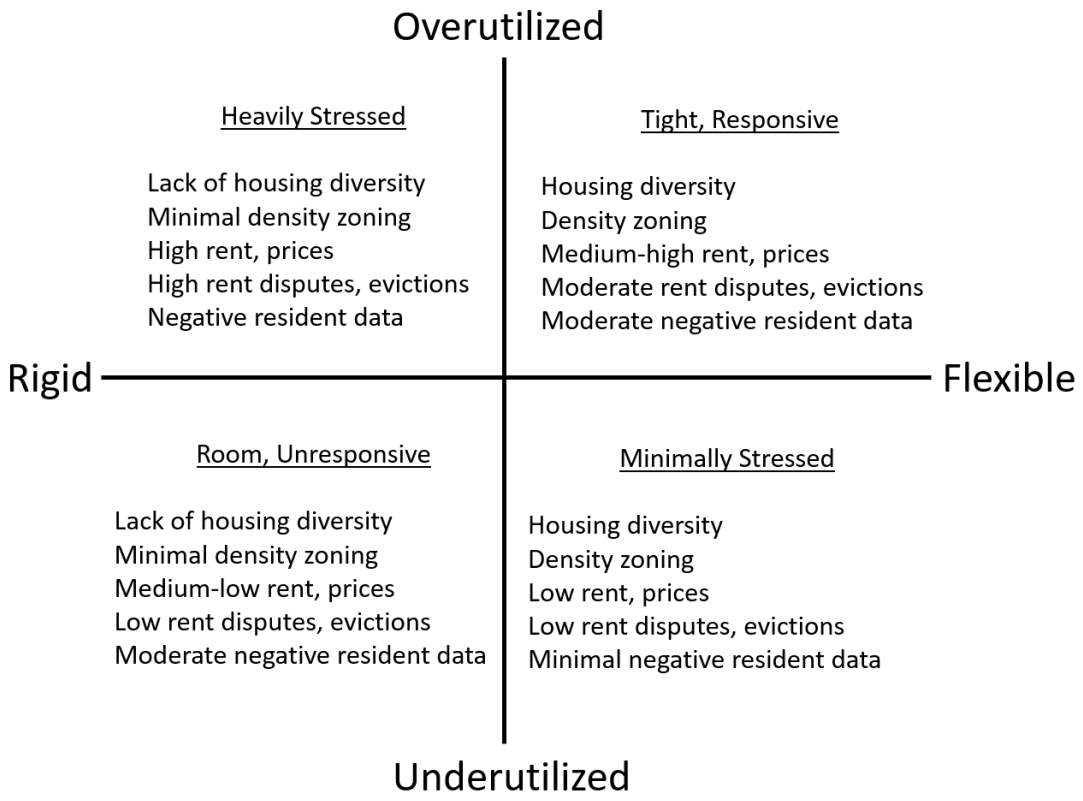

Figure 1: Two-dimensional housing health index.

Moving Forward

The immediate next step is compiling the data outlined in order to start building preliminary models to identify areas where the greatest improvements in solutions can be made. As noted, given the complexity of governmental agencies involved, such an analytic endeavor should be undertaken in collaboration with either as many of those agencies as possible or with a centralized agency. Given data and data availability variance across cities, we recommend starting with either a single city or small number of cities. The data compilation and resulting models could be hosted by the cites themselves or in conjunction with a sponsor that provides data and compute capability.

Visions for the Future: Housing Equality in Post-COVID Cities

Ultimately, housing crises are humanitarian crises. Thus, improving the welfare of people should be at the center of any framework for post-COVID reconstruction. To this end, in addition to leveraging data analytics, we also need to engage, understand, and elevate community voices. Concretely, this means

including residents, social workers, and community leaders in advising and planning post-COVID housing initiatives.

The story of Quayside offers a cautionary lesson in this regard. The project, a collaboration between Toronto and Sidewalk Labs, proposed to build a sustainable smart city in the industrial district of Quayside. Although it was initially well-received by most residents, activists and community groups were quick to raise concerns about data privacy and gentrification. The project's failure to address these concerns fomented distrust within the community and eventually turned residents against its implementation. Quayside highlights the importance of transparency and community trust in urban innovation. In particular, the debate over data privacy will only grow in time, as the public becomes more aware of their digital rights. Such concerns are especially pertinent to smart cities, and should inform decision makers to prioritize data protection when building and updating urban digital infrastructures, including housing-related data analytics.

To further facilitate a framework that puts resident wellness at its center, we may want to create a resident stress metric, alongside a housing stress metric. Homelessness is a multifaceted problem. To truly solve it, we have to understand and tackle its many root causes. A metric that factors in education, job security, wealth distribution, racial segregation, and mental health of residents (similar to Tacoma's Equity Index) will help lead cities in this direction, by shedding light on not only where new housing should be built, but how it should serve residents.

There is no silver bullet to solving homelessness. Rather, we need comprehensive solutions that include providing mental health support, increasing affordable housing supply, reducing racial inequality, and more. To achieve this ambitious agenda, it is essential for cities to develop proper frameworks for coordinating responses between various stakeholders. For instance, the City of Seattle, which has invested hundreds of millions of dollars over the last decade to address homelessness, admits that "the lack of coordination among governments and other stakeholders has limited the effectiveness of those investments. The response to homelessness has been divided among many agencies and government structures, with none having authority to establish clear priorities, reduce duplicative efforts, and align reporting measures across the board." The added strain and urgency of COVID-19 induced housing crises calls for governments and innovators to accelerate efforts to eliminate data barriers between stakeholders.

Further, it is important to recognize that living arrangements can heavily impact someone's mental and physical health. When rehousing homeless people, cities should ensure that the built environment and surroundings of new housing are empowering and not retraumatizing. Proper housing solutions should provide a sense of stability and access to economic opportunities - both key to helping people get back on track.

Finally, when considering housing solutions for post COVID-19 cities, we must avoid exacerbating existing inequities. As the COVID-19 pandemic has demonstrated, low-income and vulnerable communities are the hardest hit in times of duress. Similarly, these communities have the fewest resources to respond to the climate crisis. Already, urban resources are allocated based on socioeconomic strata. Low-income communities have fewer green spaces, less access to healthy food, and are more exposed to air and water pollution. Meanwhile, buildings with housing innovations like the aforementioned HVAC systems and sustainable materials are often exclusive to wealthier neighborhoods, further driving the disparities between low and high-income urban residents. Solving

these complex problems requires comprehensive political and social change, and technology alone is not enough. But as urbanists and technologists, we have a responsibility to challenge our own biases and work on minimizing inequalities, not amplifying them. A greener and fairer urban future should be available to all, not just a select few.

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