Sarcouncil Journal of Engineering and Computer Sciences

ISSN(Online): 2945-3585

Volume- 04| Issue- 09| 2025

Review Article **Received:** 05-08-2025| **Accepted:** 25-08-2025 | **Published:** 19-09-2025

Data-Driven Approaches to Identifying and Addressing Housing Inequality and Disaster Vulnerability in U.S: A Critical Review

Stella Agyeiwaah Adu, [1] Phyllis Ang-E-Mwin Gyang [2], and Joshua Akwetey Djangmah [3]

[1]Department of City and Regional Planning, University of Memphis, Memphis Tennessee, USA
[2]Michigan State University, East Lasing, MI, USA
[3]Department of Geography, University of Winneba, Ghana

Abstract: Housing inequality and disaster vulnerability remain pressing and interconnected challenges in the United States, disproportionately affecting historically marginalized populations. Communities facing inadequate housing, economic precarity, and spatial segregation often bear the brunt of climate-induced disasters such as floods, wildfires, and hurricanes. These overlapping vulnerabilities not only exacerbate social inequities but also hinder effective emergency response and long-term recovery. This review critically examines the role of data-driven approaches in identifying and addressing these dual crises. The paper synthesizes a wide range of methodologies, such as Geographic Information Systems (GIS), remote sensing, social vulnerability indices, machine learning models, and participatory data tools that are increasingly used to assess housing conditions, map hazard exposure, and support targeted interventions. Emphasis is placed on the integration of demographic, infrastructural, and environmental datasets to uncover spatial patterns of risk and inequity. Key findings highlight both the promise and limitations of current data-driven practices. While these tools enhance risk assessment, support predictive modeling, and inform equitable policy design, they are often constrained by data silos, methodological bias, and limited representation of community knowledge. The review highlights the importance of ethical data governance, transparency, and inclusive data collection in advancing socially just outcomes. The paper concludes with policy recommendations that call for enhanced interagency collaboration, investments in local data capacity, and the development of standardized frameworks to align housing and disaster resilience planning. Together, these strategies can help build more adaptive, equitable, and data-informed urban futures.

Keywords: Housing inequality; disaster vulnerability; data-driven planning; GIS; social vulnerability; machine learning; spatial analysis; U.S. housing policy.

INTRODUCTION

Housing inequality and disaster vulnerability are two converging crises that define the contemporary urban landscape in the United States. Housing inequality refers to the systematic disparities in the availability, quality, affordability, and accessibility of housing among different population groups, especially when stratified by race, income, and geography (Desmond, 2016; Rutan, 2022). These disparities are perpetuated by factors such as discriminatory zoning practices, economic disinvestment, and the legacy of redlining, which continue to shape where and how people live. On the other hand, disaster vulnerability represents the degree to which individuals, communities, and systems are susceptible to harm from natural or human-induced hazards. This concept encompasses not only physical exposure to threats such as floods, hurricanes, and wildfires but also the social, economic, and infrastructural factors that influence a community's ability to prepare for, respond to, and recover from disasters (Cutter, Boruff, & Shirley, 2003; Flanagan *et al.*, 2011).

These two phenomena intersect profoundly, particularly among marginalized communities. Populations already burdened by housing insecurity are often disproportionately located in high-risk areas such as flood zones, industrial corridors, or poorly maintained housing stock conditions that amplify disaster risks (Elliott & Howell, 2017; Bullard & Wright, 2009). For example, during Hurricane Katrina, many of the hardest-hit neighborhoods in New Orleans were home to low-income Black residents living in substandard housing situated below sea level. Their limited access to evacuation resources and recovery aid laid bare the compounded effects of housing and environmental inequality (Pastor *et al.*, 2006). More recently, in the aftermath of Hurricane Harvey and California wildfires, studies have revealed that wealthier, whiter neighborhoods were more likely to receive aid and recover quickly, while vulnerable populations experienced prolonged displacement and economic losses (Howell & Elliott, 2019). This recurring pattern of unequal risk and recovery highlights how the dual crises of housing inequality and disaster vulnerability reinforce one another, deepening social and spatial inequities.

Addressing these challenges requires more than conventional policy responses; it demands nuanced, data-informed interventions that reflect

***Corresponding Author:** Joshua Akwetey Djangmah

DOI- https://doi.org/10.5281/zenodo.17162241

the complexity of vulnerability. Over the past two decades, the proliferation of data-driven methods has transformed the fields of urban planning and disaster risk management. Technological advancements in Geographic Information Systems (GIS), remote sensing, machine learning, and big data analytics have enabled researchers and policymakers to better map at-risk communities, monitor housing conditions, and model hazard exposures with unprecedented precision (Chen *et al.,* 2020; Cutter & Derakhshan, 2022). For instance, the Centers for Disease Control and Prevention's Social Vulnerability Index (SVI) and FEMA's National Risk Index (NRI) integrate demographic, socioeconomic, and environmental variables to assess community-level resilience and guide resource allocation (Flanagan *et al.,* 2011; FEMA, 2023). Similarly, HUD's Comprehensive Housing Affordability Strategy (CHAS) dataset and Census tract-level indicators offer critical insights into affordability gaps and residential instability.

These data tools not only enhance situational awareness but also serve as powerful instruments for advocacy, planning, and program design. Community-based organizations have increasingly adopted participatory GIS and crowdsourced data platforms to visualize disparities and demand equitable infrastructure investments (Goodchild & Glennon, 2010; Haworth *et al.,* 2018). At the institutional level, predictive models are being developed to anticipate climate impacts on housing markets, simulate disaster scenarios, and prioritize resilience upgrades in vulnerable neighborhoods (Sun *et al.,* 2023; Zhang, Li, & Yan, 2022). However, while the promise of data-driven approaches is undeniable, their effective application depends on issues of data quality, granularity, accessibility, and ethics. Biases in algorithmic modeling, data fragmentation across jurisdictions, and the underrepresentation of lived experiences all pose critical challenges to deploying these tools equitably. Consequently, this review critically examines the landscape of data-driven methodologies used to identify and address housing inequality and disaster vulnerability in the U.S.

LITERATURE REVIEW

Data Integration for Vulnerability Assessment

Effective disaster response and recovery planning depend on accurately identifying vulnerable populations, those who are most at risk of harm and least able to recover. Historically, vulnerability assessments have been limited by fragmented or unidimensional data approaches that overlook the interplay of multiple risk factors. However, recent advances in data integration have enabled the development of more holistic and nuanced frameworks for assessing vulnerability, particularly in the context of housing inequality and disaster exposure.

One of the most promising approaches is the creation of comprehensive vulnerability indices that combine diverse data streams mobility patterns, socioeconomic characteristics, housing conditions, and geographic risk exposure. Patel et al. (2024) argue that integrating these data dimensions provides a more accurate representation of vulnerability, especially in the face of compound disasters, where multiple hazards interact or occur in succession. Their study demonstrates that static measures of income or housing alone are insufficient to capture the full scope of community vulnerability. Instead, dynamic mobility data such as cell phone location data during hurricanes combined with indicators like racial composition, age, health status, and infrastructure resilience, offer a multidimensional view of at-risk populations. This approach helps planners move from reactive to predictive models of disaster management.

The utility of integrated indices is also evident in widely adopted tools such as the Centers for Disease Control and Prevention's Social Vulnerability Index (SVI) and the Federal Emergency Management Agency's National Risk Index (NRI). These indices incorporate variables such as housing crowding, vehicle access, language proficiency, and income level to rank communities' capacity to withstand and recover from disasters (Flanagan *et al.*, 2011; FEMA, 2023). While useful, these tools are often based on cross-sectional datasets and may not fully account for evolving community dynamics or systemic inequalities. Thus, more adaptive and real-time data integration models are increasingly advocated for localized and context-specific planning.

Another critical dimension of data integration is longitudinal analysis, which captures how vulnerability and recovery unfold over time. Several studies have revealed that even when communities are exposed to the same disaster event, recovery trajectories differ dramatically based on race, income, tenure status, and prior neighborhood disinvestment. The study "Inequities in Long-Term Housing Recovery After Disasters"

Publisher: SARC Publisher

(2022) compares post-disaster recovery patterns following Hurricane Andrew (1992) and Hurricane Ike (2008), showing that predominantly Black and Latino neighborhoods faced delayed housing recovery and persistent displacement, even years after the initial disaster. These disparities were not solely due to the physical damage sustained but were compounded by unequal access to insurance, credit, FEMA assistance, and rebuilding resources. Importantly, the study underscores the need for time-series data that track not only structural damage but also population shifts, rent increases, evictions, and changes in land use that follow disasters.

Integrated data systems also help illuminate the role of housing precarity in disaster vulnerability. Rent-burdened households, undocumented residents, and unhoused populations often fall through the cracks of traditional data collection methods, making them invisible to formal vulnerability assessments. By linking administrative datasets (e.g., eviction filings, HUD housing vouchers, utility shutoffs) with disaster risk data, planners and researchers can better understand how pre-existing housing insecurity shapes post-disaster outcomes. For example, linking property appraisal data with FEMA flood maps and census demographics can identify neighborhoods where renters face high flood exposure and limited ability to relocate, informing equitable relocation assistance and affordable housing strategies.

However, while data integration offers powerful tools for identifying at-risk populations, it also presents challenges. Issues of data quality, granularity, standardization, and privacy often limit the effectiveness of integrated approaches. Many administrative datasets are not interoperable or are housed in siloed agencies, impeding comprehensive analysis. Additionally, concerns about surveillance, consent, and misuse of data, particularly in historically over-policed and under-served communities, must be addressed through transparent governance frameworks and participatory data practices (Kwan, 2016).

Housing Insecurity and Disaster Preparedness

Disaster preparedness is a cornerstone of community resilience, but the capacity of individuals and households to adequately prepare for emergencies is often undermined by housing insecurity. Housing insecurity, which includes unaffordable rent or mortgage costs, frequent moves, overcrowding, and risk of eviction, limits a household's ability to invest in preparedness measures such as emergency supplies, insurance coverage, or structural home improvements. Increasingly, research has shown that housing security is not merely a socioeconomic issue; it is a critical determinant of disaster readiness and survivability.

Rao *et al*., (2023) provide compelling evidence that housing insecurity directly reduces the likelihood that households will be adequately prepared for disasters. Their nationwide survey analysis found that individuals facing housing instability were significantly less likely to have basic preparedness resources such as emergency kits, evacuation plans, or secure housing during extreme weather events. In fact, nearly one in three households experiencing moderate to high levels of housing insecurity reported being “not at all prepared” for emergencies. This preparedness gap is further exacerbated in marginalized communities where systemic inequality, limited access to credit, and prior experiences of displacement undermine trust in institutional response systems.

The mechanisms through which housing insecurity affects disaster preparedness are both material and psychological. On a material level, insecure households often lack financial resources to make prepared investments, such as home retrofitting, purchasing generators, or storing non-perishable food and water. They may also lack access to secure tenure, making them reluctant to invest in properties they may soon be forced to vacate (Eisenman *et al.*, 2009). On a psychological level, the chronic stress associated with unstable housing conditions may reduce a household’s bandwidth for proactive disaster planning, contributing to a cycle of vulnerability that compounds over time.

Data-driven approaches have the potential to transform how disaster preparedness is targeted in high-risk populations. Rao *et al.*, (2023) emphasize that integrating housing insecurity indicators into vulnerability mapping such as rent burden, eviction filings, housing tenure, and overcrowding can significantly improve the precision of resource allocation. For instance, when these indicators are layered with geospatial hazard data, emergency planners can identify “hotspots” where natural hazard exposure intersects with acute housing instability. These insights allow for more equitable distribution of disaster preparedness materials (e.g., first-aid kits, flashlights, sandbags), pre-

Publisher: SARC Publisher

disaster educational outreach, and evacuation transportation resources.

Furthermore, integrating data from eviction courts, public housing authorities, and rent relief programs into emergency management systems can support pre-emptive interventions that stabilize housing ahead of anticipated events. In areas with high rates of rent nonpayment or expiring leases, targeted financial assistance or temporary eviction moratoriums may not only reduce displacement risk but also improve disaster readiness. Such proactive strategies were partially deployed during the COVID-19 pandemic, but broader and more sustained implementation is needed to protect vulnerable renters in the face of climate-related threats (Benfer *et al.,* 2021).

GIS-based tools and predictive analytics have also been applied to visualize the convergence of housing insecurity and disaster exposure. For example, recent applications in cities such as Houston and Miami have used parcel-level data to identify neighborhoods where floodplain location overlaps with high rent burdens, guiding city agencies in pre-positioning flood barriers and outreach teams. By embedding housing indicators into resilience dashboards, municipalities can track the progress of vulnerability reduction efforts and assess the long-term impact of housing investments on disaster preparedness.

However, efforts to incorporate housing data into preparedness planning must contend with several challenges. First, data access and interoperability remain obstacles, as housing data are often collected by disparate agencies with varying formats and privacy restrictions. Second, temporal mismatch between housing conditions and disaster events limits the real-time utility of many datasets. Finally, community engagement is crucial to ensure that data-driven solutions are not only technically sound but also responsive to lived realities and local knowledge. Participatory mapping initiatives and partnerships with tenant organizations can enhance the accuracy and legitimacy of housing insecurity data used in preparedness planning.

Racial and Ethnic Disparities in Homeownership

Homeownership remains a key measure of household wealth, stability, and long-term economic mobility in the United States. Yet access to homeownership is deeply unequal along racial and ethnic lines, a structural inequality that plays a pivotal role in perpetuating broader housing disparities. Despite policies aimed at promoting equitable access to housing since the mid-20th century, the homeownership gap between White Americans and communities of color has remained persistently wide, reflecting both historical injustices and ongoing socioeconomic discrimination (DeSilva & Elmelech, 2009; Choi *et al.,* 2019).

National data consistently show that White households have significantly higher homeownership rates compared to Black, Hispanic, and Native American households. As of 2022, the U.S. Census Bureau reported a homeownership rate of nearly 74.4% among non-Hispanic White households, compared to 45.3% for Black households, 48.6% for Hispanic households, and approximately 55% for Native American households (U.S. Census Bureau, 2022). These disparities are not solely attributable to income or education gaps. Research by DeSilva and Elmelech (2009) demonstrates that even after controlling socioeconomic factors such as income, age, and marital status, significant racial and ethnic differences in homeownership rates persist. This points to the importance of spatial context, credit access, intergenerational wealth, and historical housing policies in shaping these outcomes.

Redlining, predatory lending, discriminatory zoning, and unequal access to mortgages have all contributed to the racialized geography of homeownership. For example, historically Black neighborhoods were deliberately denied access to federally backed home loans under New Deal-era policies, creating a legacy of disinvestment and exclusion that still influences contemporary housing patterns. Even today, people of color especially Black and Hispanic applicants are more likely to be denied conventional mortgage loans and charged higher interest rates, even with comparable credit profiles. This disparity in credit access contributes directly to the lower homeownership attainment rates among racial and ethnic minorities.

Beyond the act of purchasing a home, spatial context plays a crucial role in shaping the stability and value of homeownership for minority groups. Many households of color purchase homes in neighborhoods with lower property values, less access to quality schools, fewer public services, and higher exposure to environmental hazards all of which reduce long-term equity accumulation and resilience to external shocks like natural

Publisher: SARC Publisher

disasters. In addition, minority homeowners are disproportionately affected by housing market volatility and are more likely to face foreclosure during economic downturns, as was observed during the 2008 financial crisis (Rugh, Albright, & Massey, 2015).

These racial and ethnic disparities in homeownership have direct implications for disaster vulnerability and resilience. Homeownership is often associated with greater control over property-level preparedness such as retrofitting homes against hazards, purchasing flood or fire insurance, and making structural improvements. Renters, by contrast, typically rely on landlords to make such investments and may lack the resources or legal rights to initiate preparedness measures themselves. However, even among homeowners, racial disparities persist in post-disaster recovery outcomes. Black and Hispanic homeowners are less likely to receive adequate insurance payouts and disaster recovery assistance and face longer recovery periods due to financial precarity and systemic bias in relief distribution.

From a data-driven policy perspective, these disparities underscore the importance of incorporating race and ethnicity into homeownership and vulnerability assessments. GIS and spatial equity mapping tools can help identify racially segregated areas with low homeownership rates, high foreclosure risk, or poor housing conditions enabling targeted interventions such as down payment assistance, fair lending enforcement, and neighborhood reinvestment. Additionally, predictive modeling can be used to evaluate the long-term impact of expanding minority homeownership on wealth inequality and community resilience. However, such approaches must be guided by principles of data justice and racial equity. Simply mapping disparities is insufficient if it is not accompanied by structural reforms that address the root causes of inequality, such as discriminatory appraisal practices, exclusionary zoning, and systemic underinvestment in minority neighborhoods. Moreover, policies must go beyond facilitating home purchases to ensure sustainable ownership through foreclosure prevention, home maintenance support, and community land trust models that stabilize homeownership for low-income buyers (DeFilippis *et al.*, 2019).

Table 1: Overview of Data Sources and Analytical Tools for Housing Inequality and Disaster Vulnerability Assessment

Category	Examples / Sources	Description and Applications	Strengths	Limitations
Government Datasets	U.S. Census Bureau American Community Survey (ACS) HUD CHAS FEMA CDC Social Vulnerability Index (SVI)	Provides demographic, socioeconomic, housing, and disaster risk data used for mapping vulnerability and informing policy.	Widely accessible; standardized; longitudinal	Limited granularity in local contexts; time lags in updates
GIS and Spatial Analytics	ArcGIS QGIS GeoDa	Tools for spatial data integration, mapping, and analysis; used to identify hotspots of inequality and disaster exposure.	Visual, intuitive; effective for layering data and communicating risk	Requires technical expertise; data quality-dependent
Remote Sensing and Satellite Imagery	Landsat Sentinel MODIS	Captures physical and environmental conditions (e.g., land use, flood extents, urban heat islands); used to assess hazard exposure and infrastructure vulnerability.	High spatial coverage; useful for real-time or large-scale analysis	Resolution and cloud cover limitations; interpretation complexity
Machine	Python (scikit-	Used for pattern	Can detect complex	Risk of

Publisher: SARC Publisher

Learning and Predictive Modeling	learn, TensorFlow) R Google Earth Engine	recognition, risk prediction, and scenario modeling in housing affordability, displacement, and disaster impact analysis.	patterns and forecast trends	algorithmic bias; requires large, clean datasets
Participatory and Community-Based Data	OpenStreetMap Maptionnaire Community Asset Maps	Involves residents in data collection and mapping; enhances representation of local knowledge in vulnerability assessments.	Empowers communities; adds local context	Data consistency and validation challenges; may lack technical rigor

Identifying Housing Inequality Using Data

Housing quality, affordability, and access are commonly assessed using quantitative indicators derived from large-scale datasets such as the American Community Survey (ACS), Comprehensive Housing Affordability Strategy (CHAS) dataset, and local housing authorities. Quality is often measured by physical conditions e.g., the presence of plumbing, overcrowding, or structural disrepair while affordability is evaluated using ratios such as housing cost burden (spending more than 30% of income on housing). The Housing Affordability Index (HAI) developed by the National Association of Realtors provides a standardized benchmark for whether a typical family can qualify for a mortgage on a median-priced home (Joint Center for Housing Studies, 2022). Access, in turn, can be measured by proximity to transit, schools, jobs, and healthcare factors that significantly impact housing opportunity and long-term stability.

Spatial analytics have been instrumental in uncovering the geographic patterns of housing segregation and exclusion. GIS tools allow researchers and planners to layer demographic, economic, and zoning data to identify concentrations of disadvantage and track patterns of racial and income segregation. For instance, spatial autocorrelation methods such as Moran's I or Getis-Ord Gi* can detect statistically significant clustering of poverty or rent burden across urban landscapes. These spatial analyses often reveal that low-income and minority communities are disproportionately located in areas with poor housing stock, environmental hazards, and limited public investment patterns that reproduce cycles of disadvantage.

Indices such as the Displacement Risk Index (DRI) and the Urban Displacement Project's mapping tools have become essential in identifying areas at high risk for gentrification, eviction, and rent hikes. These indices integrate multiple dimensions of housing costs, demographic change, zoning designations, and real estate trends to flag neighborhoods experiencing or susceptible to displacement. When paired with policy levers such as rent control maps and housing subsidy data, they can guide targeted anti-displacement strategies and equitable development planning.

Real-world case studies further illustrate the utility of data in identifying and addressing housing inequality. In cities like San Francisco, Washington D.C., and New York, data on eviction filings, building permits, and rent changes have been used to map gentrification hotspots and displacement pathways. For example, the Anti-Eviction Mapping Project in San Francisco combines eviction court records with demographic and real estate data to visualize where vulnerable tenants are being pushed out of their neighborhoods. In Atlanta, researchers have used parcel-level data to show how public housing demolitions, combined with market pressures, have led to the large-scale displacement of Black residents from historically underserved communities. While data tools provide powerful insights into housing inequality, they must be deployed ethically and in partnership with affected communities. Participatory data collection and transparency in methodology are essential to ensure that tools designed to highlight injustice do not inadvertently contribute to displacement or stigmatization. Ultimately, the ability to identify housing inequality using data is not just a technical task it is a political one that requires commitment to racial equity, affordable housing, and inclusive urban planning.

Mapping and Modeling Disaster Vulnerability

Understanding and mitigating disaster vulnerability in U.S. communities requires more than identifying where hazards occur; it involves assessing how different populations are affected based on social, economic, infrastructural, and environmental characteristics. Mapping and modeling disaster vulnerability using data-driven techniques provides crucial insight into these

Publisher: SARC Publisher

differential impacts and enables proactive planning, equitable resource allocation, and targeted interventions.

At the core of this work are hazard exposure and risk modeling techniques that simulate the physical dynamics of disasters such as floods, wildfires, and extreme heat. For example, hydrological models like HAZUS and SWMM are widely used to project flood extents under various rainfall and land-use scenarios (FEMA, 2022). In wildfire-prone areas, satellite-derived vegetation indices and fire weather data have been used to predict ignition and spread patterns using tools like the Wildland-Urban Interface Risk Index (Syphard *et al.*, 2017). Similarly, urban heat risk modeling incorporates land surface temperature data, albedo, and urban form metrics to identify "heat islands" where vulnerable populations may face elevated mortality risks during extreme heat events (Hondula *et al.*, 2015).

However, physical exposure alone does not determine disaster risk. Social factors such as income, race, age, disability, and housing conditions significantly shape community resilience and recovery outcomes. Social vulnerability mapping combines demographic and socioeconomic indicators with hazard data to assess the capacity of populations to prepare for, respond to, and recover from disasters. One of the most widely used tools in this domain is the Centers for Disease Control and Prevention’s Social Vulnerability Index (SVI), which ranks census tracts across the U.S. based on 15 variables in four themes: socioeconomic status, household composition, minority status/language, and housing/transportation access. The Federal Emergency Management Agency’s National Risk Index (NRI) expands on this by incorporating exposure, vulnerability, and resilience measures for 18 hazard types at the county level.

Data integration is essential to advance these analyses. Cutting-edge research emphasizes the need to combine environmental, infrastructural, and socio-demographic data to develop holistic models of disaster vulnerability. For instance, linking floodplain maps with infrastructure condition data and renter-occupancy rates can reveal areas where low-income tenants are both physically exposed and economically unable to recover from flood events. Remote sensing data (e.g., Landsat, MODIS) can be integrated with census and parcel-level housing data in Geographic Information Systems (GIS) to identify neighborhoods with aging infrastructure, poor housing quality, and inadequate emergency access factors that significantly increase vulnerability.

Case studies from past disasters provide powerful illustrations of these concepts in action. Hurricane Katrina exposed the extreme vulnerabilities of New Orleans' low-income and predominantly Black neighborhoods. Areas such as the Lower Ninth Ward, which were situated in low-lying flood zones and had high poverty rates, suffered catastrophic damage and prolonged displacement. In California wildfires, studies have shown that lower-income communities, especially those in mobile homes or informal housing near wildland-urban interfaces, face heightened risk due to limited insurance coverage and inadequate evacuation infrastructure. Similarly, Midwest flooding events in states like Iowa and Missouri have demonstrated how a combination of aging levee systems, housing insecurity, and agricultural land-use patterns exacerbate rural and suburban vulnerability.

Ultimately, mapping and modeling disaster vulnerability must move beyond hazard-centric approaches toward frameworks that foreground equity, context, and local capacity. Future work in this space will benefit from high-resolution data, participatory modeling tools, and machine learning algorithms capable of capturing complex interactions between physical and social risk factors. These approaches are critical to designing inclusive resilience strategies that protect the most vulnerable and enable equitable recovery.

INTEGRATED APPROACHES

Bridging Housing Inequality and Disaster Risk

Traditional approaches to addressing disaster vulnerability and housing inequality have often operated in silos, treating them as separate domains. However, recent scholarships and policy practices underscore the need for integrated frameworks that combine housing and disaster data to capture the complex, overlapping risks faced by marginalized communities. These approaches recognize that housing insecurity is both a driver and consequence of disaster exposure and that disaster events often exacerbate pre-existing spatial and social inequalities.

One example of such integration is the use of multidimensional risk models that go beyond single-hazard assessments to consider the intersection of environmental, socioeconomic, and infrastructural vulnerabilities. These models

Publisher: SARC Publisher

incorporate data on hazard exposure (e.g., flood zones, wildfire perimeters), housing characteristics (e.g., age, material, tenure), and socio-demographics (e.g., income, race, disability) to assess cumulative risk at fine spatial scales. Tools such as the Urban Resilience Framework and the Climate and Economic Justice Screening Tool (CEJST) exemplify efforts to integrate risk factors into a unified platform to support equitable planning and decision-making.

Community resilience mapping is another promising method that leverages integrated data to visualize areas where adaptive capacity is low and social vulnerability is high. Unlike conventional hazard maps that focus solely on physical threats, resilience mapping layers of community assets such as healthcare facilities, emergency shelters, public transit, green space, and social service networks alongside risk indicators. For example, the Resilience Atlas developed by the U.S. Agency for International Development (USAID) overlays climate stressors with infrastructure and livelihood data to identify high-risk but underserved communities (USAID, 2021). At the municipal level, cities like New York and Los Angeles have created interactive dashboards that track neighborhood resilience metrics, including heat vulnerability, housing cost burden, and disaster recovery timelines to guide investment in climate adaptation and housing stabilization.

An essential component of integrated approaches is the incorporation of public health and infrastructure data. Public health data, including rates of chronic illness, mental health conditions, and emergency medical service access, can highlight populations that may be particularly vulnerable to disaster-related displacement or mortality. For instance, during Hurricane Sandy, neighborhoods with high concentrations of elderly and medically fragile residents experienced higher fatality rates due to delayed evacuations and power outages (Rao *et al.,* 2018). Integrating such health indicators into housing vulnerability models can inform preparedness measures such as medical outreach and resilient energy systems.

Likewise, infrastructure data on water, electricity, transportation, and broadband access is critical to understanding the capacity of a neighborhood to withstand and recover from a disaster. Poorly maintained or underfunded infrastructure often coincides with high housing insecurity, creating compounding vulnerabilities. Data from the Environmental Protection Agency (EPA), Department of Transportation (DOT), and local utilities can be layered with housing and health data to model system-wide risks and prioritize infrastructure upgrades in disadvantaged communities (Zhao *et al.*, 2022). Despite the promise of integrated models, their implementation faces several challenges. Disparate data formats, privacy concerns, and siloed governance structures hinder collaboration between housing agencies, public health departments, and emergency management offices. Additionally, the ethical use of integrated data requires transparency, consent, and safeguards against misuse, especially in communities historically subject to surveillance and displacement. Participatory data practices and community engagement are essential to ensuring that integrated tools reflect lived realities and support equitable policy outcomes.

Challenges and Gaps

While data-driven approaches have revolutionized the identification and management of housing inequality and disaster vulnerability, their implementation is not without significant challenges and gaps. These limitations span technical, methodological, ethical, and social dimensions and must be addressed to ensure equitable and effective application of spatial and predictive tools.

A central challenge lies in data accessibility and interoperability. Critical datasets on housing conditions, infrastructure, health, and hazard exposure are often housed in siloed government agencies, non-profit organizations, and private entities, each using different data formats, standards, and access policies. This fragmentation limits the ability of planners, researchers, and community groups to create integrated, cross-sectoral assessments of vulnerability. Even when data are publicly available such as the U.S. Census, FEMA's HAZUS, or HUD databases users frequently encounter outdated information, inconsistent geographic scales, and technical barriers that hinder meaningful analysis (Gomez & White, 2021). Moreover, real-time or high-resolution datasets, such as those from remote sensing or mobile tracking, may be proprietary or expensive to access, creating disparities in who can use data for resilience planning.

Equally critical is the issue of representation and bias in data. Many widely used datasets underrepresent the very populations most at risk low-income renters, undocumented immigrants,

Publisher: SARC Publisher

people experiencing homelessness, and rural or tribal communities. For example, disaster exposure maps may exclude informal housing units or unregistered mobile homes, thereby underestimating risk for entire population segments (Montano *et al.,* 2022). Historical biases are also embedded in seemingly neutral datasets. For instance, predictive policing and lending algorithms often reflect the discriminatory practices of the past, such as redlining or exclusionary zoning, and perpetuate systemic inequities under the guise of data objectivity (Benjamin, 2019). If these biases are not explicitly identified and corrected, data-driven tools risk reinforcing the very disparities they aim to address. Beyond data quality and representation, methodological limitations remain a persistent concern. Many disaster and housing models rely on static or cross-sectional data, failing to capture the dynamic and compounding nature of risk. For example, standard flood risk models may not account for future climate scenarios, land-use changes, or evolving demographic patterns. Similarly, housing affordability indices often ignore factors like gentrification momentum, tenant displacement risk, or racialized patterns of investment and disinvestment. Moreover, advanced machine learning models, while powerful, are frequently opaque, limiting transparency and interpretability for policy actors and affected communities (Kwan, 2016). The lack of standardization in methodological frameworks also makes it difficult to compare vulnerability across regions or periods.

CONCLUSION

This review has examined the evolving role of data-driven approaches in identifying and addressing the intersecting challenges of housing inequality and disaster vulnerability in the United States. Through the integration of spatial, socioeconomic, environmental, and infrastructural data, researchers and policymakers now possess powerful tools to assess risk, target interventions, and promote resilience. Key insights include the value of multidimensional indices, predictive modeling, community-based mapping, and the use of real-time data to capture dynamic patterns of exposure and displacement. These approaches have demonstrated success in revealing how historically marginalized populations, particularly low-income and communities of color, bear disproportionate burdens during and after disaster events. However, the review also highlights persistent gaps, including fragmented data systems, algorithmic biases, and ethical concerns around consent and surveillance. The current siloed nature of housing and disaster management frameworks fails to address the compounding vulnerabilities faced by at-risk populations, especially in an era of escalating climate risks.

There is an urgent need to integrate housing and disaster data into cohesive, equity-centered planning systems. Doing so would enable more accurate risk assessments, strengthen community preparedness, and inform policies that address root causes of vulnerability, such as racial segregation, housing precarity, and infrastructure neglect. Resilience must be understood not only in terms of physical infrastructure but as a function of social systems and institutional responsiveness. Advancing this integrated approach requires cross-sector collaboration, transparent governance, and meaningful engagement with affected communities to ensure that data serve justice, not just efficiency in building safer, more inclusive futures.

REFERENCES

1. Benfer, E. A., Vlahov, D., Long, M. Y., Walker-Wells, E., Pottenger, J. L., Gonsalves, G., & Keene, D. E. "Eviction, health inequity, and the spread of COVID-19: Housing policy as a primary pandemic mitigation strategy." *Journal of Urban Health* 98.1 (2021): 1–12.
2. Benjamin, R. “Race after technology: Abolitionist tools for the new Jim code.” *Polity Press*, (2019).
3. Bullard, R. D., & Wright, B. “Race, place, and environmental justice after Hurricane Katrina: Struggles to reclaim, rebuild, and revitalize New Orleans and the Gulf Coast.” *Westview Press*, (2009).
4. Chen, Y., Wang, Y., Wang, Z., & Wang, J. "GIS-based multi-criteria analysis for climate vulnerability assessment." *Sustainability* 14.5 (2020): 2678.
5. Choi, J. H., McCargo, A., Neal, M., Goodman, L., & Young, C. “Explaining the Black-White homeownership gap: A closer look at disparities across local markets.” *Urban Institute*, 2019.
6. Davies, I. P., Haugo, R. D., Robertson, J. C., & Levin, P. S. "The unequal vulnerability of communities of color to wildfire." *PLOS ONE* 13.11 (2018): e0205825.
7. DeFilippis, J., Stromberg, B., & Williams, O. R. *Wrecking the American dream: The politics*

Publisher: SARC Publisher

of homeownership and the push for affordable housing. Verso Books, 2019.

8. Eisenman, D. P., Cordasco, K. M., Asch, S., Golden, J. F., & Glik, D. "Disaster planning and risk communication with vulnerable communities: Lessons from Hurricane Katrina." *American Journal of Public Health* 97.S1 (2009): S109–S115.
9. Elliott, J. R., & Howell, J. "Beyond disasters: A longitudinal analysis of natural hazards' impacts on residential instability." *Social Forces* 95.3 (2017): 1181–1207.
10. Elliott, J. R., & Pais, J. "Race, class, and Hurricane Katrina: Social differences in human responses to disaster." *Social Science Research* 35.2 (2006): 295–321.
11. Flanagan, B. E., Gregory, E. W., Hallisey, E. J., Heitgerd, J. L., & Lewis, B. "A social vulnerability index for disaster management." *Journal of Homeland Security and Emergency Management* 8.1 (2011): Article 3.
12. Fussell, E., & Harris, E. "Homeownership and disaster recovery: Differential recovery trajectories in New Orleans following Hurricane Katrina." *Housing Policy Debate* 24.1 (2014): 171–195.
13. Gomez, L. E., & White, J. "Barriers to integrating climate and housing data in U.S. cities: A review of municipal data practices." *Journal of Urban Technology* 28.2–3 (2021): 101–120.
14. Goodchild, M. F., & Glennon, J. A. "Crowdsourcing geographic information for disaster response: A research frontier." *International Journal of Digital Earth* 3.3 (2010): 231–241.
15. Haworth, B., Bruce, E., & Middleton, T. "Emerging technologies for risk reduction: Assessing the potential of crowdsourced data and participatory mapping." *International Journal of Disaster Risk Science* 9.4 (2018): 538–546.
16. Hetty, R., Hendren, N., Kline, P., & Saez, E. "The effects of exposure to better neighborhoods on children: New evidence from the Moving to Opportunity experiment." *American Economic Review* 106.4 (2016): 855–902.
17. Hondula, D. M., Balling Jr, R. C., Vanos, J. K., & Georgescu, M. "Rising temperatures, human health, and the role of adaptation." *Current Climate Change Reports* 1 (2015): 144–154.
18. Howell, J., & Elliott, J. R. "Damages done: The longitudinal impacts of natural hazards on wealth inequality in the United States." *Social Problems* 66.3 (2019): 448–467.
19. Joint Center for Housing Studies of Harvard University. "The State of the Nation's Housing 2022". *Harvard University,* 2022.
20. Kwan, M. P. "Algorithmic geographies: Big data, algorithmic uncertainty, and the epistemology of modeling urban environments." *Annals of the American Association of Geographers* 106.2 (2016): 274–282.
21. Liu, S., & Parilla, J. *Place, race, and equity: Mapping a path forward for equitable housing markets.* Brookings Institution, 2020.
22. Maharawal, M. M., & McElroy, E. "The anti-eviction mapping project: Counter mapping and oral history toward Bay Area housing justice." *Annals of the American Association of Geographers* 108.2 (2018): 380–389.
23. Montano, A., Cox, M., & Aguilar, J. "The hidden geography of disaster: Mobile homes, informal housing, and undercounted vulnerability in U.S. hazard zones." *Environmental Justice* 15.4 (2022): 175–184.
24. Pastor, M., Bullard, R. D., Boyce, J. K., Fothergill, A., Saegert, S., & Shipp, R. *In the wake of the storm: Environment, disaster, and race after Katrina.* Russell Sage Foundation, 2006.
25. Rao, M., Johnson, M., & Lee, A. "Housing insecurity and disaster preparedness: An overlooked intersection." *Journal of Emergency Management* 21.2 (2023): 97–111.
26. Rao, M., Wu, J., & Chen, W. "Vulnerability of elderly populations in disaster-prone areas: A study of Hurricane Sandy impacts in New York City." *International Journal of Environmental Research and Public Health* 15.9 (2018): 1986.
27. Rugh, J. S., Albright, L., & Massey, D. S. "Race, space, and cumulative disadvantage: A case study of the subprime lending collapse." *Social Problems* 62.2 (2015): 186–218.
28. Rutan, J. "Housing policy, inequality, and place: A spatial analysis of housing disparities in U.S. cities." *Housing Policy Debate* 32.2 (2022): 201–220.
29. Syphard, A. D., Rustigian-Romsos, H., Mann, M., Conlisk, E., & Moritz, M. A. "The relative influence of climate and housing development on current and projected future fire patterns in San Diego County, California." *Landscape Ecology* 32 (2017): 316–331.

Publisher: SARC Publisher

30. U.S. Census Bureau. "Quarterly residential vacancies and homeownership, fourth quarter 2022. U.S." *Census Bureau,* 2022.
31. Wing, O. E. J., Bates, P. D., Smith, A. M., Sampson, C. C., Johnson, K. A., & Fargione, J. "Inequitable patterns of U.S. flood risk in the Anthropocene." *Nature Climate Change* 12.2 (2022): 156–162.
32. Zuk, M., Bierbaum, A. H., Chapple, K., Gorska, K., & Loukaitou-Sideris, A. "Gentrification, displacement, and the role of public investment: A literature review." *Journal of Planning Literature* 33.1 (2018): 31–44.
33. Zuk, M., Chapple, K., Loukaitou-Sideris, A., & Ong, P. "Gentrification, displacement and the role of public investment: A literature review*." Federal Reserve Bank of San Francisco,* (2018).

Source of support: Nil; **Conflict of interest:** Nil.

Cite this article as:

Adu, S. A., Gyang, P. A. E. M. and Djangmah, J. A. " Data-Driven Approaches to Identifying and Addressing Housing Inequality and Disaster Vulnerability in U.S: A Critical Review." *Sarcouncil Journal of Engineering and Computer Sciences* 4.9 (2025): pp 389-399.

Publisher: SARC Publisher