Anticipating Climate Challenges: Future Risk Analysis of Historical Redlining Practices

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ABSTRACT

This study investigates the long-term impacts of historical redlining on vulnerability to climate-induced disasters including floods, heat, and wind across racially and socioeconomically diverse neighborhoods. Utilizing a comprehensive dataset and employing ANOVA and Generalized Additive Models (GAM), the research identifies significant disparities in future disaster risk exposure linked to historical redlining practices. The findings reveal that redlined areas, characterized by lower investment and inadequate infrastructure, will disproportionately bear higher risks of climate disasters in the future. This study uniquely contributes to the discourse on urban inequality and environmental justice by elucidating the complex interplay between socio-economic factors such as racial demographics and economic status and increased vulnerability to environmental hazards. Despite the robust analysis, the study acknowledges limitations such as modest adjusted R-squared values and the scope of data, suggesting further research to integrate more nuanced socio-economic variables. This research underscores the necessity for targeted urban planning and policy interventions aimed at mitigating future risks and enhancing resilience in historically marginalized communities.

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INTRODUCTION

Climate change has brought unprecedented challenges, triggering environmental hazards and worsening natural disasters. These impacts are not equitably distributed, with neighborhoods predominantly inhabited by racial or ethnic minorities facing greater vulnerability due to historical neglect and limited investment (Locke et al., 2021; Mital, 2023). This susceptibility is intertwined with the legacy of redlining, a discriminatory lending practice that denied financial services based on racial or ethnic composition, leading to significant disinvestment in certain areas (D'Rozario et al., 2005; Nowak et al., 2022).

Redlining maps created by the Homeowners Loan Corporation in the 1930s divided neighborhoods into grades, with lower grades (C and D) often inhabited by minorities and characterized by economic distress and inadequate infrastructure (Mital, 2023; Hillier, 2003). These areas, historically deprived of investment, are now more vulnerable to climate-induced hazards like floods, heat, and wind.

This study analyzes the long-term effects of redlining on the susceptibility of these communities to climate-induced hazards by integrating data on flood, heat, and wind risks with historical redlining grades. The goal is to understand how past injustices continue to shape environmental vulnerabilities and to inform future policy interventions aimed at mitigating these risks and enhancing resilience in historically marginalized communities.

METHODS AND MATERIALS

Data from the Longitudinal Tract Database (LTDB) were prepared, focusing on key socio-economic and demographic variables. This data was integrated with property-specific climate risk data from the First Street Foundation, which included 2050 projections of flood, heat, and wind risks. Historical redlining grades (HOLC) were aligned with these datasets using geographical identifiers.

ANOVA tests compared disaster risk across different HOLC grades and between historically redlined and non-redlined areas, identifying significant disparities. Descriptive statistical analyses highlighted patterns in average disaster risks by city and HOLC grades.

Generalized Additive Models (GAM) were used to evaluate the influence of socio-economic and demographic factors along with HOLC grades on disaster risk. GAM's flexibility in handling non-linear relationships allowed for an accurate assessment of how historical redlining impacts community resilience to environmental hazards.

RESULTS

For flood risk, lower HOLC grades (especially grade D) face substantially higher risks, as indicated by an F value of 81.28. This is visually corroborated by a clear escalation in mean flood risk from grades A to D. Heat risk also shows significant disparities with an F value of 20.9, and wind risk presents an F value of 6.72. These results affirm the complex relationship between historical redlining and current environmental challenges, with significant disparities across disaster types.

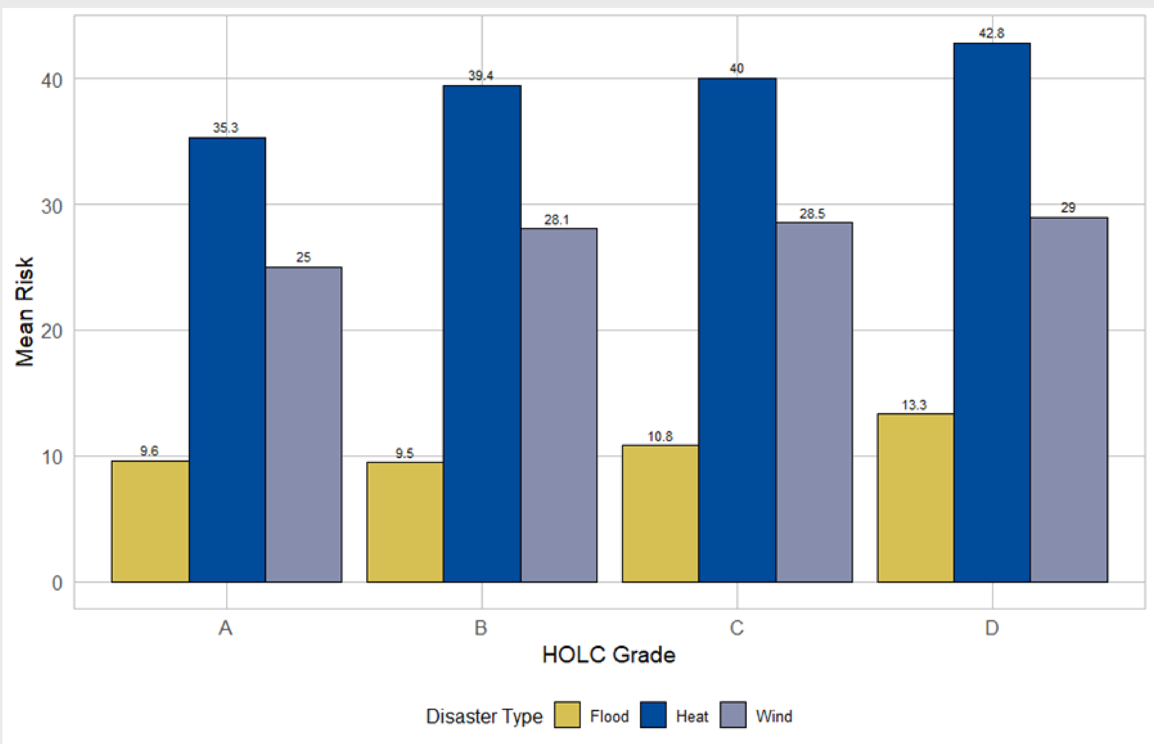
ANOVA tests (Figure 1) indicate that redlined areas consistently experience significantly higher risks across various disaster types compared to non-redlined areas. Flood risk is particularly pronounced, with significant F values for flood (207.70), heat (37.08), and wind (3.36). This highlights the continuing impact of historical redlining on current disaster risk vulnerabilities.

GAM (Table 1) highlight the influence of socio-economic and demographic factors on disaster risk. Factors such as Hispanic population, Black or African American population, vacant units, and median home value significantly impact risk levels. These models demonstrate that historical redlining, combined with current socio-economic disparities, continues to shape community vulnerability to environmental hazards.

Table 1. Comparative Summary of GAM Results for Disaster Risk Analysis

	Flood		Heat		Wind	
Variables	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Intercept	7.01	0.62***	0.15	1.56***	0.12	1.55***
Grade B	0.22	0.36	2.99	0.91**	2.84	0.90**
Grade C	1.32	0.35***	1.56	0.88 .	2.46	0.87**
Grade D	3.32	0.37***	3.00	0.94**	1.99	0.93*
Hispanic	0.07	0.005***	0.63	0.01**	0.29	0.01***
Black	-1.53e-4	<0.001	0.01	<0.001***	0.01	<0.001***
Vacant Unit	0.34	0.01***	0.39	0.03***	0.39	0.03***
Median Home Value	-1.33e-6	<0.001	<0.001	<0.001***	<0.001	<0.001***
College or More	0.06	0.007***	0.007	0.02	0.02	0.02
Unemployed	-0.06	0.02**	-0.77	0.05***	-0.86	0.05***
Less 18	-0.19	0.01***	-0.61	0.04***	-0.21	0.04***
R-sq.(adj)	0.04	N=35338	0.18	N=35358	0.06	N=35358

Note: ***P< 0.001, **P< 0.01, *P< 0.05



Notes: Flood risk - F value: 81.28, p < 0.001; Heat risk - F value: 20.90, p < 0.001; Wind risk - F value: 6.72, p < 0.001.

Figure 1. Mean Risk Across HOLC Grades by Disaster Type

DISCUSSION

This study reveals that historically redlined areas face significantly higher risks from future climate-induced disasters. Lower HOLC grades, particularly grades C and D, are associated with higher disaster risks due to past disinvestment and inadequate infrastructure. Hispanic and Black populations, along with areas with higher vacancy rates, show elevated risks, highlighting socio-economic disparities.

ANOVA results indicate significant disparities across disaster types, with redlined areas consistently experiencing higher risks. Flood risks are particularly pronounced, emphasizing the need for better mitigation. Heat risks are significant as well, reflecting the urban heat island effect exacerbated by dense housing and lack of green spaces. Wind risks, though less pronounced, still show notable disparities linked to historical redlining practices.

GAM elucidate the complex interactions between socio-economic factors and disaster risks. Variables such as race, income, housing characteristics. The positive correlation between vacant units and disaster risk underscores the importance of maintaining and investing in infrastructure.

Our findings focus on future risk, highlighting how historical redlining continues to impact vulnerability to climate-induced disasters. Understanding these future implications is essential for developing proactive measures to protect these at-risk communities.

CONCLUSIONS

This study reveals that historically redlined areas will face significantly higher risks from climate-induced disasters like floods, heatwaves, and wind in the future. Lower HOLC grades correlate with increased risks due to past disinvestment and inadequate infrastructure. Socio-economic disparities, such as higher Hispanic and Black populations and higher vacancy rates, amplify these risks.
Our findings emphasize the need for targeted urban planning and policy interventions to address future risks.

REFERENCES

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